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EGL Ref: 9169

OCEANA GOLD (NEW ZEALAND) LIMITED
WAIHI NORTH PROJECT
WILLOWS ROCK STACK
TECHNICAL REPORT

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WILLOWS ROCK STACK AND COLLECTION POND
TECHNICAL REPORT

1.0 INTRODUCTION

Engineering Geology Limited (EGL) has been appointed by Oceana Gold (New Zealand) Limited (OGNZL) to undertake a technical report for the new Willows Rock Stack (WRS) for resource consent for the Waihi North Project (WNP). As part of WRS the Willows Collection Pond is also proposed.

The WRS is required to store up to 1,100,000 m^3 of rock materials from the Wharekirauponga tunnel and mine development. The location of the WRS is shown in Figure 1. OGNZL has scheduled for the rock material to be returned to the mine and tunnel as backfill on completion of the mining, which is currently scheduled for 10 years. Some of the rock materials will be Potentially Acid Forming (PAF) and engineering controls are required to ensure the stack remains geotechnically and geochemically stable while in place. EGL notes that potential future extensions to the mine life mean rock material could remain in place longer than 10 years. It is important that the rock stack materials are returned underground in closure as the long-term control of PAF material is a key design and management assumption for the proposed WRS.

This technical report has been prepared for resource consent and details the geotechnical and civil design for the assessment of environmental effects as required under the Resource Management Act 1991. Environmental effects of the WRS are assessed by others.

Further detailed design and review is required before construction.

2.0 BACKGROUND OF CURRENT ROCK STORAGE FACILITIES

2.1. Location and existing rock storage facilities

The existing Waihi gold mining operation operated by OGNZL as shown in Figure 1 is centred in and around the Waihi Township and includes Martha Open Pit, and a series of underground mines including Trio Underground Mine, Favona Underground Mine, Correnso Underground Mine, and Martha Underground Mine (MUG).

Temporary and long-term rock storage is located at the Baxter Road (Process Plant and Water Treatment Plant) and Development Site areas shown on Figure 2. The main facilities storing rock materials at Waihi shown in Figure 2 are:

- Polishing Pond Stockpile
- Northern Stockpile
- Storage 2 (TSF2) Embankment
- Eastern Haul Road Stockpile
- Central Stockpile
- Storage 1A (TSF1A) Embankment
- East Stockpile

2.2. Rock storage experience

In the late 1980s open pit mining of Martha Hill commenced. Open pit mining created a source of earth and rock fill (overburden) material to construct downstream embankment dams to store the tailings. Material was moved from the pit to the Development Site via a crusher and conveyor, and then hauled and placed by mining trucks. Material was either placed directly in the embankment or placed in stockpile for future rehandling or permanent storage. Initially the extent of PAF materials was not fully understood. Once this was realised the TSF embankments and designated stockpiles had additional engineering controls included to manage PAF materials.

Construction of the initial TSF, Storage 2, in 1987 included the Northern Stockpile and a Southern Stockpile to manage materials delivered to the Development Site from Martha Open Pit. Both stockpiles were located against the Storage 2 embankments, to the north and south, as their titles suggest. The construction of Storage 1A followed in 1998. The Southern Stockpile was covered by the construction of Storage 1A and the existing Central Stockpile. As part of the expansion works associated with Storage 1A the Northern Stockpile was expanded to its current footprint. The Northern Stockpile is currently designated a Non-Acid Forming (NAF) stockpile. Central Stockpile is designated a PAF Stockpile. From 2000, NAF ignimbrite rockfill was separately stockpiled in the Eastern Haul Road Stockpile behind Storage 2. This stockpile is often called the Ignimbrite Stockpile (Figure 2). Around 2010 the East Stockpile was developed over a surplus soils stockpile area. East Stockpile was developed to receive PAF materials.

The Polishing Pond Stockpile located at the Baxter Road Processing Plant and Water Treatment site was developed to manage rock materials from the underground mine around 2006. The stockpile temporarily stores PAF material from the underground mine and will be used as backfill for the underground mines.

2.3. Typical stockpile engineering controls at Waihi

The **Central and East Stockpile** have subsurface drains, a low permeability (Zone A) base pad and leachate drains. PAF material placed in central stockpile was limed on the conveyor and the outside faces of these stockpiles are progressively rehabilitated with a rehabilitation capping layer which limits oxygen and water ingress. The exposed tops of the stockpiles are monitored monthly for potential acid generation and limed to maintain the pH within an acceptable range. Clean water from upstream catchments is diverted around the stockpiles. Surface water in contact with the stockpiles reports to Collection Pond S3, S4 and S5 via surface drains. All the water in the collection ponds used to report to the Water Treatment Plant before discharge. The water quality in the collection ponds is now continuously monitored and is suitable to discharge direct to the Ruahorehore Stream under controlled conditions. Functionally the collection ponds now operate more like large silt ponds. Typical sections of the East Stockpile are shown in Figure 3.

The **Polishing Pond Stockpile** has a low permeability earthfill pad and partial HDPE liner and perimeter drains that direct surface runoff to two connected Collection Ponds. This is to mitigate potential contamination of the groundwater from the stored ore or rock. The collected surface water is pumped to the Water Treatment Plant for treatment.

The **Northern Stockpile** is a NAF only stockpile. It does not have a low permeability (Zone A) base pad and is only used for NAF material. The stockpile does have some subsurface leachate drains to collect seepage from PAF material placed at the toe of the Storage 2 embankment in the early years of the mine. Ignimbrite rock was placed as a toe bund around the perimeter of the Northern Stockpile to manage wet materials placed in the stockpile. The Northern Stockpile Silt Pond retains sediment prior to surface water discharge to a tributary of the Ohinemuri River.

Extensive instrumentation is in place for monitoring of environmental effects. A system of ground water detection and compliance wells is installed around the perimeter of the stockpiles and tailings storage facilities.

2.4. Environmental monitoring and review

Comprehensive environmental monitoring and surveillance is in place for the existing mining operation including the stockpiles. This includes:

- Record of construction and rehabilitation works
- Record of material movements in and out of stockpiles
- Visual inspection of the stockpiles
- Monitoring of acid generation and lime addition on the top of the stockpiles
- Monitoring of all aspects of water quality in and around the facilities: groundwater wells, subsurface and leachate drainage, collection and silt ponds
- Annual reporting
- Annual review by the Peer Review Panel

3.0 DESCRIPTION OF THE WAIHI NORTH PROJECT

3.1. Waihi North Project

The WNP adds the Wharekirauponga Underground (WUG) Mine and Gladstone Open Pit (GOP) Mine to the existing mining operation. WUG is 10km north of Waihi township and is connected to the Processing Plant via an access tunnel. GOP is adjacent to the Processing Plant.

Underground mining requires backfill as part of the ore extraction process. Backfill for the MUG mine is currently being sourced from non-ore bearing material being stored temporarily in the Polishing Pond Stockpile and bottom of Martha Open Pit (MOP). This material will be depleted out of Polishing Pond Stockpile and Martha Open Pit during the remaining life of MUG.

The Polishing Pond Stockpile will be available for stockpiling of material from the southern portion of the WUG access tunnel. However, the initial tunnel and mine development will start at Willows Farm, the waste rock from which will be temporarily stored at the WRS.

See the Assessment of Environmental Effects for a complete overview of the project (Ref 15).

3.2. Willows Rock Stack

The WRS is proposed as the new operational PAF stockpile at the Willows Farm Site. The stockpile is required to store up to 1,100,000 m^3 of rockfill from the tunnel and mine development. The stockpile will store both NAF and PAF materials.

The proposed WRS will be formed by placing rock materials from the development of Wharekirauponga Underground Mine and tunnel in the stack. The waste rock will be placed across one of the east trending gullies on the southern slopes of the valley formed by the Mataura Stream, a tributary of the Ohinemuri River. The proposed location is shown in Figure 4.

The WRS will require a Willows Collection Pond for collection of surface water in contact with PAF material for pumping back to the Water Treatment Plant and treatment before discharge to the Ohinemuri River.

4.0 SITE DESCRIPTION AND TOPOGRAPHY

The Willows WRS site is located on Willows Farm which is located at the end of Willows Road, off State Highway 25, about 4km north of MOP and 5km north the Processing Plant in Waihi, as shown in Figure 1.

The topography of the site is a series of north to east trending gullies approximately 300 m wide, with a series of short upper branches which extend up into a north trending ridge of hills that runs along the western side of the farm. The hills on the Willows Farm comprise andesite lava flows and volcanic tuff, which have a maximum elevation ~375 m above sea level along the western boundary of the farm. The maximum elevation of the catchment of the WRS is 290 mRL. The northern boundary of Willows Farm site runs along the bottom of a 1.5km wide valley. The Mataura Stream flows along the bottom of the valley parallel with the northern boundary of the property past the toe of the proposed WRS. The valley runs approximately from northwest to southeast. At its lowest point the valley is approximately 200m above mean sea level.

Surface water on the WRS site currently flows through farm drainage channels and creeks to the Mataura Stream to the north-east. The Mataura Stream flows into the Ohinemuri River, which is located about 1.5km southeast of the WRS (See Figure 1). The Ohinemuri River meanders across the Waihi Basin and through the Karangahake Gorge to the Hauraki Plains where it reaches the Waihou River, which then flows into the sea at the Firth of Thames.

The WRS site slopes from the top of the hill west to river to the east at approximately 14 to 16 degrees (1 vertical to between 4 and 3.5 horizontal). The floor of the gully slopes at approximately 7 degrees (1 vertical to 8 horizontal). The gully side slopes are between approximately 18 and 35 degrees (1 vertical to between 3 and 1.4 horizontal).

5.0 GEOTECHNICAL INVESTIGATONS

Geotechnical investigations have been undertaken in the footprint of the proposed WRS and broader Willows Farm Site in 2020, 2021, 2023, 2024 and 2025. The 2024/2025 ground investigations and geological field mapping are documented in the Geotechnical Factual Report (GFR) for the Willows Farm Site (Ref. 2). Figures 6 and 7 show the locations of machine drillholes, hand auger boreholes, test pits and Cone Penetrometer Tests (CPTs) undertaken at the WRS site. Televiewer and V_s/V_p profiles were run in selected boreholes.

In-situ permeability testing using falling head and packer test methods has been completed within selected boreholes and a series of standpipe piezometers, and vibrating wire piezometers has been installed to characterise the hydrogeology.

Geotechnical laboratory testing has been completed including:

1. Soil classification tests
    - Water content
    - Atterberg limits
    - Particle size distribution
    - Triaxial permeabilities
2. Soil strength tests
    - Isotopically Consolidated and Undrained Triaxial
    - Unconfined Compressive Strength
    - Ring Shear
3. Rock strength tests
    - Unconfined Compressive Strength Tests
    - Hoek Cell Tests
    - 3-Stage Triaxial Tests
    - Indirect Tensile (Brazilian) Tests

The laboratory testing has been included in the Factual Report (Ref. 2).

6.0 GEOLOGY

6.1. Regional Geology

The WRS is to be situated within Willows Farm, approximately 4km north of the Martha Open Pit. The founding rock materials beneath the proposed WRS footprint comprise extrusive and intrusive volcanic rocks of various ages. These materials are mantled by alluvium at the bottom of the gullies and volcanic ash on the ridges.

Brathwaite and Christie (1996) (Ref. 3) present an interpretation of the geology of the wider Waihi Area. The Waihi area is part of the Coromandel Volcanic Zone, a sub-aerial Late Miocene to Early Pleistocene andesite-dacite-rhyolite sequence that forms the Coromandel-Kaimai ranges.

The oldest known volcanic formations in the wider Waihi area are andesites and dacites of the Late Miocene Waiwawa Subgroup of the Coromandel Group and includes the Waipupu Formation (7.9-6.3 Ma), Whiritoa Andesite (6.7 to 5.6 Ma), Waiharakeke Dacite (<7.3 Ma), and the Whakamoehau Andesite (6.7-6.6 Ma).

K-Ar dating indicates an erosional time break of about 1 Ma between the andesites and dacites of the Waiwawa Subgroup and the eruption of andesites and dacites of the Kaimai Subgroup which contains dacites belonging to the Uretara Formation (5.6-4.3 Ma) (Ref. 3) (Figure 5).

The Waihi Basin Caldera located south of Willows Farm is infilled with Pliocene to early Pleistocene lake sediments and ignimbrites of the Whitianga Group. At the base are lacustrine sediments of the Romanga Formation (4.5-3.0 Ma) which are part of the Coroglen Subgroup. The overlying ignimbrites are grouped into the Ohinemuri Subgroup consisting of Corbett (0.2-0.9 Ma) and Owharoa ignimbrites (late Pliocene) and Waikino Ignimbrite (1.5 Ma) (early Pleistocene).

Eruptions of ash and pumice blanket the wider Willows Farm area. Such materials potentially include the Waihi Ash Series, the Hauparu Ash and the Rotoehu Ashes.

The most recent ash unit, which also happens to be the most widespread, is the Waihi Ash Series. This series comprises various rhyolitic ash showers that are less than 10,000 years old. The Waihi Ash unit is characterised in the field by its loose friable nature and firm strength. The soil is normally a slightly clayey sandy silt. The soil colour is commonly yellowish to orangish brown.

The second unit is referred to as the Hauparu Ash and comprises various ash showers 10,000 to 40,000 years old. This unit is characterised by its higher clay content and slightly plastic nature. Soil colours tend to be light yellowish brown to slightly greyish brown.

The third major unit is the Rotoehu Ash shower, an airfall equivalent of the extensive Rotoiti Breccia (Bay of Plenty) the age of which is around 40,000 years. The Rotoehu ashes are commonly light yellowish brown and characterised by their sandy nature (silty sand). In open cuts and pits the Rotoehu Ash shows distinct bedding and where poorly drained (low lying areas) often shows slight iron cementing. The volcanic ashes are normally well drained however, the less cohesive units are prone to erosion.

6.2. Site Geology

6.2.1. Overview

The geology of Willows Farm in the vicinity of the WRS is dominated by lava flows and tuff breccias of the Whitiroa Andesite which comprise the hills surrounding the Mataura Stream. Overlying the Whitiroa Andesite, in particular at the top of the ridge crests, are layers of volcanic ash. Alluvium covers the above volcanic materials along the river terraces and banks of the Mataura Stream.

The following sub-sections describe the material encountered on the WRS site in order from the youngest and shallowest to the oldest and deepest.

Attached Figure 05 shows the underlying geology beneath the ash soils. Figure 08 summarises the thickness of topsoil observed. Figure 09 shows the thickness of the surficial layers of ash, colluvium and alluvium. Figure 10 and 11 show cross sections of the site geology. The locations of the site geology cross sections are shown on Figure 05 and 06.

6.2.2. Topsoil

Topsoil blankets the site. It typically varies in thickness from 0.1 m to 0.3 m. The inferred variation in Topsoil thickness is shown on Figure 08.

6.2.3. Volcanic Ash

The boreholes drilled around the WRS encountered at least two ash units, Waihi and Hauparu. Waihi Ash was observed to be the most common.

Volcanic ash is exposed in most of the cut excavations that have been made across the Willows Farm property to form farm tracks. Such ash materials were observed to drape over residual soil of the underlying andesite.

Different ash layers were often separated by a thin paleosol. The boreholes which were drilled during 2024 as part of the current geotechnical investigation program generally encountered a layer of volcanic ash between 0.8 and 2.8m thick.

Waihi Ash was the most common ash encountered and observed beneath the wider WRS area with the underlying Hauparu Ash being observed in some of the boreholes.

The Waihi Ash unit was typically observed to comprise an orange to orange-brown silt with varying amounts of clay and sand. It is also recorded as being dry, firm and friable in nature.

The Hauparu Ash unit was typically observed to comprise a clayey silt to silty clay material and is further typically described on the borehole logs as being light brown, moist, stiff and slightly plastic in nature.

The ash layers generally appear to be absent in the bottom of the gullies and on the steeper gully slopes. In particular, the ash materials are currently assessed to be predominately absent from the lower valley floor adjacent to Mataura Stream.

Ash depths are shown in Figure 09.

Of the locations where ash was identified, the Waihi Ash layer was always encountered, and the thickness of such material typically varied between 0.7 and 2.8m. The occurrence of the Hauparu Ash material is variable, with the observed thickness typically varying between 0.5 and 0.8 m.

In some locations along the southern banks of the Mataura Stream more recent alluvium and colluvium may overlie the ash units.

6.2.4. Colluvium

Colluvium was not encountered in any of the boreholes which were drilled on the ridge crests during the current (2024) site investigation program. However, many of the slopes on site show signs of shallow slope movement. Further, landforms along the Mataura Stream banks indicate the presence of debris deposits from ground movement originating up slope. It is likely that colluvial deposits are present in the bottom of gullies and near the southern bank of the Mataura Stream. Colluvium was encountered in boreholes and test-pits from previous investigations.

6.2.5. Alluvium

Alluvial deposits were not encountered in any of the boreholes which were drilled within the WRS footprint as part of the current (2024/2025) geotechnical investigation program. Alluvium was encountered in boreholes and test-pits from previous investigations. Alluvial deposits are present on the terraces adjacent to the Mataura Stream and will likely be encountered by the Willows Collection Pond.

6.2.6. Andesite

Below the topsoil and volcanic ash units the boreholes encountered layers of Whitiroa Andesite lava flows and Tuff Breccias.

6.2.6.1. Lava Flows

The Whitiroa Andesite lava flows contain phenocrysts of plagioclase, hypersthene, augite and Fe/Ti oxides in a devitrified glass matrix. The plagioclase phenocrysts can be up to about 2mm size (Ref. 3). The white mottles seen in the rock core are likely to be Plagioclase phenocrysts. Exposures of the lava flows often exhibit columnar jointing. The joints within the rock outcrops located on site are often steeply inclined.

6.2.6.2. Tuff Breccias

The Whitiroa Andesite Tuff Breccias grade from clast supported to matrix supported and are mostly monolithic with angular clasts of Andesite between 10 and 100mm size in a fine grained matrix.

7.0 HYDROGEOLOGY

The WRS site is overlain by ash deposits and residual soils which overlie weathered andesite rock. Localised perched groundwater can be expected in the superficial ash and residual soils. The residual soils are typically low permeability and act as an aquitard separating any surface water from the underlying weathered rock. As the weathering and fracturing of the rock reduces, the permeability reduces limiting any downward flow of groundwater.

The 2024/2025 ground investigations indicate that groundwater table typically underlies the WRS site at a depth of between 10 to 15m below the existing ground surface and sits within the highly to moderately weathered andesite unit. Any perched groundwater present in the superficial ash deposits and the residual soils are expected to be under-drained by the permeable weathered rock.

The permeability of the slightly weathered to unweathered andesite is primarily governed by defects in the rock mass, typically cooling joints or shear zones associated with faulting. Weathering of the rock towards the surface can increase or decrease permeability depending on the degree of weathering and how it effects defects. The permeability test results in the rock from the 2024/2025 geotechnical investigation program ranged between 2.70×10^{-8} m/s and 1.2×10^{-5} m/s. These 63 packer tests had a median result of approximately 6.0×10^{-7} m/s. Excluding the outliers, the rock mass typically had a permeability between 1×10^{-7} m/s and 5×10^{-6} m/s.

The gully and slope to the Mataura Stream represent the natural drainage point. Seepage on the ridge beneath the WRS is expected to drain to the gully where it can be controlled and collected. Natural seepage beyond the toe of the WRS is expected to drain to the Mataura Stream.

8.0 SEISMIC HAZARD

Estimates of seismic hazard for the site have been provided by GNS Science in 2007 and 2017 (Ref. 4). The 2017 update incorporated the knowledge of the Kerepehi Fault System (Ref. 5) and the Hikurangi subduction zone and updated estimates of background seismicity. The tectonic environment and seismic hazard estimates are discussed in Volume 1 (Ref. 6). The National Seismic Hazard Model (Ref. 1627) was updated in 2022. The estimates of seismic hazard which are based on NSHM (2022) are higher, however, they do not make a material difference to the assessed performance of the WRS. For consistency, the 2017 study has been applied across the Waihi North Project. The estimates of seismic hazard will be updated, as appropriate, during the detailed design process.

The design uniform hazard spectra from the probabilistic and deterministic estimates of seismic hazard Appendix B with for the Stability Assessment. The spectra are 5% damped, larger horizontal component acceleration spectra, for Site Class B rock conditions.

Peak ground acceleration (PGA) values and corresponding average magnitudes at the base of the stack are as follows:

- 150-year return period PGA = 0.10g, M_w = 6.3
- 84th percentile level for Kerepehi Fault Rupture PGA = 0.23g M_w =7.3
- 2500-year return period: PGA = 0.27g M_w = 6.6
- 10,000-year return period: PGA = 0.39g, M_w = 6.9

9.0 FLOOD HAZARD

The flood hazard from the Mataura Stream was assessed by GHD (Ref. 7). A 1 in 100 year flow was modelled by GHD for this project area. The proposed WRS and Willow Collection Pond are not located within the Mataura Stream 1 in 100 year flood path.

10.0 DESIGN BASIS

10.1. Operation life

OGNZL has scheduled for the rock material to be progressively returned to the mine and tunnel as backfill during the mine operation. Some of the rock materials will be PAF and engineering controls are required to ensure the stack remains geotechnically and geochemically stable while in place.

Potential future extensions to the mine life mean rock material could remain in place longer than 10 years. EGL notes it is important that the rock stack materials are returned underground as the long-term control of PAF material and highlights that this is a key design and management assumption for the proposed WRS.

10.2. Geotechnical stability

The proposed design criteria for the WRS are summarised below in Table 1.

TABLE 1: SUMMARY OF PROPOSED GEOTECHNICAL DESIGN CRITERIA

Design Parameter	Design Criteria
Earthquake loading • Operational Basis Earthquake (OBE) • Safety Evaluation Earthquake (SEE)	 Probabilistic 150 year return period Probabilistic 2,500 year return period
Geotechnical stability • Static	 - Internal batter slopes in stockpile Factor of Safety (FOS)≥1.2 - Stockpile global stability drained conditions FOS≥1.5 - Stockpile global stability undrained conditions FOS≥1.5 - Post-earthquake undrained conditions FOS≥ 1.2
• Seismic	OBE: The performance requirement for the OBE is that the WRS remain functional and that the resulting damage is minor and easily repairable. SEE: The performance requirement for the SEE is that there is no major instability when the WRS is subjected to the seismic load imposed by the SEE. Damage to the structure (liner, drains, capping) may have occurred, however, it is readily recoverable or manageable.

10.3. Uphill diversion and perimeter drain sizing

The uphill diversion drain will be sized for a minimum requirement of a 10 year ARI (Average Recurrence Interval) flow with freeboard allowance specific to the flow condition at each channel section. EGL recommends that freeboard depths are not specified in the conditions as they have the potential to be unnecessarily restrictive with respect to designing of the channels.

10.4. Willows Collection Pond sizing

The collection ponds will be sized to manage runoff from a 10-year ARI (24 hour storm) as recommended by GHD (Ref. 8) without discharging.

11.0 DEVELOPMENT OF THE WILLOWS ROCK STACK

11.1. Design concepts

The WRS is required to store approximately 1,100,000 m^3 of rock from the tunnel and mine development. This will including both NAF and PAF materials.

The proposed site is selected due to its location and geometry. The WRS is located close to the Willows Farm tunnel portal to minimise surface haul distances. The tunnel requires distance for the tunnel decline to drop to a suitable depth to pass below streams. Options in gullies further to the north are difficult for the tunnel to pass the Matarua Stream and start to become distant from the suitable areas for the surface infrastructure. Geometrically the gully has suitable storage to meet the current project requirements.

Geochemical control of the WRS is important. Material placed in the WRS will be dosed with lime, however seepage will need to be managed to not impact the Mataura Stream. The WRS is positioned over an incised gully and adjoining ridge feature. The gully has formed within the weathered profile of the andesite from surface water erosion over millions of years. The ash and residual soils which blanket the ridge provide a low permeability blanket which will naturally act like a liner to minimise seepage from the WRS into the ground water. In the gully the ash and residual soils are eroded. Seepage in the gullies is hydraulically contained by the incised nature of the gully and the higher groundwater level within the adjacent gully side slopes. Subsoil drainage is proposed in the gullies to maintain this hydraulic containment and capture seepage (Figure WAI-985-080-DWG-EA-0004 in Appendix A).

Seepage through the natural ash and residual soil materials will be collected in the gully subsoil drain (Figure WAI-985-080-DWG-EA-0004 in Appendix A). Along the northern perimeter of the WRS the stack toe is in the centre of the ridge. A toe drain located within a shear key cut (Figure WAI-985-080-DWG-EA-0003 in Appendix A) is proposed to minimise seepage through the residual soils into the groundwater where the natural path for seepage is not to the gully.

Seepage from the subsoil drains is to be collected in a concrete sump (Figure WAI-985-080-DWG-EA-0004 in Appendix A) and pumped back to the Willows Collection Pond.

The average slopes of the WRS are flatter than 26 degrees (1 vertical to 2.0 horizontal). Locally, for a relatively short length, the inter-berm slopes within the stack footprint are up to 34 degrees (1 vertical to 1.5 horizontal).

The box cut of the portal is at the toe of the north slope of the WRS. Local stability of the portal cut is to be designed by others.

A shear key cut is required through the residual soils to completely weathered andesite rock for WRS north slope stability (Figure WAI-985-080-DWG-EA-0003 in Appendix A).

11.2. Site establishment and construction

Figure WAI-985-080-DWG-EA-0003 in Appendix A shows the initial layout for the establishment of the WRS. This lower portion of the WRS is established at the same time as the tunnel portal, access road, and Willows Collection Pond. The box cut for the tunnel portal is into weathered andesite rock and will provide a source of NAF fill for the construction of the toe of the WRS and suitable material to line the shear key cut with a low permeability (Zone A) base pad.

To establish the WRS the subsoil drainage and culvert is required to be installed in the gully. The culvert allows clean water from the upper catchment of the gully to pass the WRS as it is established and raised.

Topsoil is to be stripped and removed to the designated topsoil stockpile area south of the surface infrastructure area.

A toe embankment constructed of weathered rock to form a low permeability (Zone A) cutoff to seepage and direct it into the subsoil drain at the toe of the stack and also allow surface water to be diverted to the Willows Collection Pond once established. Zone A specification material at Waihi has a $1x10^{-8}$m/s permeability. The culvert and subsoil drains will be concreted through the toe embankment. Immediately behind the toe embankment on top of the culvert and subsoil drains the gully will be partially backfilled. The toe embankment will provide initial erosion and sediment control options for the initial works. Once the Collection Pond is established then surface water will be directed to the Collection Pond.

A double laned access road 16m wide is to be formed in the slope behind the Collection Pond between the surface facilities area and the underground portal.

Table 2 and Table 3 below provide a summary of the earthworks cut, fill and stockpile volumes which are estimated to be associated with the WRS project. The balance of cuts and fills indicates the available volume for rockfill material from the tunnel and mine is up 1,226,000 m^3. This achieves the required volume for the project.

Table 4 summarises the quantities of materials which are to be imported to site as part of the construction program for this project.

TABLE 2: WILLOWS ROCK STACK AND COLLECTION POND SUMMARY OF CUT EARTHWORKS VOLUME ESTIMATES

WRS and Collection Pond Area Component	Estimated Cut Volumes (m^3)			
	NAF	PAF	Topsoil	**Total**
Access Road	17,750	-	1,290	**19,040**
Toe Embankment	-	-	90	**90**
Tunnel Portal Box Cut	41,850	-	2,000	**43,850**
Rock Stack Foundation Key Cut	34,000	-	900	**34,900**
Tunnel Rockfill to Stack		1,226,450		**1,226,450**
Rock Stack Site Strip	-	-	12,300	**12,300**
Collection Pond Earthworks	25,700	-	1,860	**27,560**
Total	**119,300**	**1,226,450**	**18,440**	**1,364,190**

TABLE 3: WILLOWS ROCK STACK AND COLLECTION POND SUMMARY OF FILL AND STOCKPILE EARTHWORKS VOLUME ESTIMATES

WRS and Collection Pond Area Component	Estimated Fill Volumes (m^3)			
	NAF	PAF	Topsoil	**Total**
Access Road	1,750	-		**1,750**
Toe Embankment	3,400	-		**3,400**
Tunnel Portal Box Cut	700	-		**700**
Rock Stack Foundation Key Cut	3,500	-		**3,500**
Tunnel Rockfill to Stack	-	1,226,450		**1,226,450**
Collection Pond Earthworks	14,250	-		**14,250**
Surplus NAF material (infrastructure building platform)	95,700			**95,700**
Topsoil stockpile (future rehabilitation)			18,440	**18,440**
Total	**119,300**	**1,226,450**	**18,440**	**1,364,190**

TABLE 4: WILLOWS ROCK STACK AND COLLECTION POND SUMMARY OF IMPORTED MATERIAL QUANTITIES

Item	**Quantity***	**Units**
WRS culvert pipe 560OD PE100 Pipe	365	m
Punched subsoil pipes 110-160mm dia.	945	m
Concrete	66	m^3
Drainage metal	640	m^3
Geotextile	3965	m^2
Perimeter access track wearing course	1300	m^3
Geo-ladders 20m long	3	No.
1m high fence (TBC)	280	m
Manhole sump, 1.5m dia., 5m deep	2	No.
Decant pump and pontoon	1	No.
HDPE	6130	m^2
Rip rap rock D50 min 200	25	m^3
Access Road Culvert	1	No.

*Preliminary estimates only, actual volumes will vary. Tanks and grass lining not included.

11.3. Raising of the rock stack

The rock stack will be progressively raised up the gully. Initially it is proposed that the rock material is placed in the area established in Figure WAI-985-080-DWG-EA-0003 in Appendix A. This minimises the disturbed area to start and also allows the toe of the rock stack to be loaded first to allow any excess pore pressures in the ash and residual soils to dissipate and gain strength.

To raise the rock stack up the gully the culvert and subsoil drainage will be extended first. Rock material can then be placed over the top of the drains but leaving the culvert inlet free of cover that might otherwise compromise the natural runoff quality.

The layer thickness for placement of rock material will vary between approximately 0.5m and 5m. The thickness will depend on the geochemical controls required including liming and oxygen and water ingress. Liming of every layer of the rock stack is expected however the rate of application is to be determined by the geochemical specialists. Currently it is proposed that the outside of the rock stack is not capped with rehabilitation materials as the stack materials will be removed and placed back underground within a relatively short timeframe.

As the slopes and the ridge are blanketed in ash and residual soils which are low permeability, the gully is hydraulically contained, and the rock material is to be removed before closure, it is proposed not to have an engineered liner like the permanent rock stacks at the Development Site.

Haul roads on the WRS are approximately at a slope of 1 in 7.

A perimeter access track is required around the full facility (Figure WAI-985-080-DWG-EA-0004 in Appendix A).

11.4. Surface water management

As discussed above, as the rock stack is raised a culvert will be extended to divert clean water under the stack without compromising the natural water quality. This culvert is to be extended to a spring in the upper parts of the gully where it will pick up this spring. At this point the culvert will be redirected to the seepage collection sump at the base of the rock stack. A clean water diversion drain will be established at the final elevation of the stack along with an access track and run-on water directed away from the stack (Figure WAI-985-080-DWG-EA-0004 in Appendix A). Clean water will already have been directed around the portal box cut.

Surface water in contact with the stack will be diverted to a perimeter diversion drain which will be earth lined. Contact water will be directed around the perimeter of the stack over the toe embankment to the Collection Pond. The earth lining will utilise the residual soils and weathered rock from the shear key and box cut. Erosion protection in the form of grass lining, armour rock (rip rap), spray concrete, or concrete matting will be required depending on the flow velocity.

The Willows Collection Pond will have a capacity to manage a 1 in 10 year 24 hour storm event without overtopping. Under larger rainfall events the pond will spill to land and flow to the Matarua Stream. The Willows Collection Pond is south of the WRS gully, cut into slopes and built up above the Matarua Stream flood plain. The pond is proposed to be HDPE lined across its base to minimise seepage at low volumes. The minimum height of HDPE lining is proposed to be 1.5 m above the base of the pond floor. This is consistent with the Collection Ponds at TSF1A. The option to line the full height of the pond is available and is a detailed design and operation decision around managing and cleaning the pond (Figure WAI-985-080-DWG-EA-0010 in Appendix A).

11.5. Depletion of the rock stack

As the mine progresses the rock material will be hauled back underground and placed as backfill. All PAF rock material shall be removed from the WRS prior to closure to avoid any long-term environmental effects.

11.6. Closure

In closure any remnant rock material will be removed and disposed of underground.

Once all the PAF rock material is removed the site be rehabilitated. Before all the surface water controls are removed the site will be re-topsoiled and pasture and vegetation established.

The upper sections of the culvert and subsoil drainage can then be removed.

There will be a period before the surface water and groundwater quality allows direct discharge back to the natural streams. During this period the seepage collection at the toe of the gully and the Willows Collection Pond will need to remain in place.

Once the water quality has improved in the gully the toe embankment material can be used to reprofile the shear key cut and the tunnel portal. The Willow Collection Pond can be disestablished and reprofiled or converted to another use such as farm water supply. Specific local erosion and sediment control measures will be required to manage the disestablishment works.

12.0 DESIGN ASSESSMENT

12.1. Geotechnical stability

A geotechnical slope stability assessment for the proposed WRS has been carried out and is presented in Appendix B.

Three cross sections (as labelled on Figure WAI-985-080-DWG-EA-0003 to 0006) were checked for geotechnical stability:

- Section 2 – Checked stability of rock stack profile through the gully.
- Section 3 – Checked stability of rock stack profile over the northern ridge.
- Section 4 – Checked global stability of rock stack profile above the portal cut.

Local stability of the portal cut will be checked and designed by others.
For each section the following three loading conditions were considered in the stability analyses:

- Peak drained
- Peak undrained
- Residual undrained

The assessed factor of safety (FOS) values and co-seismic displacement estimates for each loading condition are summarised in Table 5 and Table 6 below respectively. Appendix B provides further detail of the analyses results that are presented below. The stability and earthquake performance criteria are as described previously in Section 10.1.

The results of the geotechnical stability assessment indicate that the proposed WRS profile can be engineered to achieve a geotechnically stable form and is typically expected to sustain minimal damage if subjected to a design level earthquake. Measures to ensure appropriate levels of geotechnical stability are achieved and maintained by the WRS include:

- Construction of a shear key cut through the residual soils on the rock ridge along the north slope of the WRS. Preliminary widths assessed were:
  - Section 3 shear key cut width required is 25m
  - Section 4 shear key cut width required is 15m

  The shear key widths are perpendicular to the section.
- A minimum fill profile at the toe of the WRS in the bottom of the gully to secure and appropriately stabilise the toe of the rock stack.
- Monitoring of excess porewater pressure within the residual soils during and after placement of the rock materials to confirm key design assumptions, and
- Monitoring and verification of the earthwork's construction quality and extent.

TABLE 5: SUMMARY OF SLOPE STABILITY ANALYSIS – STATIC LOAD CASE

Load case description	**Target Minimum FOS**	**Section 2 Estimated FOS**	**Section 3 Estimated FOS**	**Section 4 Estimated FOS**
Stockpile global static stability	≥1.5	1.53 (OK)	1.53 (OK)	1.81 (OK)
Internal batter slopes in stockpile	≥1.2	1.74 (OK)	1.57 (OK)	1.79 (OK)
Post-earthquake global static stability	≥ 1.2	1.30 (OK)	1.21 (OK)	1.26 (OK)

TABLE 6: SUMMARY OF SLOPE STABILITY ANALYSIS – SEISMIC LOAD CASES

Load case description	**EQ target performance criteria**	**Section 1 estimated slope displacement**	**Section 2 estimated slope displacement**	**Section 2 estimated slope displacement**
1 in 150 year earthquake slope displacement estimate	Damage is minor and easily repairable	- Max Operation <0.5 cm - Negligible displacement. Criteria can be met.	- Max Operation 1 to 4 cm - Negligible displacement. Criteria can be met.	- Max Operation <0.5 to 1 cm - Negligible displacement. Criteria can be met.
1 in 2,500 year earthquake slope displacement estimate	No major instability. Damage is recoverable.	- Max Operation 6 to 23 cm - Minor displacement. Criteria can be met	- Max Operation 11 to 44 cm - Minor displacement. Criteria can be met	- Max Operation 4 to 14 cm - Minor displacement. Criteria can be met

12.2. Collection pond sizing

The stormwater runoff for the design 1 in 10 year 24 hour event reporting to the WRS Collection Pond has been assessed as described below.

The runoff coefficients that were applied during the above analysis were as follows:

- Rock stack and access road 0.57
- Grass areas 0.58

The assessed catchment areas are shown on Figure 12 and the staged development of the areas is summarised in Table 7 below. Table 8 reports the volume of runoff contributing from each catchment area. The collection pond design volumes are summarised in Table 9.

The Collection Pond has been sized to be just under the Building Act 20,000m^3 criteria defining a large dam. This is sufficient to achieve the design criteria. Table 10 summarises the preliminary volume to height storage data for the Willows Collection Pond.

TABLE 7: AREA OF CATCHMENTS REPORTING TO COLLECTION POND

Catchment	**Catchment area (ha)**		
	Only lower area	**Lower and middle area**	**Full area**
Collection Pond	0.54	0.54	0.54
Catchment Access Road Middle	0.50	0.50	0.50
Catchment Collection Pond Approach Crest and Cut	0.49	0.49	0.49
Catchment Rock Stack Lower	2.16	2.16	2.16
Catchment Portal	0.64	0.64	0.64
Catchment Initial Silt Pond	0.15	0.15	0.15
Catchment Grass South		0.84	0.84
Catchment Rock Stack Middle		1.63	1.63
Catchment Rock Stack Upper			2.85
Total	4.48	6.95	9.8

TABLE 8: RUNOFF VOLUME OF CATCHMENTS REPORTING TO COLLECTION POND

Catchments	**Runoff (m^3)**		
	Only lower area	**Lower and middle area**	**Full area**
Collection Pond	1,436	1,436	1,436
Catchment Access Road Middle	758	758	758
Catchment Collection Pond Approach Crest and Cut	756	756	756
Catchment Rock Stack Lower	3,275	3,275	3,275
Catchment Portal	970	970	970
Catchment Initial Silt Pond	227	227	227
Catchment Grass South		1,296	1,296
Catchment Rock Stack Middle		2,471	2,471
Catchment Rock Stack Upper			4,321
Total	7,423	11,191	15,512

TABLE 9: WILLOWS COLLECTION POND DESIGN VOLUMES

Parameter	Volume, m^3
Total pond volume to crest (163.0 mRL)	19,950
Collection pond storage to spillway level (162.7 mRL)	18,435
Dead storage (10% of total to spillway, noting that there is a forebay to minimise sediment accumulation in the pond)	1,843
Live storage (90% of total to spillway, meets design basis)	16,592
Daily pumping capacity (when required)	5,000
Available 24 hour collection pond and pumping capacity (if required)	21,592

TABLE 10: VOLUME TO HEIGHT STORAGE DATA FOR WILLOWS COLLECTION POND

Height	Volume to height	Plan area	Slope area
(mRL)	(m^3)	(m^2)	(m2)
163.0	19,990	5375	5579
162.7	18,435	5144	5335
162.5	17,398	4990	5172
162.0	14,998	4613	4775
161.5	12,783	4250	4392
161.0	10,745	3902	4025
160.5	8879	3567	3672
160.0	7176	3247	3335
159.5	5629	2941	3012
159.0	4233	2649	2704
158.5	2978	2371	2411
158.0	1860	2107	2133
157.5	869	1857	1870
157.0	0	0	0

12.3. Surface Water Drainage Sizing

The runoff for the 1 in 10 year 1 hr storm event reporting to the uphill diversion drains, perimeter drain, and the rock stack culvert has been assessed. Runoff coefficients were applied as per Section 12.2. The rock stack will be developed in stages with corresponding catchment areas of undisturbed and contaminated water. The delineated catchment areas during the initial and final height rock stack development stages are summarised in Table 11.

TABLE 11: CATCHMENT AREAS REPORTING TO SURFACE WATER DRAINAGE SYSTEMS

Catchments	Catchment Area (ha)	
	Initial Height Stage	Full Height Stage
WRS Culvert Inlet	7.64	-
Access Road Diversion Drain	1.77	1.77
Portal Uphill Diversion Drain	1.37	0.60
WRS Uphill Diversion Drain South	-	1.00
WRS Uphill Diversion Drain North	-	2.42
Perimeter Drain 2 and 3	4.01	-
Perimeter Drain 3		1.97
Perimeter Drain 1 and 2	-	7.03
Total	14.79	14.79

12.3.1. Uphill Diversion and Perimeter Drains

The uphill and access road diversion drains function to divert undisturbed water around the WRS. The perimeter drains collect contaminated surface runoff flows from the WRS and direct it to the collection pond. Three typical channel designs have been selected to achieve the design criteria and are summarised below in Table 12 and Table 13.

12.3.2. Willows Rock Stack Culvert

The WRS culvert picks up the spring water and divert it past the rock stack during the construction phase. To achieve the design criteria, we have allowed for 3 m high headwater to pond at the culvert inlet location. The culvert configuration is summarised in Table 14.

TABLE 12: TYPICAL CHANNEL DESIGN

Design Channel Type	Channel Depth (m)	Base Width (m)	Side Slope (V:H)	Lining Type
A	0.4	1	1:2	Grass-lined
B	0.5			
C	0.6			

TABLE 13: ADOPTED CHANNEL DESIGN

Catchments	Max Design Flows (m^3/s)	Gradient (V:H)	Channel Type
Access Road Diversion Drain	0.31	1:6	B
Portal Uphill Diversion Drain	0.25	1:4	A
WRS Uphill Diversion Drain South	0.18	1:10	A
WRS Uphill Diversion Drain North	0.42	1:7	B
Perimeter Drain 1	0.41	1:6	B
Perimeter Drain 2	0.69	1:6	B
Perimeter Drain 3	1.49	1:9	C

Note: Perimeter Drain 1 extends west of the Portal Uphill Diversion Drain. Perimeter Drain 2 extends from the haul road at the base of the WRS to the Portal Uphill Diversion Drain. Perimeter Drain 3 extends from the collection pond to the haul road at the base of the WRS.

TABLE 14: WRS CULVERT INLET SIZING

Max Design Flows (m^3/s)	Gradient (V:H)	Culvert Size	Minimum Rock Stack Height (m) above culvert to develop inlet pressure head
1.26	1:10	1 x 560mm PE100 Pipe	3

13.0 DESIGN FIGURES

The figures listed in Table 15 below have been prepared as part of the scope of work completed for this report and to support the resource consent application for the WRS and Willows Collection Pond. A copy of these figures is presented in Appendix A.

TABLE 15: WRS RESOURCE CONSENT DRAWING LIST

Design Figure No.	Design Figure Title
WAI-985-080-DWG-EA-0001	General – Locality Plan
WAI-985-080-DWG-EA-0002	General – Site Plan
WAI-985-080-DWG-EA-0003	Rock Stack – Layout Plan – Initial Works
WAI-985-080-DWG-EA-0004	Rock Stack – Layout Plan – Full Arrangement
WAI-985-080-DWG-EA-0005	Rock Stack – Rock Stack Cross Sections 1
WAI-985-080-DWG-EA-0006	Rock Stack – Rock Stack Cross Sections 2
WAI-985-080-DWG-EA-0009	Collection Pond – Collection Pond Layout Plan
WAI-985-080-DWG-EA-0010	Collection Pond – Collection Pond Cross Sections
WAI-985-080-DWG-EA-0015	Collection Pond – Collection Pond Details 2

14.0 DETAILED DESIGN AND DESIGN PEER REVIEW

This report describes a preliminary design that has been completed to a level which outlines the general requirements of the rock stack appropriate for an assessment of effects for resource consent application purposes. Detailed design of the WRS and Willows Collection Pond is required prior to construction.

No building consent is required for the WRS or Willows Collection Pond. However, WRS is a notable stockpile on relatively steep ground which could have poor environmental outcomes if it were to fail. Therefore, it is recommended that the detailed design of the WRS and of the Willows Collection Pond is peer reviewed prior to construction. Record of this peer review should be submitted to Waikato Regional Council and Hauraki District Council prior to construction.

15.0 CONSTRUCTION

The Construction of the WRS civil works will be undertaken by an independent Contractor supervised by OGNZL. The Contractor shall prepare a Construction Management Plan. This plan shall set out specifically, among the other things that are required, their construction methodology and internal quality control and assurance to meet the specification.

OGNZL shall operate a Principal’s Quality Assurance Plan for construction monitoring and testing to confirm the Contractor has met the Specification.

As-built records of construction will be maintained by OGNZL. As a minimum such records will include:

- As-built survey records of all stripped surfaces prior to placement of fill.
- As-built survey records of all final surfaces.
- Earthworks quantities.
- Photographs.
- A description of the construction plant and methodology used.
- Quality control test results.
- Issues and actions taken to resolve.

A schedule of the construction inspections and monitoring required to be undertaken will be prepared during detailed design. Construction related inspections and monitoring will be incorporated into the Principal’s Quality Assurance Plan and the Contractors Management Plan. Operational monitoring items will be incorporated into the Operational Management Plan for the WRS.

15.1. Erosion and Sediment Control

The WRS will have a site-specific erosion and sediment control plan (SSESCP). This plan will establish the specific erosion and sediment controls required during construction, prior to the Collection Pond and perimeter drain controls being established. As a minimum such plan will cover the following key stages of the works:

- Site establishment.
- Willows portal excavation and initial silt pond.
- Clean and dirty water diversions, WRS underdrains and WRS Culvert.
- Foundation works.
- Willows Collection Pond construction.

An initial silt pond in the main gully will be used for erosion and sediment control during site establishment and construction of clean and dirty water diversions, WRS underdrains, and WRS Culvert, and foundation works. Only NAF material will be cut or placed during this stage and therefore erosion and sediment controls can follow typical erosion and sediment control practices as outlined by Waikato Regional Council Guidelines for Soil Disturbing Activities (Ref. 11). Use of flocculant may be required to meet these guidelines.

PAF material can be placed once the perimeter controls, subsurface drainage, collection pond, and return pumping system are in place. At this stage the site will be managed within the WRS engineering controls.

16.0 OPERATION AND MAINTENANCE

The WRS operation will include quality control and assurance and erosion and sediment control during construction, maintenance of surface water and subsurface drains, surveillance of ground water and surface water quality, monitoring of surfaces for acid generation, application of limestone to surfaces, monitoring of the stack for deformations and annual review of stability and controls.

OGNZL will have principal hazard management plans for the safe WRS stockpile operation. This is required under the Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016 (Ref. 10). OGNZL is experienced in developing and enacting principal hazard management plans to look after its workforce.

17.0 MONITORING AND PEER REVIEW PANEL

Surveillance is to be undertaken to monitor the as-built performance of the WRS. The purpose of this is to allow the performance of the WRS to be assessed and reported and to provide for the detection and mitigation of potential deficiencies or undesirable trends. This is important for geotechnical stability and ground water quality protection.

Instrumentation that is likely to be required to robustly monitor the WRS performance includes:

i. Piezometers located within the rock stack and foundations which are read monthly.
ii. Deformation monitoring stations installed along the toe of the WRS embankment and on benches which are surveyed yearly.
iii. Monthly measurement of seepage flows and groundwater sampling in the subsurface and leachate drains.
iv. Monthly visual inspection of the rock stack.
v. Monthly slurry testing of the surface material for pH and lime dosing.
vi. Visual inspection of the WRS Collection Pond to occur weekly or during rainfall.
vii. Visual inspection of the uphill and perimeter drain to occur weekly or during rainfall.

Records of the above surveillance program shall be compared against compliance and performance requirements upon completion of each monitoring round and reported by OGNZL annually.

It is further recommended that the WRS annual monitoring results are reviewed by the councils' Peer Review Panel that is already in place for the Waihi Operation.

18.0 WILLOWS ROCK STACK MANAGEMENT PLAN

A Willows Rock Stack Management Plan (WRS Management Plan) shall be prepared outlining the design, construction, operation, maintenance, monitoring and review, required for a safe and stable WRS as outlined in Sections 14 to 17. This shall be prepared by OGNZL, the WRS designer, and experts and reviewed and certified by Waikato Regional Council and/or Hauraki District Council.

19.0 CONSENTING REQUIREMENTS

Consent requirements relate to the obligations under the Resource Management Act (1991) and the Building Act (2004). The Resource Management Act relates to the use of resources (air, water, land) and discharges to the environment and requires an assessment of effects. The Building Act relates to the structures and their performance requirements, which are set out in the Building Code under the Building Regulations (1992).

The WRS and Willows Collection Pond do not require building consent. It is EGL's opinion that the WRS is not a structure under the Building Act. As the Willow Collection Pond is less than 20,000m^3 it does not meet the large dam definition in the Building Act and therefore does not require building consent.

The likely consenting requirements are set out for the relevant parts of the WRS in the following sections.

19.1. Willows Rock Stack

The WRS will be an operational stockpile that will be removed and the site rehabilitated in closure.

Assessment of civil engineering related aspects in regard to design layout, material quantities and sources, geotechnical stability and construction have been made by EGL in this report. The following effects have been considered by others:

- Geochemical assessment of the overburden sources has been made by AECOM (Ref. 12).
- Assessment of the groundwater quality effects have been made by GHD (Ref. 7).
- Assessment of surface water effects have been made by GHD (Ref. 8).
- Assessment of dust effects will be prepared by Beca.
- Assessment of noise effects will be prepared by Marshall Day.

Past resource consent conditions for similar structures have set requirements specific to the sizing of key elements. The following recommendations are made regarding the WRS:

- **Topsoil:**
  Topsoil shall be stripped from the site and stockpiled for closure rehabilitation.

- **Uphill diversion drain sizing:**
  The uphill diversion drains are to be sized based on a 1 in 10 year flow.

- **Perimeter drain sizing:**
  The perimeter drains are to be sized based on a 1 in 10 year flow.

- **Collection pond sizing:**
  The Willows Collection Pond is to be sized to retain runoff from a 1 in 10 year return period, 24-hour storm without overtopping.

- **Foundation seepage controls:**
  A continuous coverage of natural or engineered low permeability ($1x10^{-8}$m/s) soils shall be maintained over the ridge beneath the WRS northern slope.

  Subsurface drainage shall capture seepage over the ridge beneath the WRS northern slope.

  Subsurface drainage shall capture seepage within the gully beneath the WRS. Continuity of low permeability soils in the gully are not required due to hydraulic containment and the ability to collect seepage in the gully floor.

- **PAF rock materials geochemical management:**
  PAF rock material placed in the rock stack shall have limestone added and be placed in layers to mitigate acid generation as recommended by a suitably qualified geochemical specialist.

  The surface of the rock stack shall be regularly monitored using slurry testing and limestone addition reviewed during construction.

- **Detailed Design and Design Peer Review:**
  A detailed design report, drawings, and specification for the Willows Rock Stack and Willows Collection Pond shall be prepared and peer reviewed by a suitably qualified engineer and the design and peer review letter and comments provided to the Waikato Regional Council and Hauraki District Council prior to construction.

- **Willows Rock Stack Management Plan:**
  A management plan shall be prepared for the Willows Rock Stack defining the design, construction, operation, maintenance, monitoring, review, and rehabilitation of the stack. This shall be provided to the Waikato Regional Council and Hauraki District Council prior to construction commencing.

- **Geotechnical Monitoring and Annual Review:**
  A monitoring network including piezometers and deformation markers shall be established to confirm the rock stack geotechnical stability. The monitoring shall be reviewed by a suitably qualified geotechnical engineer and a letter outlining the stability or any issues and actions provided to the Waikato Regional Council and/or Hauraki District Council annually.

- **Environmental Monitoring and Peer Review Panel:**
  The Willows Rock Stack shall be included in the annual environmental monitoring reports for geochemistry and water quality. The reports shall be reviewed annually by the Peer Review Panel.

- **Removal of all PAF rock materials in closure:**
  In closure all PAF rock materials shall be removed and placed back underground.

- **Rehabilitation:**
  Surface and seepage water controls shall be maintained until water quality improves in the gully.

  The toe embankment shall be removed from the gully and the gully rehabilitated.

  The portal box cut shall backfilled and the area rehabilitated.

  The site shall be topsoiled and re-established in pasture or other vegetation.

20.0 SUMMARY OF POTENTIAL RISKS AND MITIGATION MEASURES

1. Potential risks associated with the proposed WRS will be minimised by designing, constructing and operating in accordance with practices that have already been employed successfully at the Waihi Operation.

2. The risks associated with inadequate design will be mitigated by using a Designer with appropriate experience and undertaking a peer review of the design.

3. The risks associated with the WRS construction not being in accordance with the design and not responding to actual site conditions, which may be different to those assumed, will be mitigated by supervision by OGNZL which employs people with expertise in the construction of such facilities and the Design Engineer undertaking regular inspection of the sites. The Design Engineer will undertake inspections during construction to confirm design assumptions, advise on any design amendments, inspect critical details to ensure they are in accordance with the design, and confirm that construction standards meet specified requirements.

4. The risks associated with poor construction will be mitigated by using a Contractor with experience in the construction and operation of similar facilities.

5. The main design risks are the stability of the rock stack and the management of PAF materials in the rock stack. These risks can be mitigated by design, construction, and operation in accordance with high standards. Specific design, construction and monitoring features include removal of weak foundation soils, the adoption of appropriate geometry and zoning, placement and compaction of fill in structural zones to specified standards, controls on layer thickness and locations of bulk fill, subsurface drains to intercept seepage beneath and within the WRS to control the level of saturation, appropriate detailing of drains and monitoring of groundwater levels within, beneath and downstream of the WRS.

6. Potential geotechnical risks have been investigated by comprehensive geotechnical investigations. Extensive investigations have been undertaken and are documented in the Willows Farm GFR (Ref. 2).

7. A shear key cut through the residual soils to completely weathered rock along the north slope toe will minimise risks associated with instability in the foundations.

8. Site specific erosion and sediment control plans will be prepared for the works. The layout of the site allows for effective erosion and sediment control measures to be prepared. Specific plans depend on the staging of the works.

9. During initial construction water will be available from water trucks and through collection from temporary collection and silt ponds. When the services trench is completed, water will be conveyed though pipes within this trench from the existing processing plant area.

10. Dust will be controlled by spraying dry surfaces with water. Water will also be required to condition the earthfill in the liners and this will assist in reducing the potential for dust.

11. Potential environmental risks will be controlled and managed by appropriate design, construction, operation, maintenance, monitoring, review, and rehabilitation. This is to ensure the WRS is maintained in a geotechnically and geochemically stable condition to protect the environment downstream. The requirements will be incorporated in a Willows Rock Stack Management Plan.

21.0 CONCLUSIONS

The proposed WRS rock storage facility as part of WNP has a maximum working crest level of 265 m RL (approx. 100m high) and will be an operational stockpile, located north of Waihi at the Willows Farm Site.

The WRS is required to effectively manage rock materials from tunnel and WUG mine development. In closure, all material will be returned to the underground mine as backfill and the site rehabilitated.

The WRS will be required to stockpile both NAF and PAF materials. This technical report presents the proposed WRS design, construction, operation, maintenance, monitoring, review, and rehabilitation strategies, which are relevant to the WRS and have been successful for the management of the existing stockpiles at Waihi.

REFERENCES

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16. Gerstenberger M, Bora S, Bradley B (2022). New Zealand National Seismic Hazard Model 2022 revision: model, hazard and process overview. GNS Science Report 2022/57. September 2022.

FIGURES

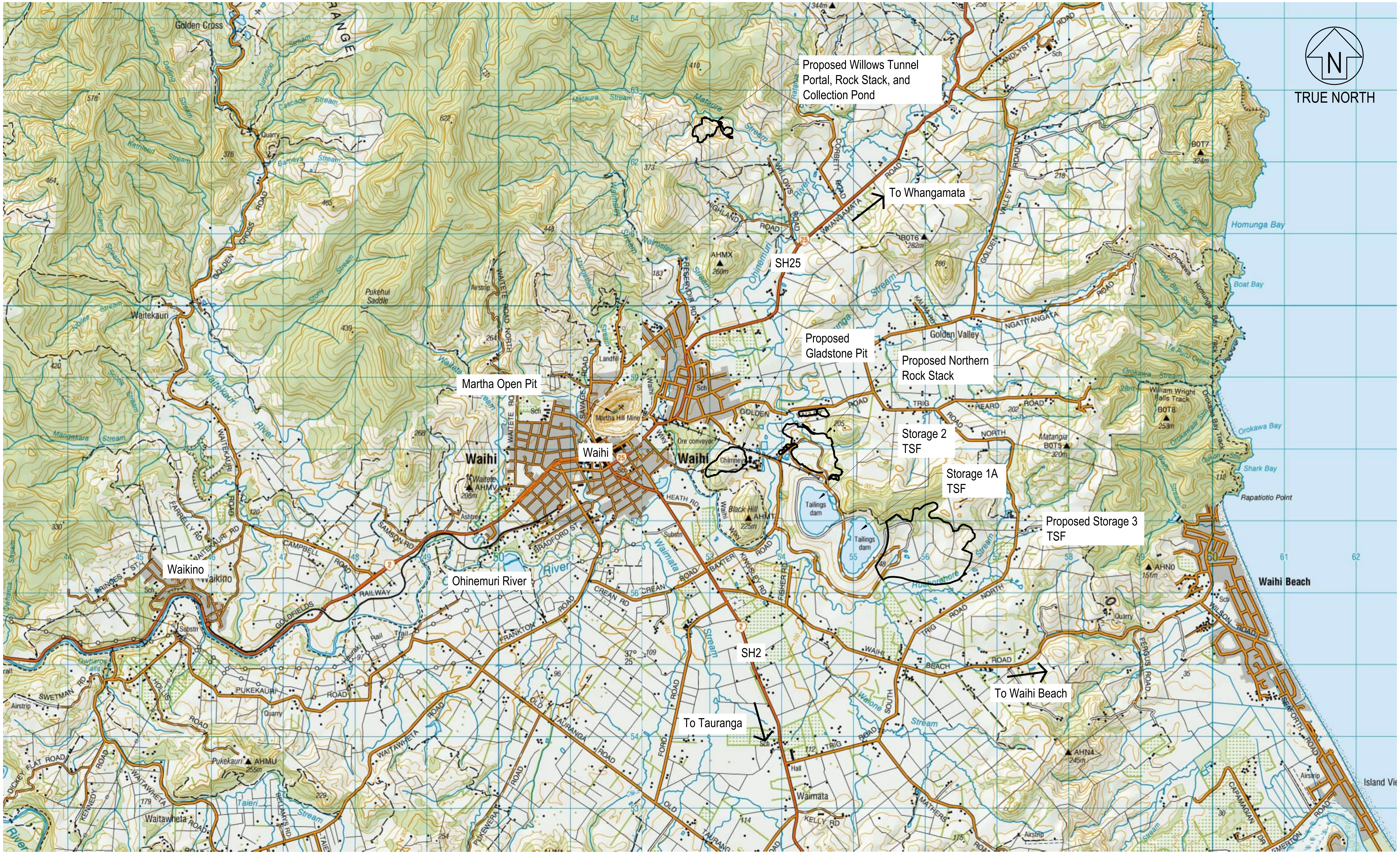


FIGURE 01

EGL
Geotechnical, Earthquake and Dam Engineers
Engineering Geology Ltd www.egl.co.nz

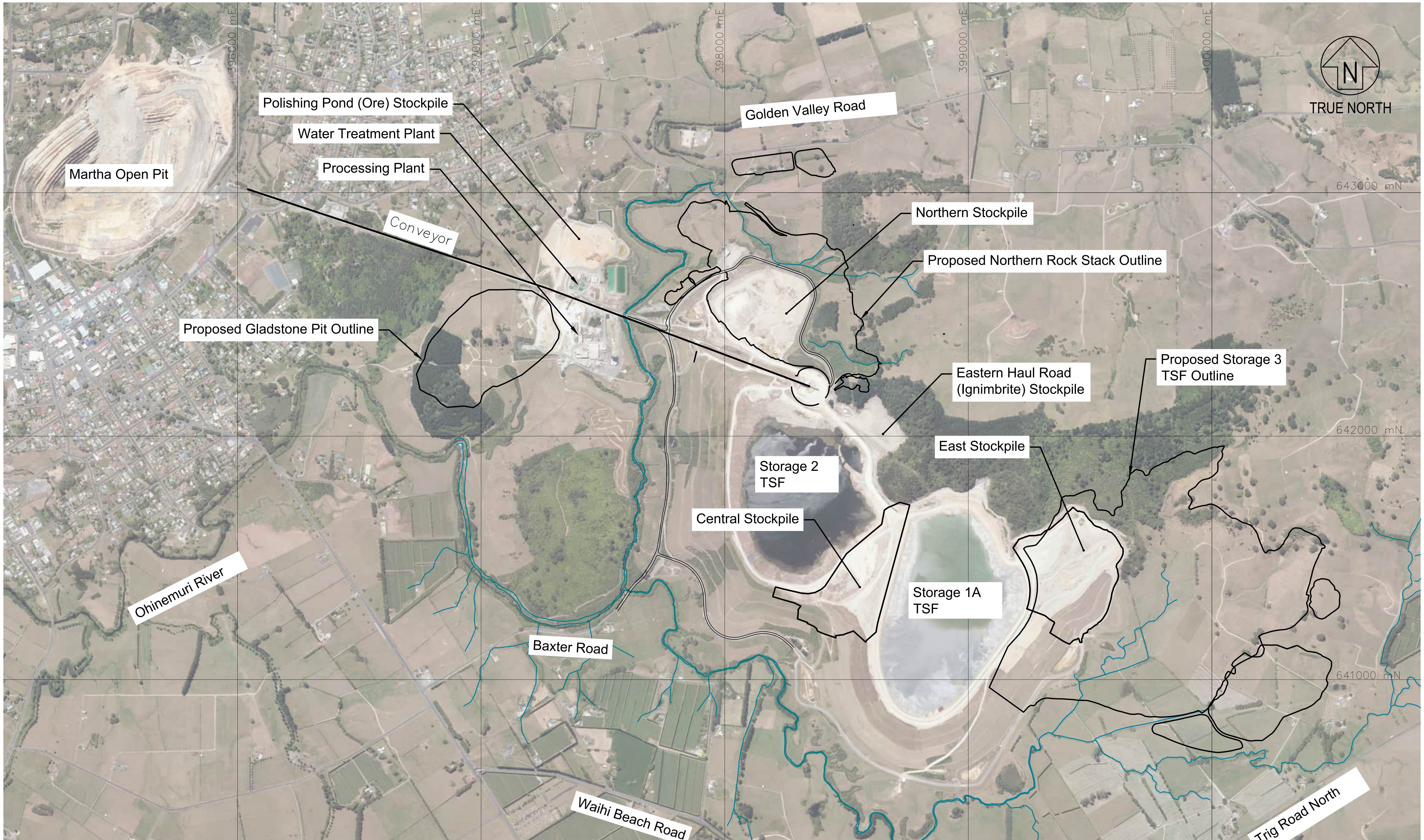
OCEANAGOLD
WAIHI OPERATION

WAIHI NORTH PROJECT
LOCALITY PLAN

DRAWN	RM	DATE	JOB No	SCALE (A3)	REV.
CHECKED	AH	19/12/2024	9169	1:50,000	A

PRINTED: 2024-12-20 13:58:53

egl\nas\Active\Jobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-01.dwg



NOTES:
1. MAP GRID SHOWN IS MINE GRID: Mount Eden Old Cadastral

FIGURE 02

EGL
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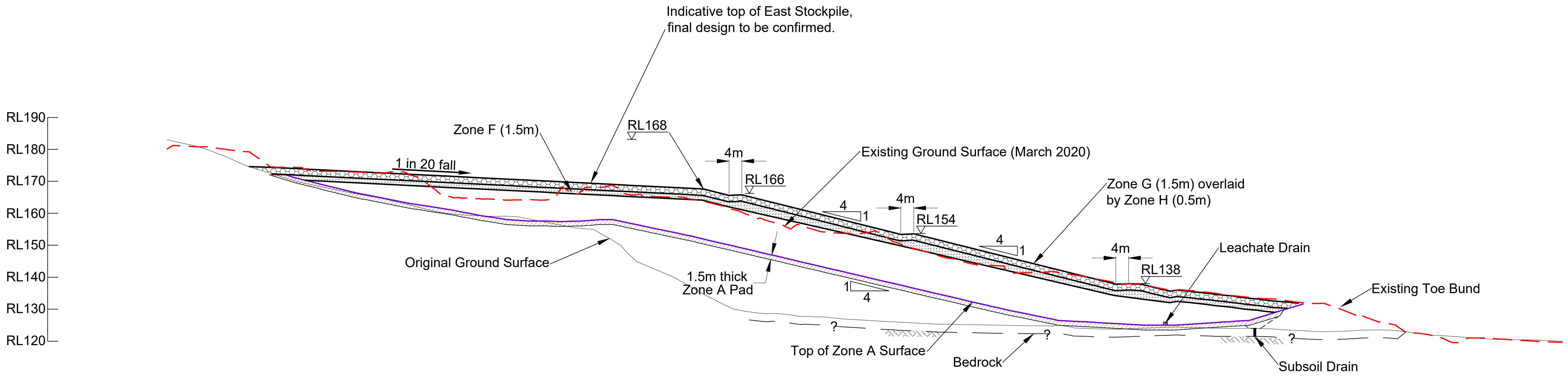
OCEANAGOLD
WAIHI OPERATION

WAIHI NORTH PROJECT
DEVELOPMENT SITE
SITE LAYOUT

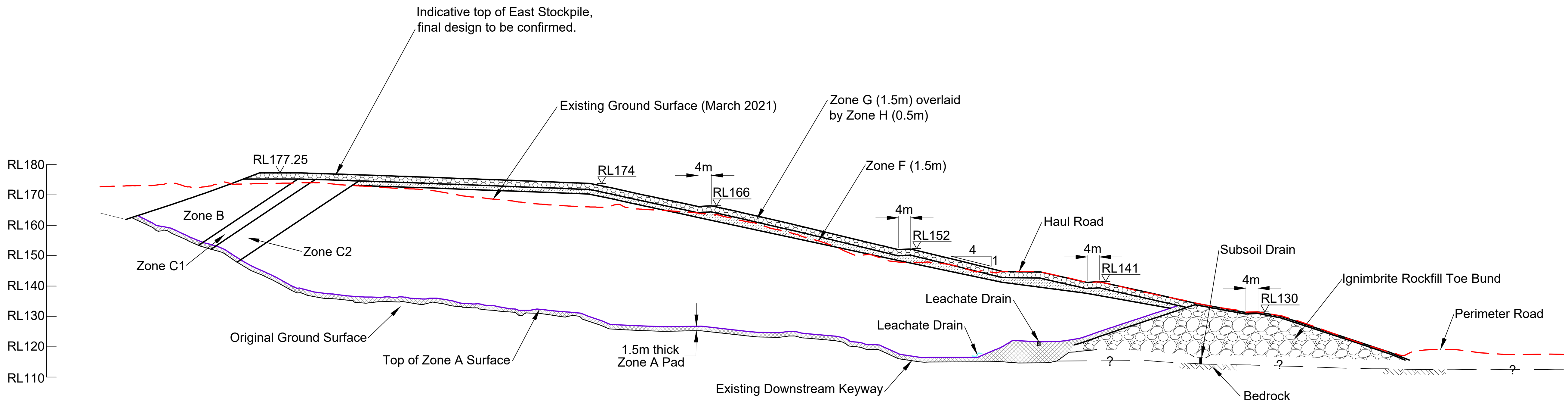
DRAWN	R.M.	DATE	JOB No	SCALE (A3)	REV.
CHECKED	A.H.	19/12/2024	9169	1:15,000	A

PRINTED: 2024-12-20 13:22:58

eglnas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-02.dwg



East Stockpile - Cross Section 10/50



East Stockpile - Cross Section 11/50

FIGURE 03

OG DWG No. WAI–983–080–DWG–CI–9379

OCEANAGOLD WAIHI OPERATION

EGL Engineering Geology Ltd
+64 9 486 2546
info@egl.co.nz
Unit 7C, 331 Rosedale Road, Albany, Auckland
PO Box 301054, Albany, Auckland 0752
www.egl.co.nz
Geotechnical, Earthquake and Dam Engineers

Preliminary Issue	Signed:	Date:
Tender Issue	Signed:	Date:
Construction Issue	Signed:	Date:26–04–2014

No.	BY	DATE	REVISION	CHECKED	APPROV.
3	JL	24–05–2021	Asbuilt March 2021 Contours	ET	TM
2	JL	04–12–2020	Project Title / OG DWG No.	ET	TM
1	JL	26–11–20	Construction 2020 Update	ET	TM
0	PHH	18–6–2014	Construction issue	TM	TM
A	BL	6–12–2013	Tender issue	TM	TM

	BY	DATE
PROJECT APPR.		
DESIGN APPR.	TM	6–12–2013
DESIGNED	TM	6–12–2013
CHECKED	TM	6–12–2013
DRAWN	PHH	18–6–2014

PROJECT: Storage 1A RL173.3

AREA: Development Site

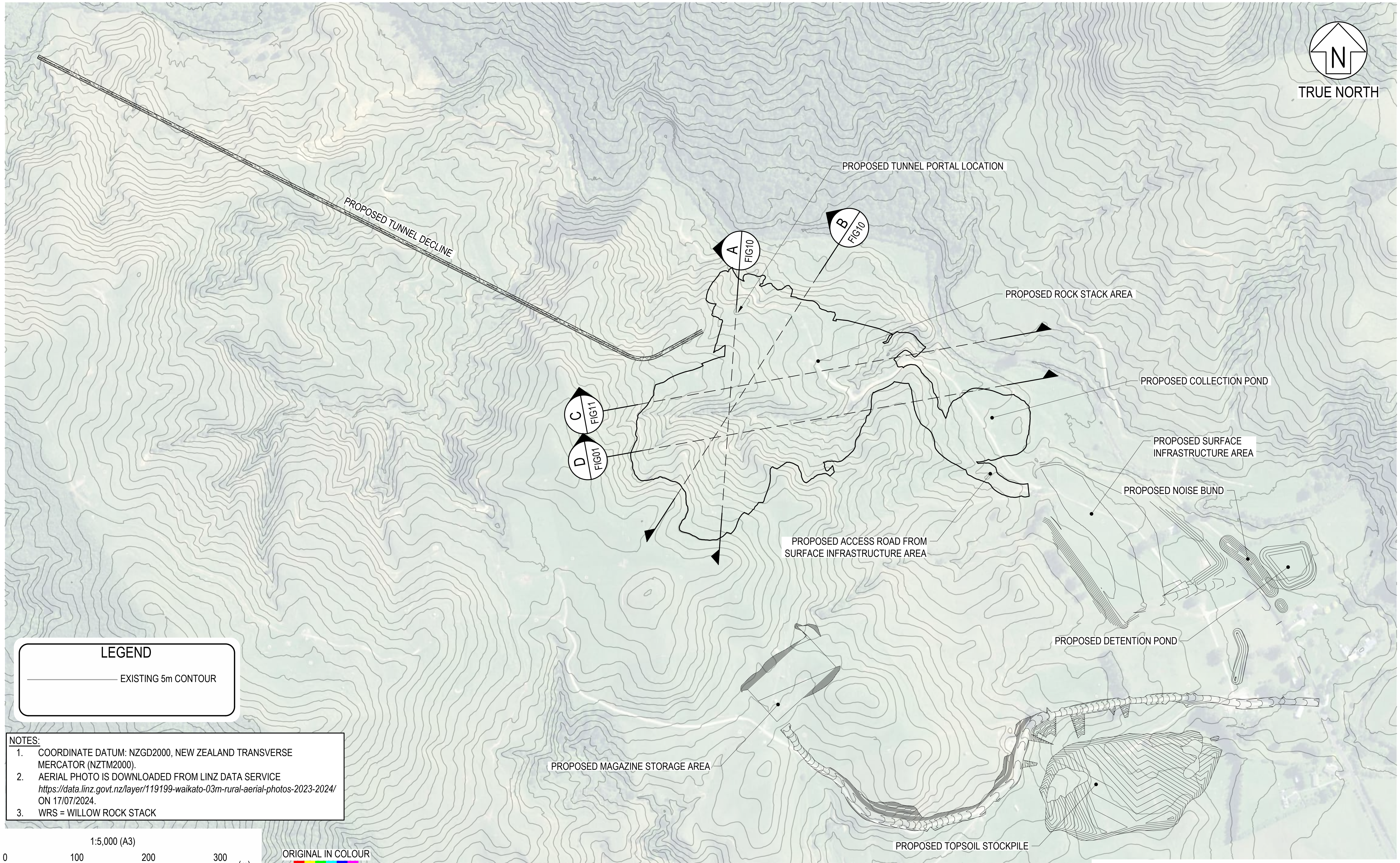
CONSULTANT DRAWING No. 7604–52.dwg

JOB NUMBER:	ORIGINAL SCALE:	SIZE:
7604	1:1500	A3

TITLE
EAST STOCKPILE
Cross Sections

DRAWING No. 7604–52

REV. No. 3



LEGEND

EXISTING 5m CONTOUR

NOTES:
1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
3. WRS = WILLOW ROCK STACK

1:5,000 (A3)

0 100 200 300 (m)

ORIGINAL IN COLOUR

FIGURE 04

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OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
SITE LAYOUT

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
CHECKED	T.F.	17/02/2025	9169	1:5,000	B

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eglnas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-04.dwg

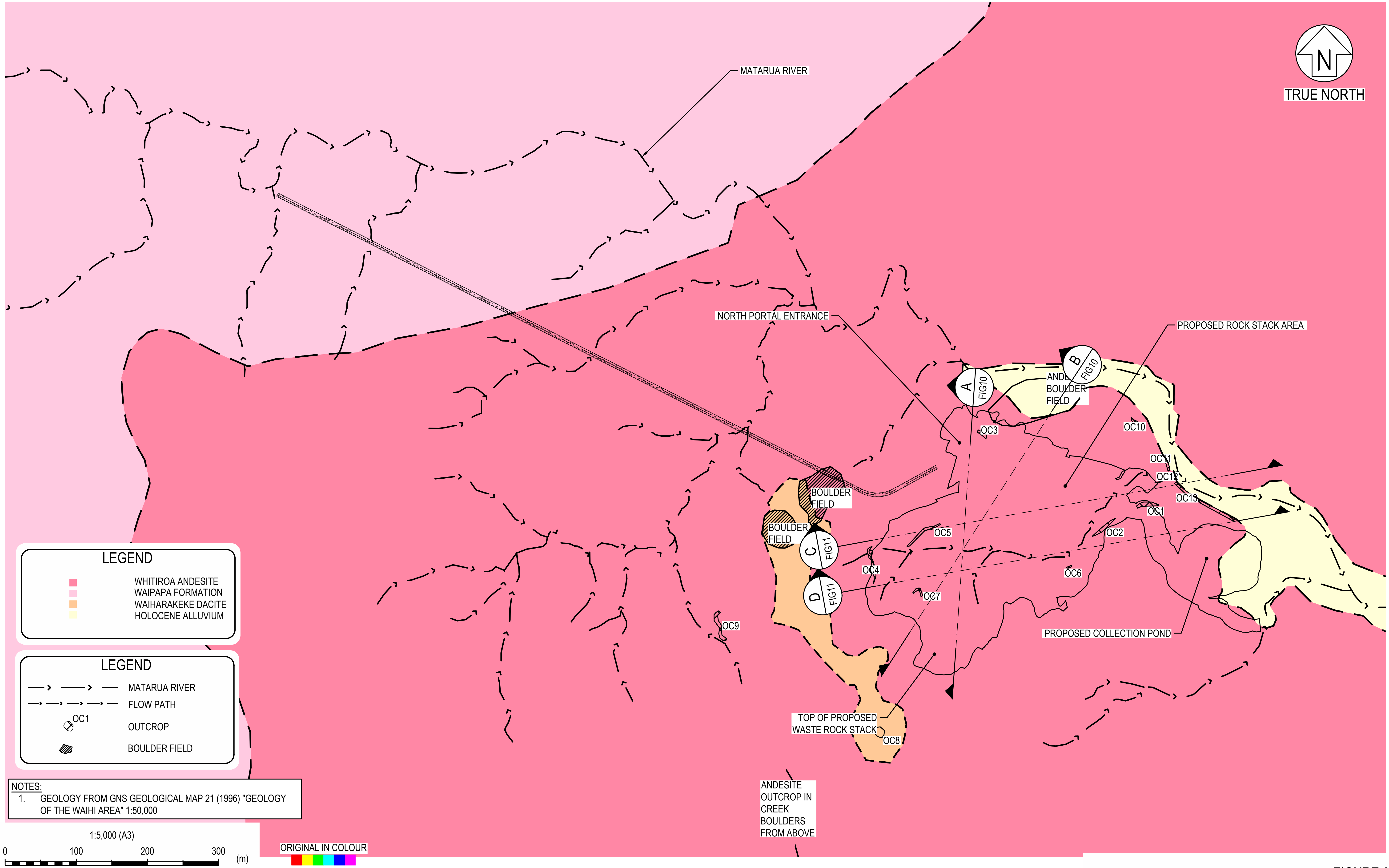

FIGURE 05

Geotechnical, Earthquake and Dam Engineers

Engineering Geology Ltd www.egl.co.nz

OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
GEOLOGICAL MAP

DRAWN	D.L.M	DATE	JOB No	SCALE (A3)	REV.
CHECKED	T.F.	17/02/2025	9169	1:5,000	B

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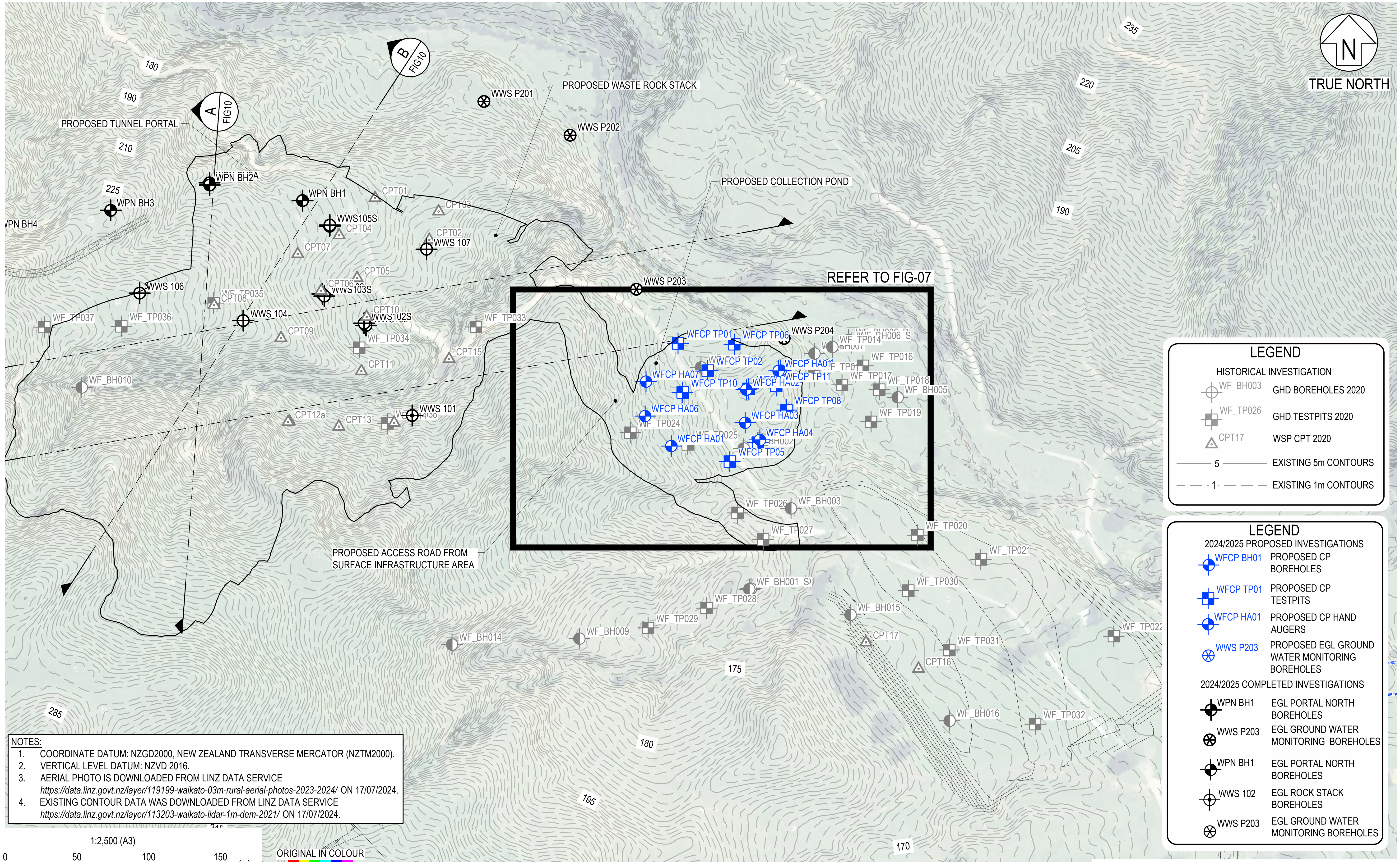
egl\nas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-05.dwg



NOTES:

1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. VERTICAL LEVEL DATUM: NZVD 2016.
3. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
4. EXISTING CONTOUR DATA WAS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/113203-waikato-lidar-1m-dem-2021/* ON 17/07/2024.

1:2,500 (A3)

0 50 100 150 (m)

ORIGINAL IN COLOUR

LEGEND

HISTORICAL INVESTIGATION

WF_BH003	GHD BOREHOLES 2020
WF_TP026	GHD TESTPITS 2020
CPT17	WSP CPT 2020
5	EXISTING 5m CONTOURS
1	EXISTING 1m CONTOURS

LEGEND

2024/2025 PROPOSED INVESTIGATIONS

WFCP BH01	PROPOSED CP BOREHOLES
WFCP TP01	PROPOSED CP TESTPITS
WFCP HA01	PROPOSED CP HAND AUGERS
WWS P203	PROPOSED EGL GROUND WATER MONITORING BOREHOLES

2024/2025 COMPLETED INVESTIGATIONS

WPN BH1	EGL PORTAL NORTH BOREHOLES
WWS P203	EGL GROUND WATER MONITORING BOREHOLES
WPN BH1	EGL PORTAL NORTH BOREHOLES
WWS 102	EGL ROCK STACK BOREHOLES
WWS P203	EGL GROUND WATER MONITORING BOREHOLES

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eglias\Active\Jobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-06.dwg

FIGURE 06

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Engineering Geology Ltd www.egl.co.nz

OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
GEOTECHNICAL INVESTIGATION PLAN
PROPOSED ROCK STACK SITE PLAN

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
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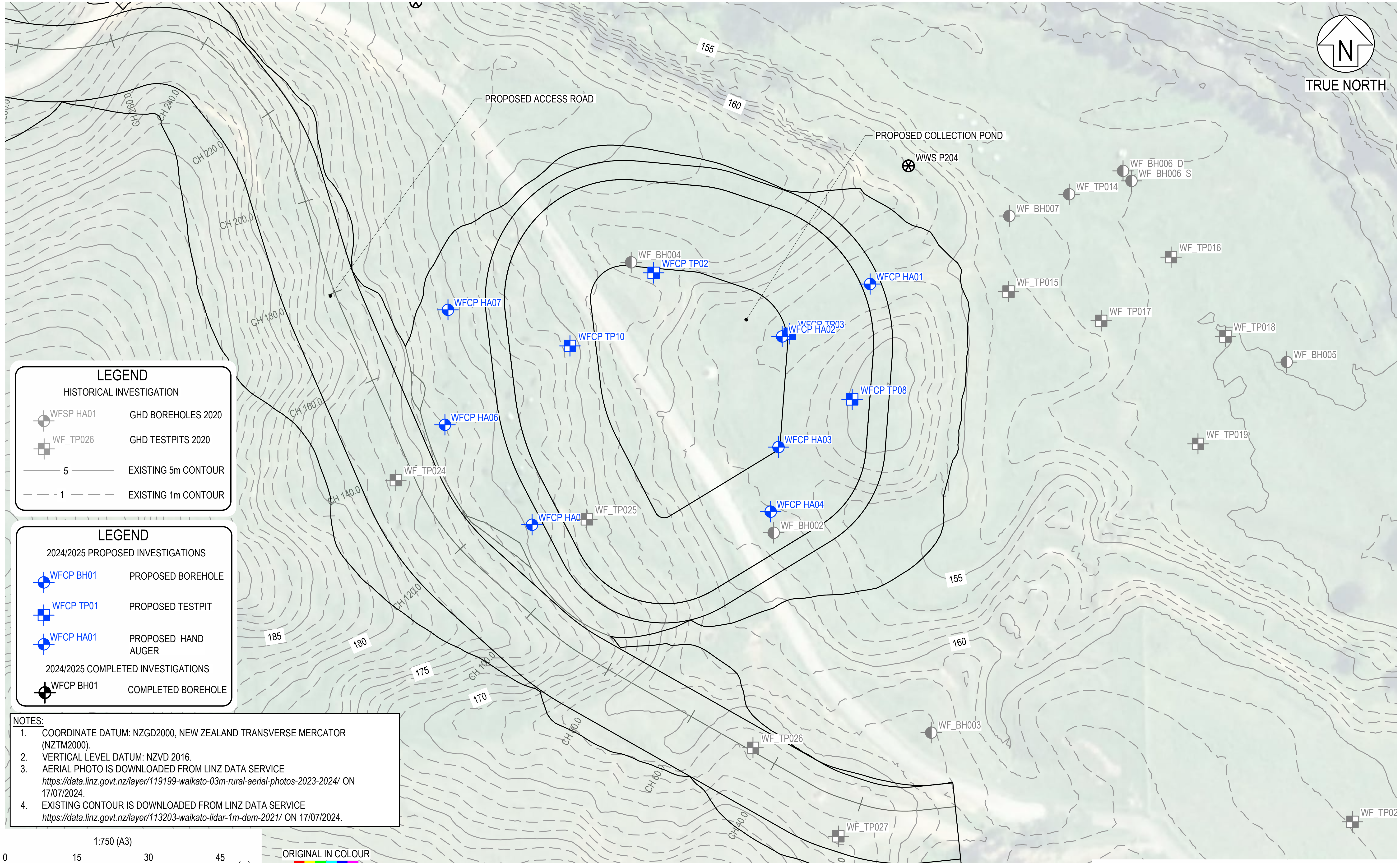

LEGEND

HISTORICAL INVESTIGATION

WFSP HA01	GHD BOREHOLES 2020
WF_TP026	GHD TESTPITS 2020
5	EXISTING 5m CONTOUR
1	EXISTING 1m CONTOUR

LEGEND

2024/2025 PROPOSED INVESTIGATIONS

WFCP BH01	PROPOSED BOREHOLE
WFCP TP01	PROPOSED TESTPIT
WFCP HA01	PROPOSED HAND AUGER

2024/2025 COMPLETED INVESTIGATIONS

WFCP BH01	COMPLETED BOREHOLE

NOTES:
1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. VERTICAL LEVEL DATUM: NZVD 2016.
3. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
4. EXISTING CONTOUR IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/113203-waikato-lidar-1m-dem-2021/* ON 17/07/2024.

1:750 (A3)

0 15 30 45 (m)

ORIGINAL IN COLOUR

FIGURE 07

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eglnas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-07.dwg

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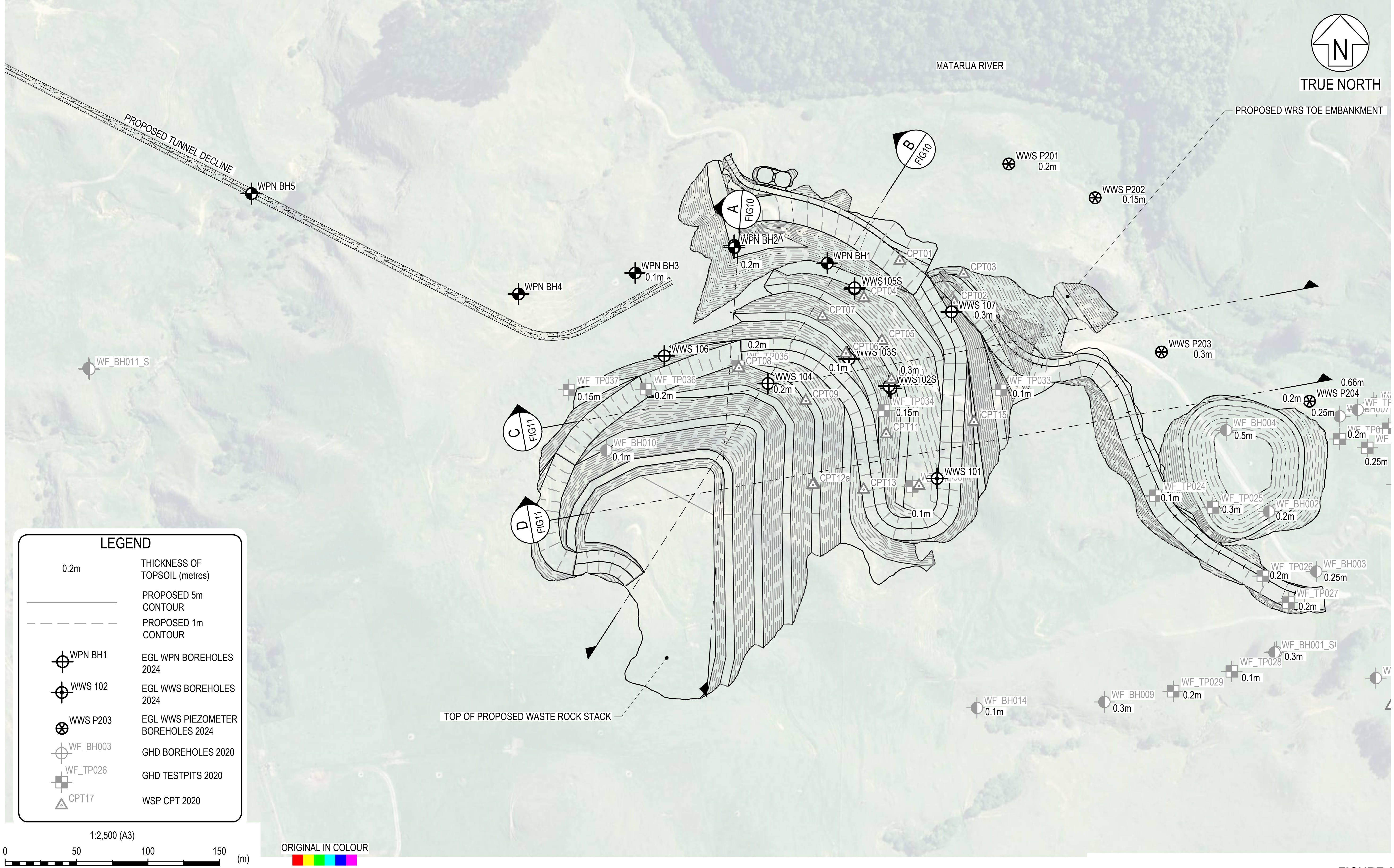
OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
GEOTECHNICAL INVESTIGATION PLAN
COLLECTION POND

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
CHECKED	E.T.	17/02/2025	9169	1:750	B



ORIGINAL IN COLOUR

FIGURE 08

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OCEANAGOLD
WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
THICKNESS OF TOPSOIL MAP LAYOUT

DRAWN	D.L.M.	DATE	JOB No	SCALE (A3)	REV.
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egl\nas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-08.dwg

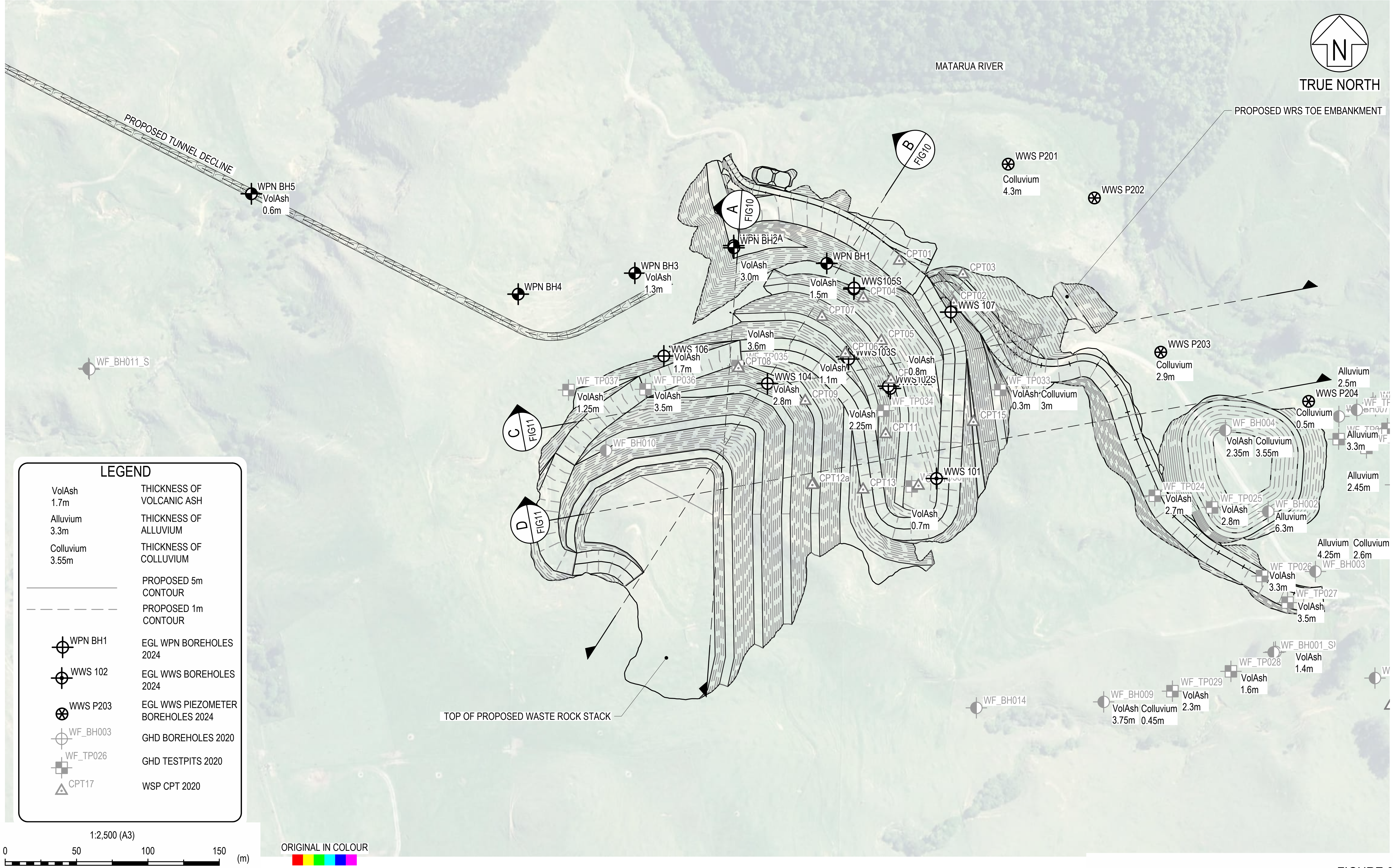

FIGURE 09

EGL Geotechnical, Earthquake and Dam Engineers
Engineering Geology Ltd www.egl.co.nz

OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
THICKNESS OF VOLCANIC ASH/ALLUVIUM/ COLLUVIUM MAP LAYOUT

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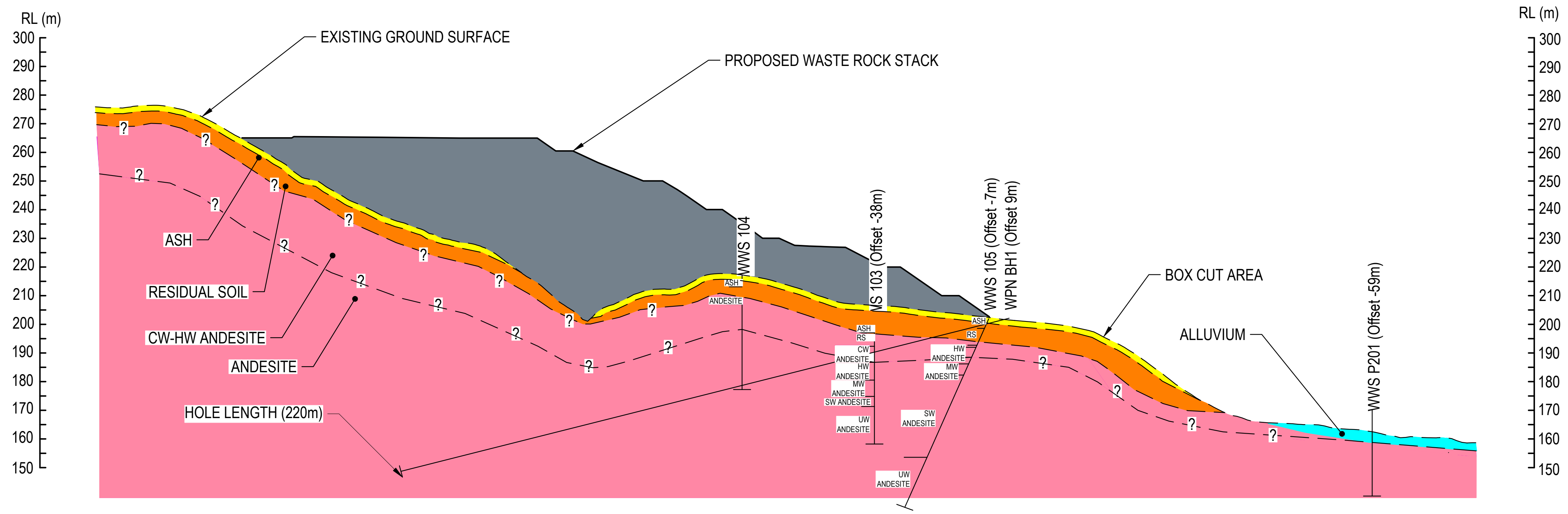
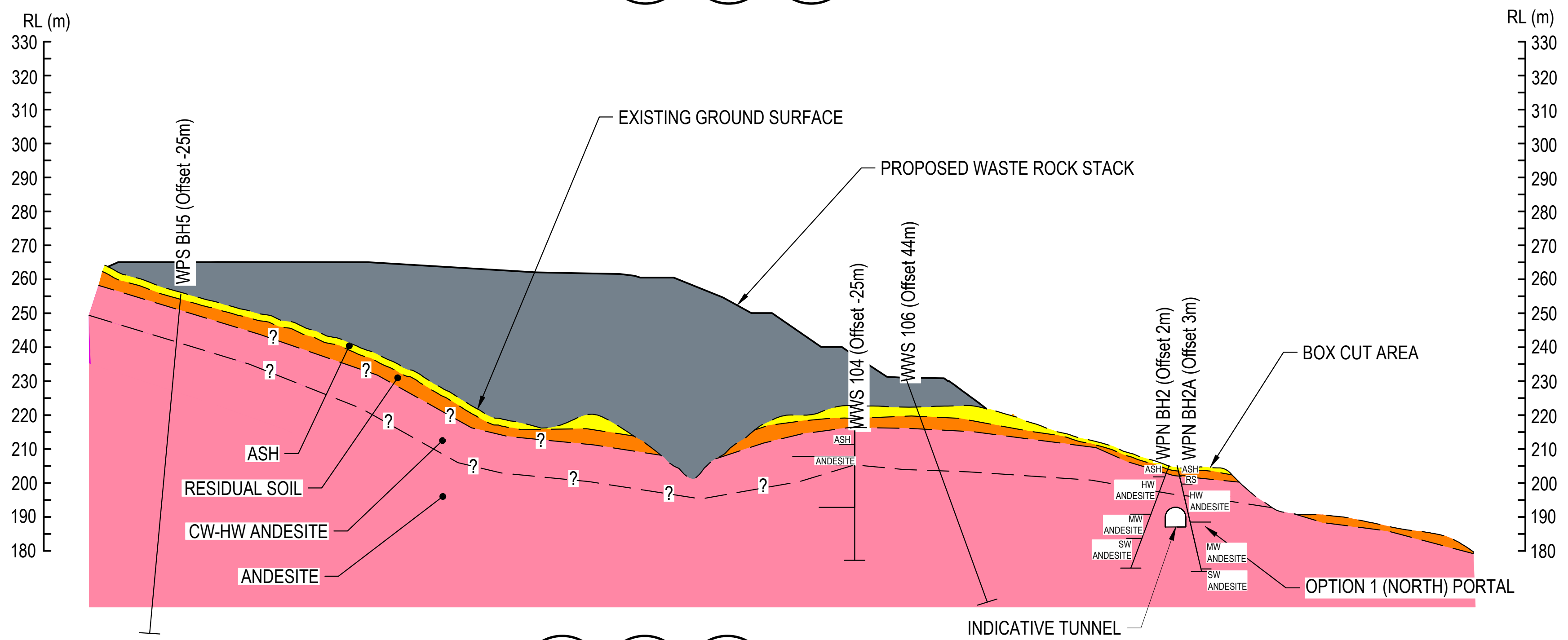


B FIG04 | B FIG05 | B FIG06 GEOTECHNICAL SECTION
SCALE (A3) - 1:2000



A FIG04 | A FIG05 | A FIG06 GEOTECHNICAL SECTION
SCALE (A3) - 1:2000

NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. VERTICAL LEVEL DATUM: NZVD 2016.

1:2,000 (A3)
0 40 80 120 (m)

LEGEND
- FILL:
- ASH:
- COLLUVIUM:
- ALLUVIUM:
- RESIDUAL SOIL:
- WHIRITOA ANDESITE:

FIGURE 10

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OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
ROCK STACK AND PORTAL SECTIONS
SHEET 1

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
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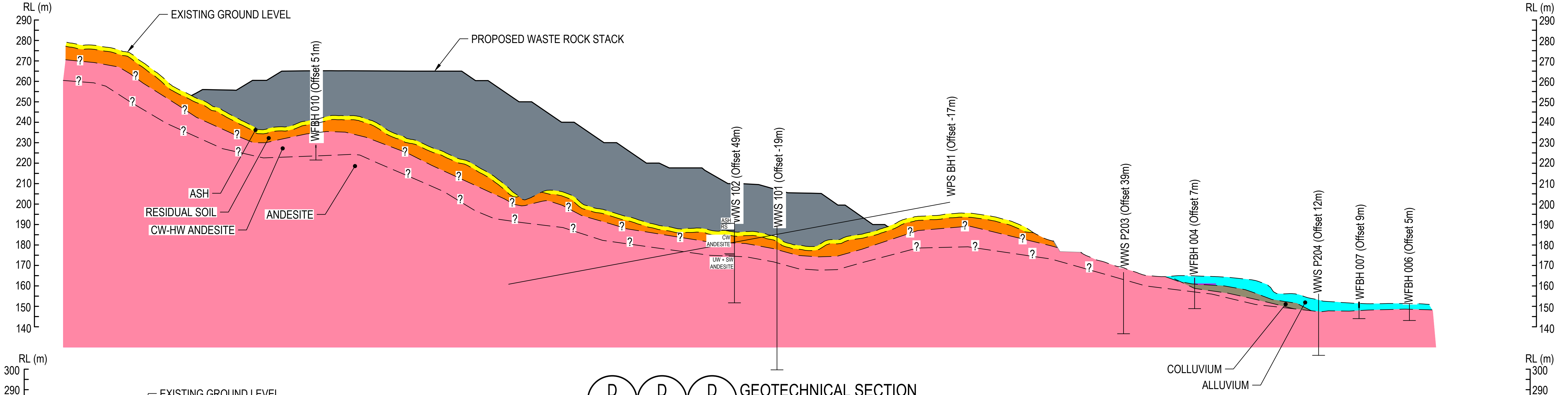
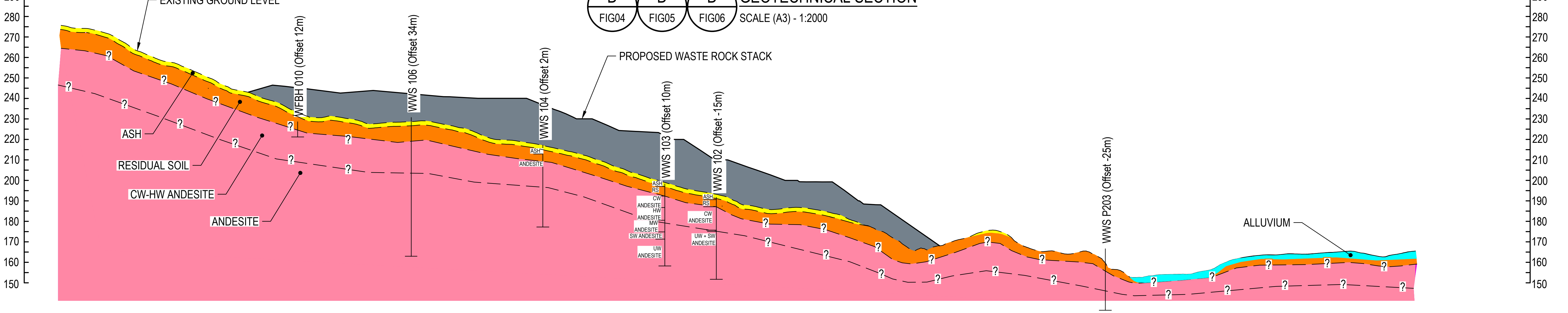


D FIG04 | D FIG05 | D FIG06 GEOTECHNICAL SECTION
SCALE (A3) - 1:2000



C FIG04 | C FIG05 | C FIG06 GEOTECHNICAL SECTION
SCALE (A3) - 1:2000

NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. VERTICAL LEVEL DATUM: NZVD 2016.

1:2,000 (A3)
0 40 80 120 (m)

LEGEND
- FILL:
- ASH:
- COLLUVIUM:
- ALLUVIUM:
- RESIDUAL SOIL:
- WHIRITOA ANDESITE:

FIGURE 11

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OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
ROCK STACK AND PORTAL SECTIONS
SHEET 2

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
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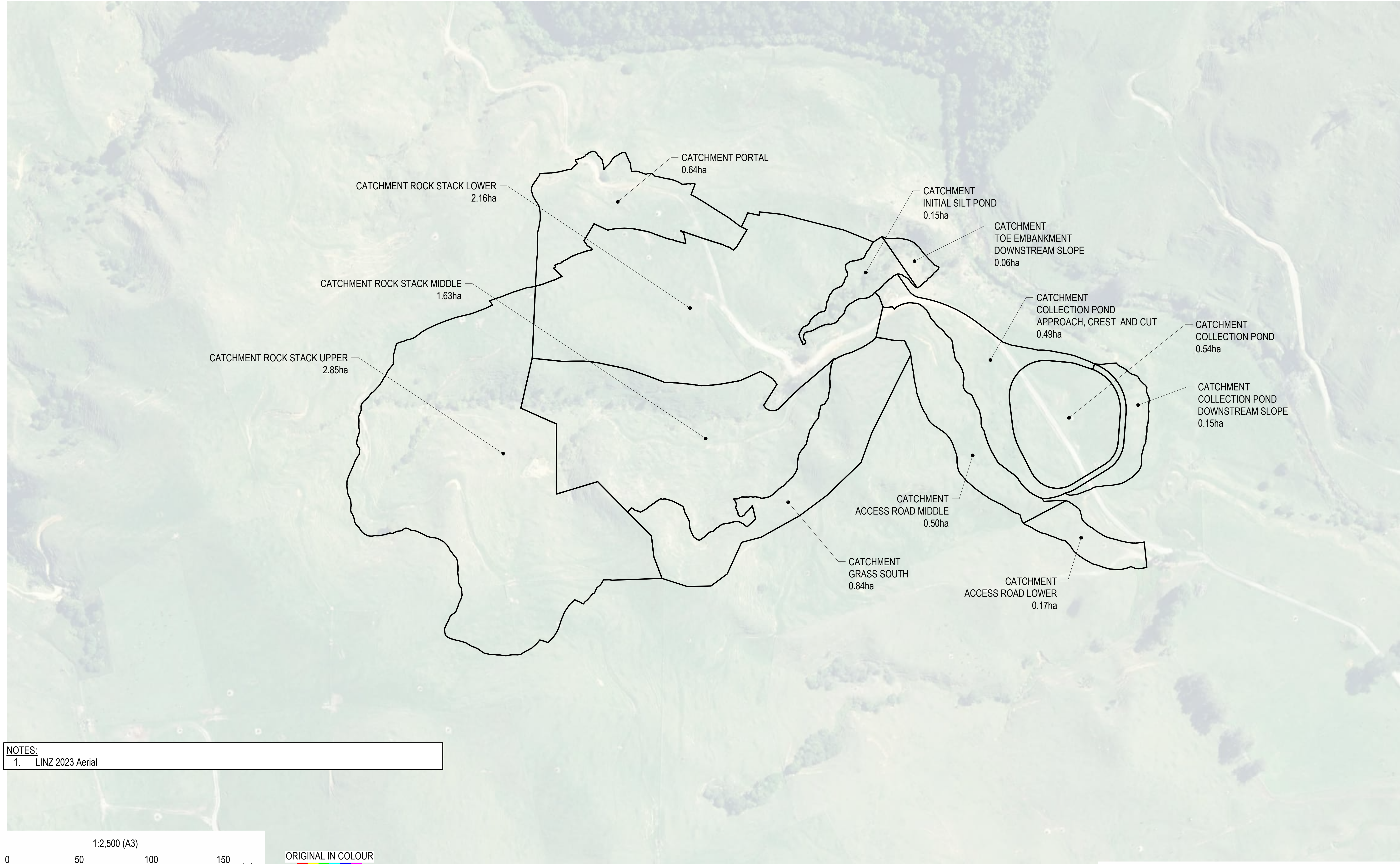
egl\nas\Active\Jobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-10 & 11.dwg



NOTES:
1. LINZ 2023 Aerial

1:2,500 (A3)
0 50 100 150 (m)

ORIGINAL IN COLOUR

FIGURE 12

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OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
WILLOWS ROCK STACK
CATCHMENT PLAN

DRAWN	ET	DATE	JOB No	SCALE (A3)	REV.
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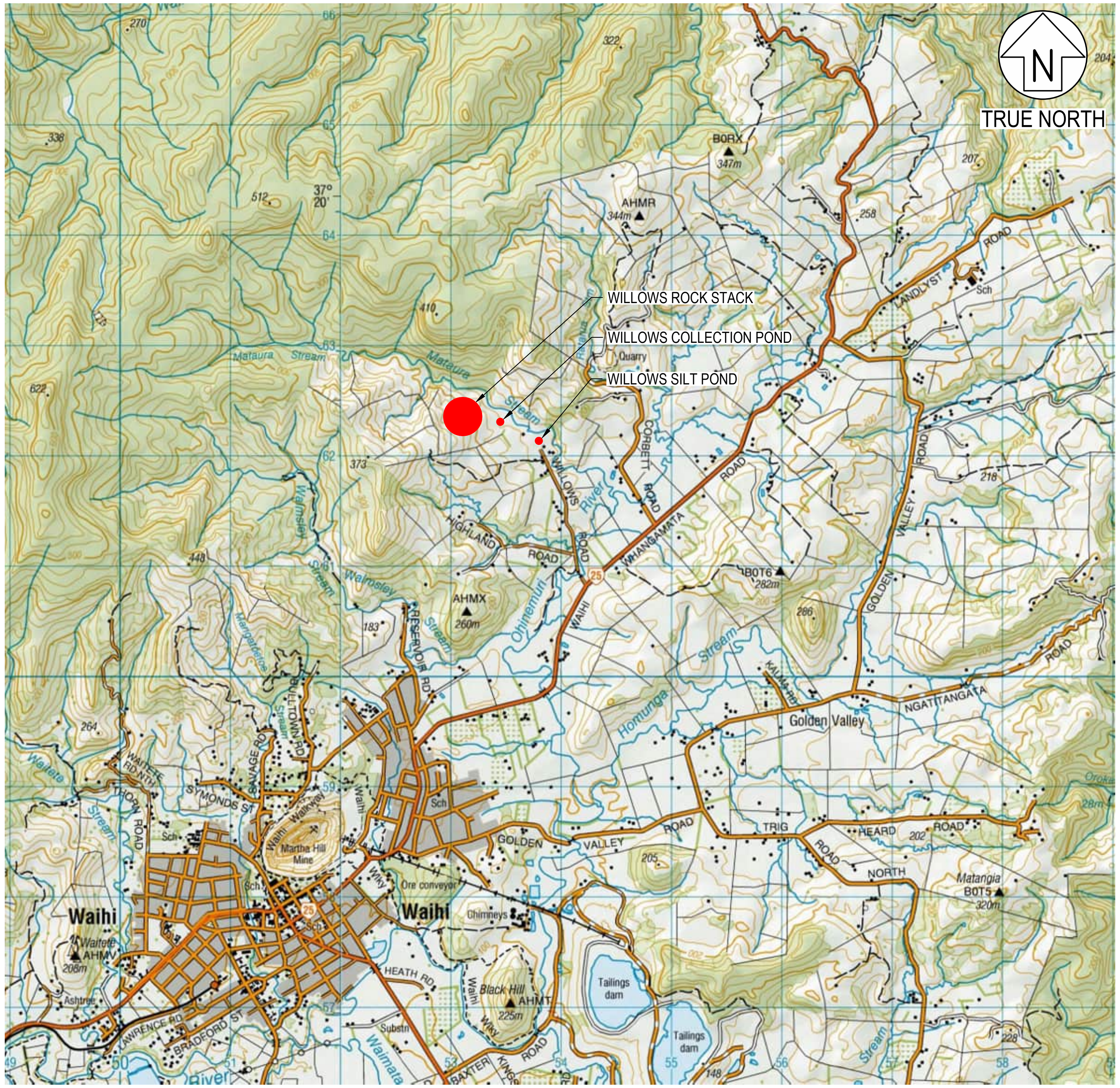
PRINTED: 2024-12-22 21:47:28
eglnas\ActiveJobs\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\2024.12.19 - WRS Technical Report Figs\9169-FIG-12.dwg

APPENDIX A
DESIGN FIGURES



LOCALITY PLAN
SCALE 1:50,000

WAIHI NORTH PROJECT-WILLOWS FARM

FIGURE NO.	REV	SUBSET	DRAWING TITLE
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WAI-985-000-DWG-EA-0002	E	GENERAL	SITE PLAN
WAI-985-000-DWG-EA-0003	E	ROCK STACK	LAYOUT PLAN - INITIAL WORKS
WAI-985-000-DWG-EA-0004	G	ROCK STACK	LAYOUT PLAN - FULL ARRANGEMENT
WAI-985-000-DWG-EA-0005	D	ROCK STACK	ROCK STACK CROSS SECTIONS 1
WAI-985-000-DWG-EA-0006	E	ROCK STACK	ROCK STACK CROSS SECTIONS 2
WAI-985-000-DWG-EA-0007		ROCK STACK	ROCK STACK DETAILS 1
WAI-985-000-DWG-EA-0008		ROCK STACK	ROCK STACK DETAILS 2
WAI-985-000-DWG-EA-0009	D	COLLECTION POND	COLLECTION POND LAYOUT PLAN
WAI-985-000-DWG-EA-0010	D	COLLECTION POND	COLLECTION POND CROSS SECTIONS
WAI-985-000-DWG-EA-0011		COLLECTION POND	COLLECTION POND DETAILS 1
WAI-985-000-DWG-EA-0012	C	COLLECTION POND	COLLECTION POND DETAILS 2
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WAI-985-000-DWG-EA-0014		SILT POND	SILT POND CROSS SECTIONS
WAI-985-000-DWG-EA-0015		SILT POND	SILT POND DETAILS 1
WAI-985-000-DWG-EA-0016		SILT POND	SILT POND DETAILS 2

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1:50,000 (A3)
0 1 2 3 (km)

ORIGINAL IN COLOUR

WAI-985-000-DWG-EA-0001

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OCEANAGOLD WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
GENERAL
LOCALITY PLAN

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
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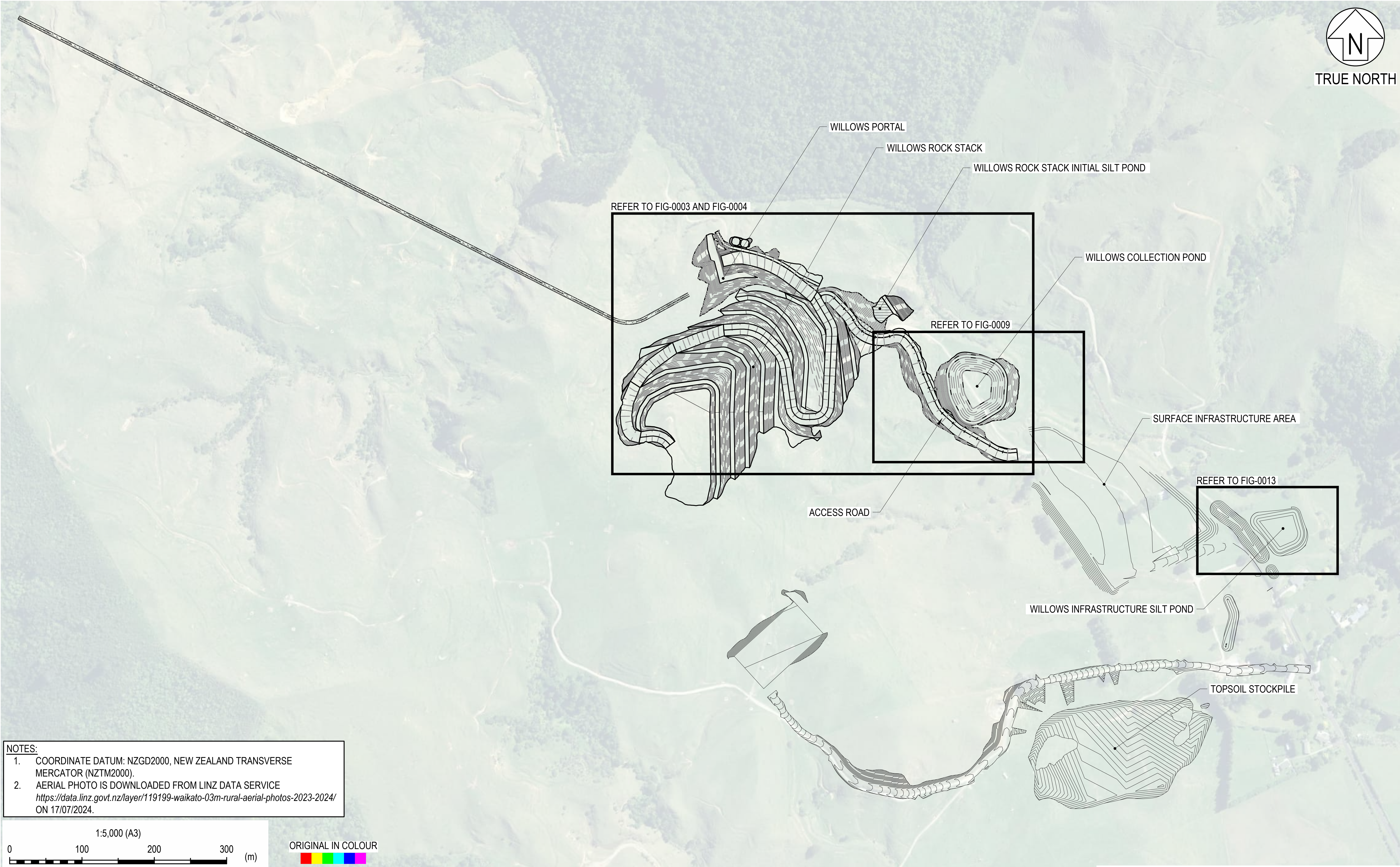
Z:\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\20241001 Willows Design Package\9169-FIG-01.dwg



NOTES:
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2. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.

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WAI-985-000-DWG-EA-0002

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OCEANAGOLD
WAIHI OPERATION

WAIHI NORTH PROJECT
WILLOWS FARM
GENERAL
SITE PLAN

DRAWN	S.K.	DATE	JOB No	SCALE (A3)	REV.
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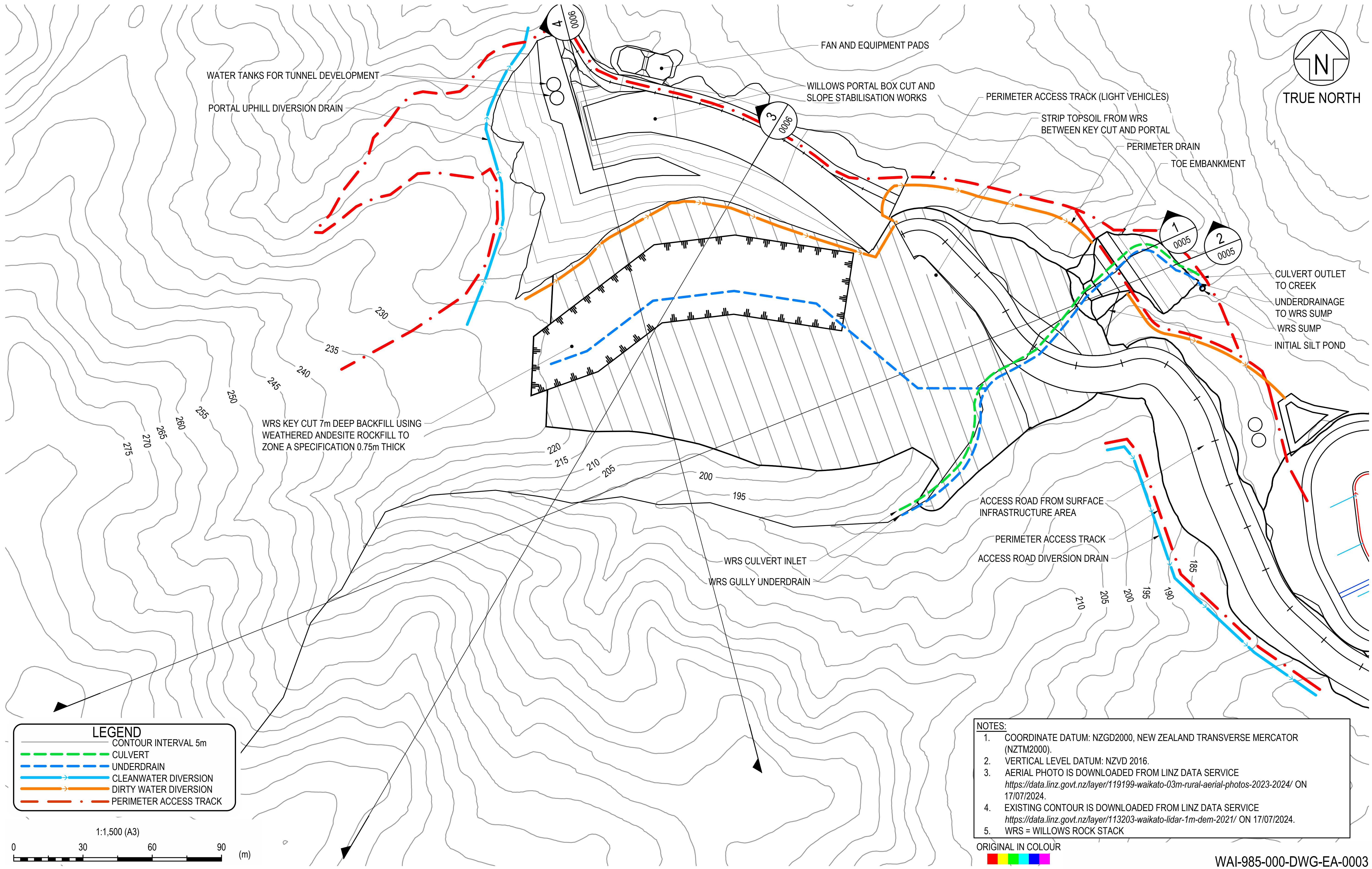
Z:\Mining Jobs\0-Waihi\9169 Willows Road\10 CAD\FIG\20241001 Willows Design Package\9169-FIG-02.dwg



NOTES:

1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. VERTICAL LEVEL DATUM: NZVD 2016.
3. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
4. EXISTING CONTOUR IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/113203-waikato-lidar-1m-dem-2021/* ON 17/07/2024.
5. WRS = WILLOWS ROCK STACK

ORIGINAL IN COLOUR

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WAIHI NORTH PROJECT
WILLOWS FARM
ROCK STACK
LAYOUT PLAN - INITIAL WORKS

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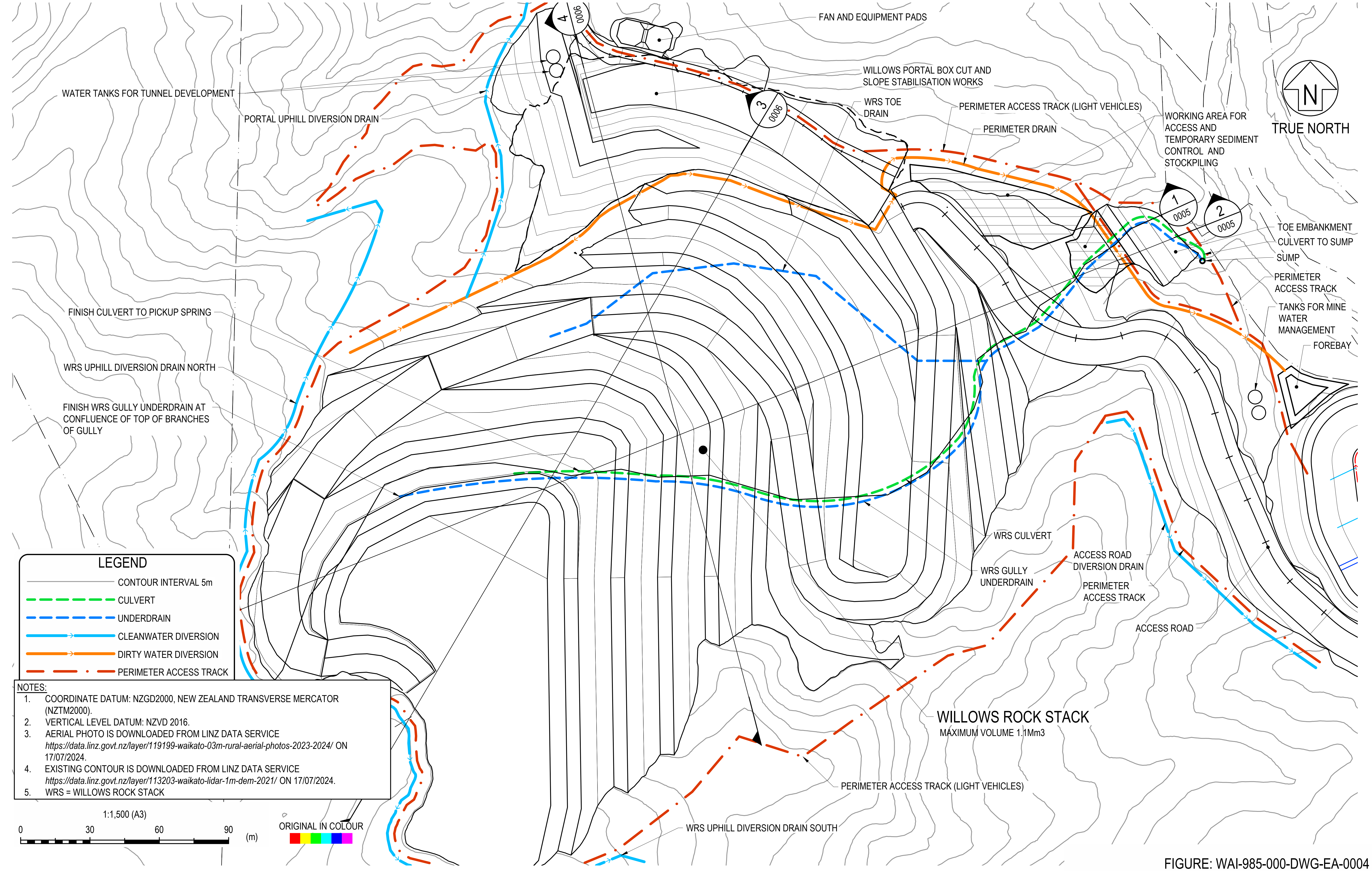

LEGEND

- CONTOUR INTERVAL 5m
- CULVERT
- UNDERDRAIN
- CLEANWATER DIVERSION
- DIRTY WATER DIVERSION
- PERIMETER ACCESS TRACK

NOTES:

1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. VERTICAL LEVEL DATUM: NZVD 2016.
3. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
4. EXISTING CONTOUR IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/113203-waikato-lidar-1m-dem-2021/* ON 17/07/2024.
5. WRS = WILLOWS ROCK STACK

1:1,500 (A3)

0 30 60 90 (m)

ORIGINAL IN COLOUR

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FIGURE: WAI-985-000-DWG-EA-0004

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WILLOWS FARM
ROCK STACK
LAYOUT PLAN - FULL ARRANGEMENT

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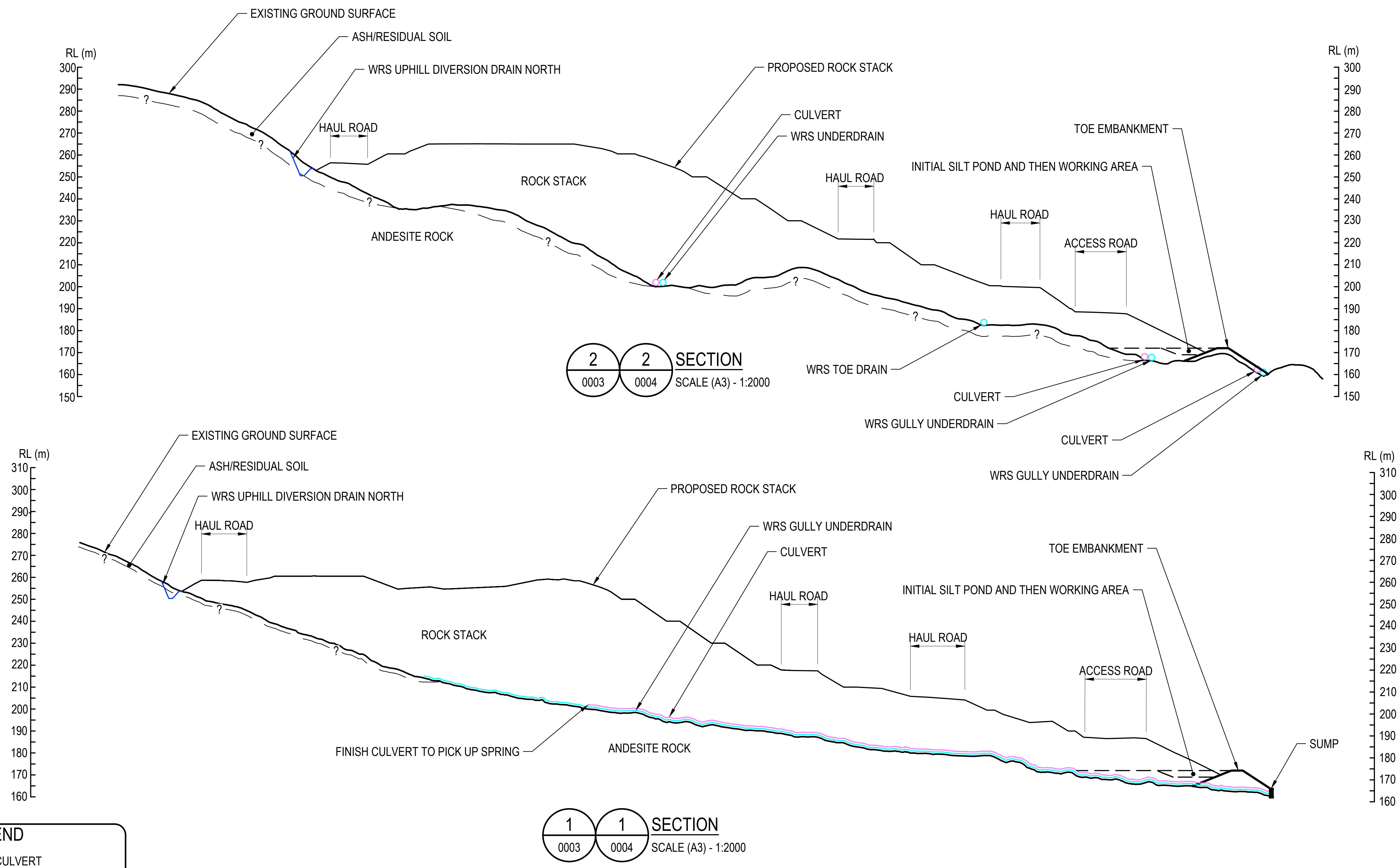

LEGEND

CULVERT

WRS UNDERDRAIN

NOTES:
1. VERTICAL LEVEL DATUM: NZVD 2016.
2. WRS = WILLOWS ROCK STACK.

1:50 (A3)

0 1 2 3 (m)

ORIGINAL IN COLOUR

WAI-985-000-DWG-EA-0005

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WILLOWS FARM
ROCK STACK
CROSS SECTIONS 1

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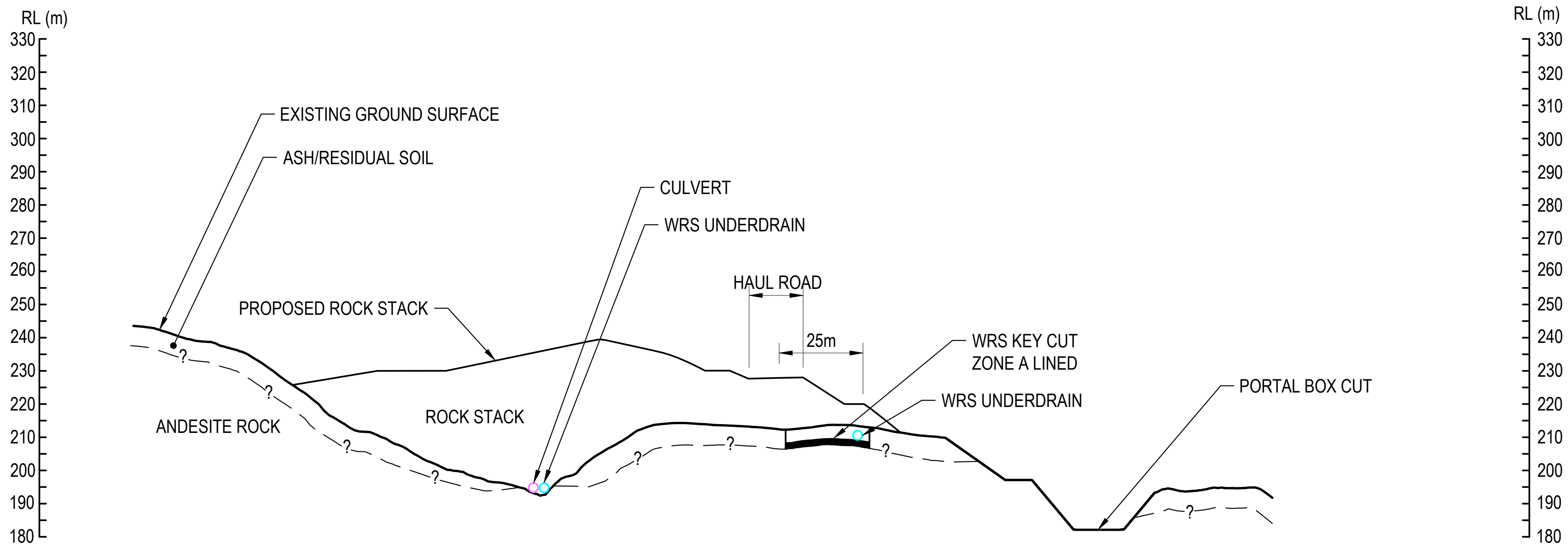
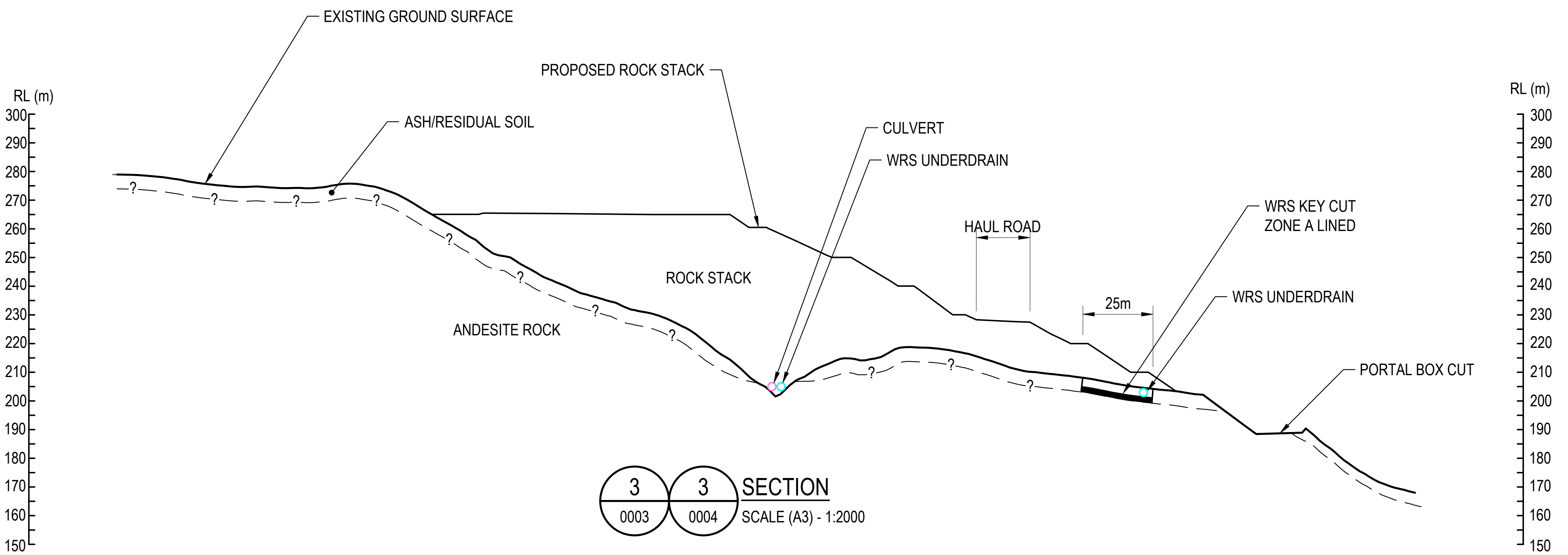


4 / 0003 4 / 0004 SECTION
SCALE (A3) - 1:2000



3 / 0003 3 / 0004 SECTION
SCALE (A3) - 1:2000

LEGEND
CULVERT
WRS UNDERDRAIN

NOTES:
1. VERTICAL LEVEL DATUM: NZVD 2016.
2. WRS = WILLOWS ROCK STACK.

1:2,000 (A3)
0 40 80 120 (m)

ORIGINAL IN COLOUR

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WILLOWS FARM
ROCK STACK
CROSS SECTIONS 2

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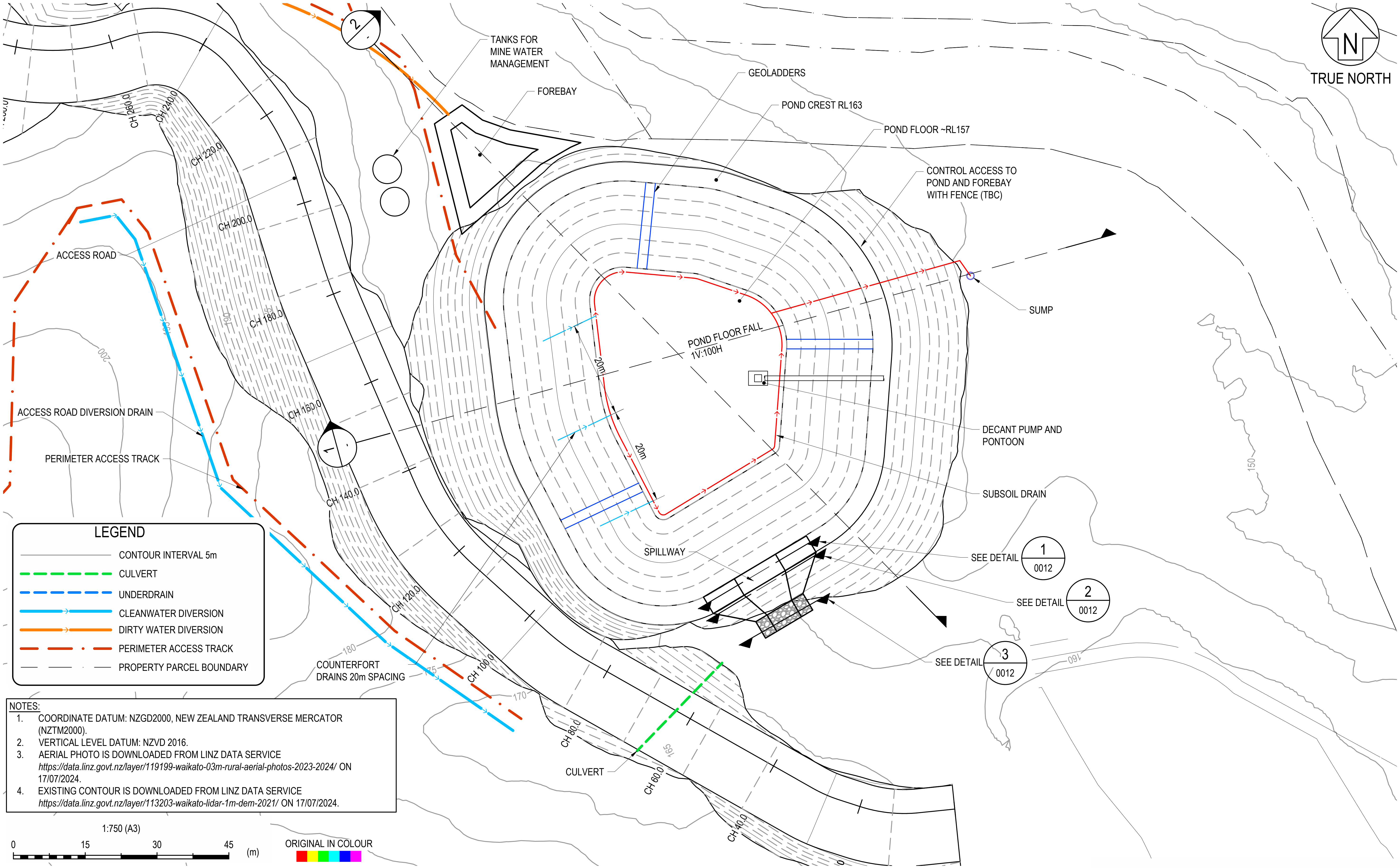

LEGEND

- CONTOUR INTERVAL 5m
- CULVERT
- UNDERDRAIN
- CLEANWATER DIVERSION
- DIRTY WATER DIVERSION
- PERIMETER ACCESS TRACK
- PROPERTY PARCEL BOUNDARY

NOTES:

1. COORDINATE DATUM: NZGD2000, NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. VERTICAL LEVEL DATUM: NZVD 2016.
3. AERIAL PHOTO IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/119199-waikato-03m-rural-aerial-photos-2023-2024/* ON 17/07/2024.
4. EXISTING CONTOUR IS DOWNLOADED FROM LINZ DATA SERVICE *https://data.linz.govt.nz/layer/113203-waikato-lidar-1m-dem-2021/* ON 17/07/2024.

1:750 (A3)

0 15 30 45 (m)

ORIGINAL IN COLOUR

FIGURE: WAI-985-000-DWG-EA-0009

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COLLECTION POND
LAYOUT PLAN

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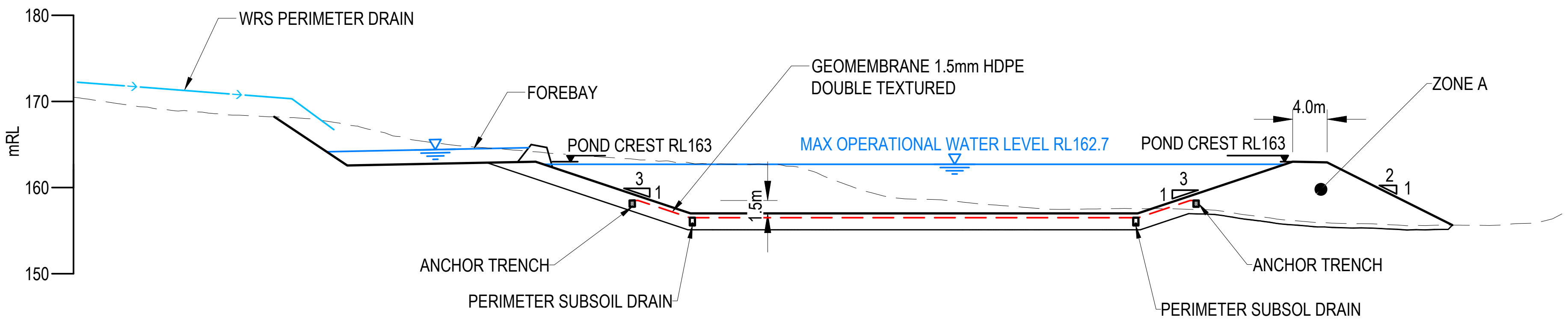
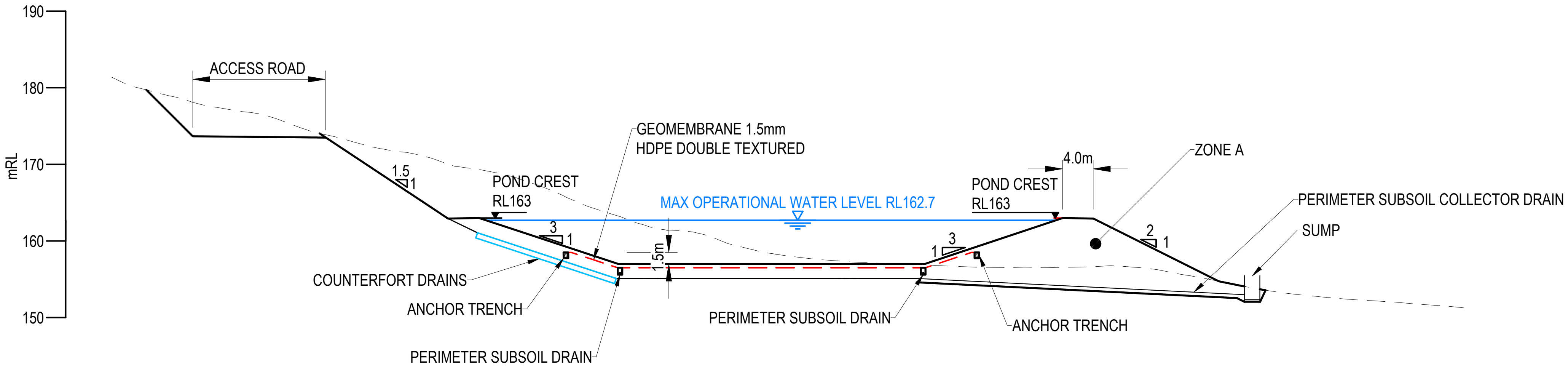


2 SECTION - POND EMBANKMENT

09 SCALE (A3) - 1:750



1 SECTION - POND EMBANKMENT

09 SCALE (A3) - 1:750

NOTES:
1. LEVEL DATUM: NZVD2016.
2. ALL HDPE LINER IS 1.5mm THICK.
3. EXTENT OF FOUNDATION UNDERCUT TO BE CONFIRMED BY ENGINEER DURING CONSTRUCTION ON SITE.

1:750 (A3)

0 15 30 45 (m)

ORIGINAL IN COLOUR

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WILLOWS FARM
COLLECTION POND
CROSS SECTIONS

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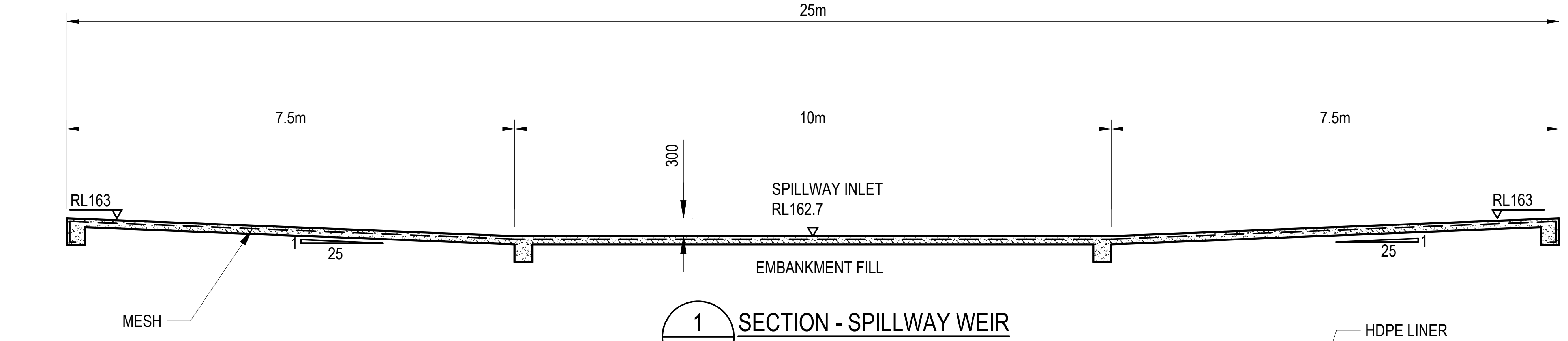
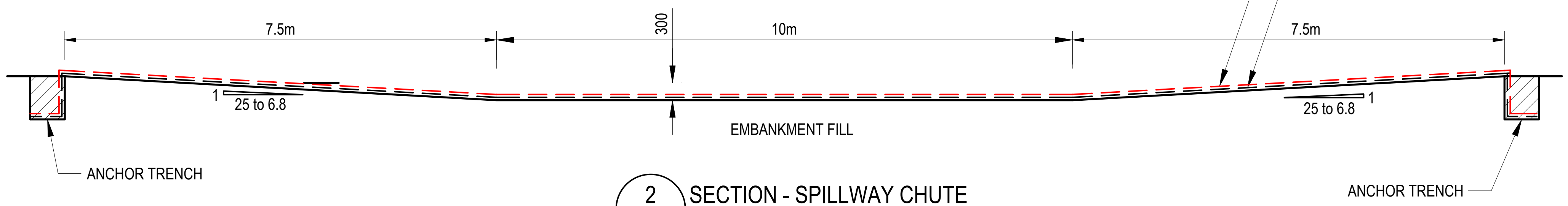
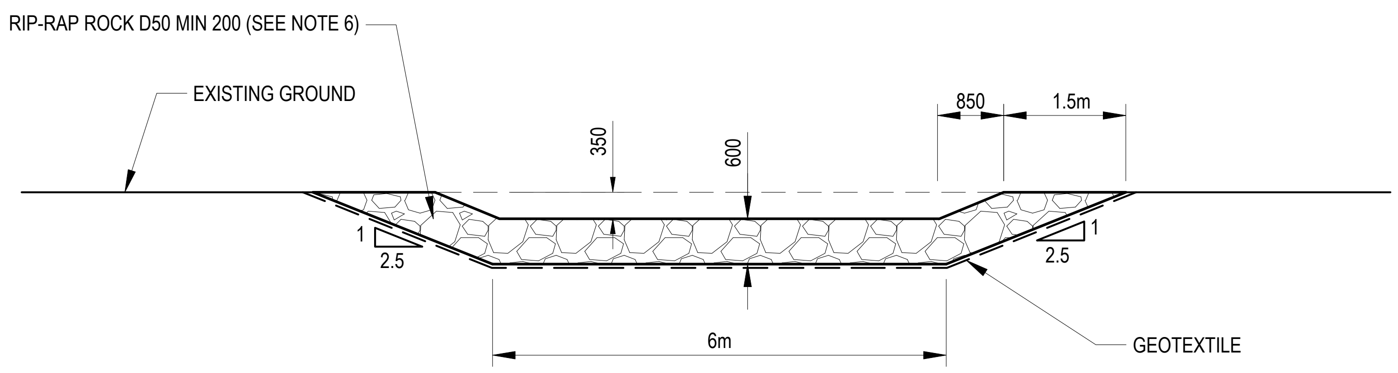


1 / 0009 SECTION - SPILLWAY WEIR
SCALE (A3) - 1:100



2 / 0009 SECTION - SPILLWAY CHUTE
SCALE (A3) - 1:100



3 / 0009 SECTION-SPILLWAY OUTLET CHANNEL
SCALE (A3) - 1:100

NOTES:
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.

1:100 (A3)
0 2 4 6 (m)

ORIGINAL IN COLOUR

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WILLOWS FARM
COLLECTION POND
DETAILS 2

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APPENDIX B
STABILITY ASSESSMENT

APPENDIX B

WILLOWS ROCK STACK STABILITY CALCULATIONS

B1. PURPOSE

Assess the proposed profile for geotechnical stability.

B2. OBJECTIVES

1. Select geotechnical strength parameters for each material for the different loading cases. Consider peak drained strengths, peak undrained strengths, residual undrained strengths. Compare selected design parameters against laboratory testing.
2. Consider maximum operational case for static and post-earthquake stability.
3. Assess earthquake displacements for maximum operational profiles.
4. Assess stability for Sections 2, 3, 4 shown on Figure B1.
5. Apply Spencer Method for circular mechanism and Janbu Method for block slide.
6. Achieve the follow factor of safety:

Peak Drained	FOS=1.2 to 1.5	1.2 for rock stack internal batter slopes 1.5 for rock stack global stability
Peak Undrained	FOS=1.2 to 1.5	1.2 for rock stack internal batter slopes 1.5 for rock stack global stability
Residual Undrained	FOS=1.2	1.2 for rock stack global post-earthquake stability using residual strength

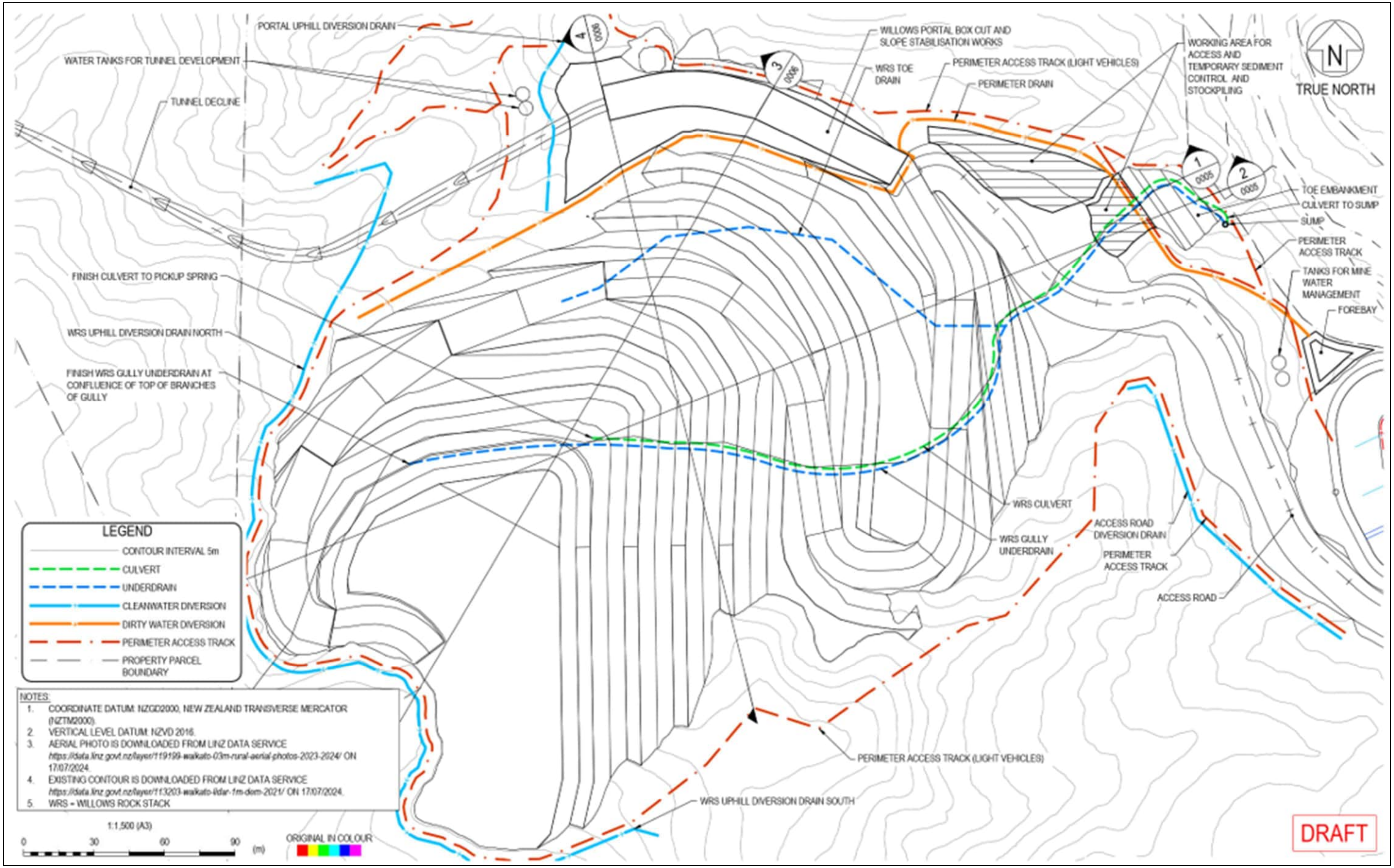


FIGURE B1: WILLOWS ROCK STACK LAYOUT PLAN SHOWING CROSS SECTIONS

B3. STABILITY ASSESSMENT

The stability analyses are undertaken for three cross sections across the Willows Rock Stack (WRS).

- Section 2 – Stability of rock stack profile through gully
  Section runs approximately west to the east through the main east slope of the WRS into the gully through the toe embankment. Section to check overall stability of the rock stack down gully and determine required profile of toe of stack for stability.

- Section 3 – Stability of rock stack profile over ridge
  Section runs approximately southwest to northeast over the ridge above the start of the portal box cut. Section to check for stability of rock stack across weathered rock ridge for critical profile and determine required shear key width and position for stability.

- Section 4 – Stability of rock stack profile above portal cut
  Section runs approximately south to north over the ridge above the maximum portal box cut. Section to check for stability of rock stack across weathered rock ridge for and interaction with portal box cut and determine required shear key width and position for stability.

For each section the following three loading conditions were considered in the stability analyses:

- Peak drained
- Peak undrained
- Residual undrained

Achieving the assessed strength parameters and proposed factors of safety indicates that proposed profile is stable.

B3.1. Strength Parameter Selection

Strength parameters were selected for the three loading conditions and adopted in the stability analyses. The strengths parameters adopted are summarised in Tables B1 to B5.

Laboratory tests were available for the soil and rock samples taken from various depths as part of the geotechnical investigation program. Laboratory tests included Consolidated Undrained (CU) triaxial tests and ring shear tests on soil samples, and Consolidated Undrained (CU) triaxial tests, point load and Unconfined Compressive Strength (UCS) tests on rock samples.

The soil profile comprising the volcanic ash and residual soils were assigned identical drained and undrained strength parameters. Selected strength parameters were picked to target 25th percentile estimates. The adopted peak undrained strength parameter is shown on Figure B2 with the triaxial test results.

Six sets of rock strength relationships were defined, ranging from extremely weak to strong rock strengths. The andesite rock strength generally increases with depth however at depth there is variation in the slightly and unweathered andesite rock. Andesite rock strengths were defined using Hoek Brown Rock Mass Strength relationships, based on the point load and

UCS test results, rock structure, and defect surface condition. The selection of parameters were based on inspection of the core photos across the rock stack area and combined with review of the point load strength and UCS test results. UCS values of the rock samples were derived from point load test results using a generalized correlation relationship (Bieniawski, Z.T., 1974). The rock strength relationships were compared with triaxial test results. These are shown on Figures B2 and B3 with the triaxial test results.

The completely weathered rock strength was defined using an extremely weak Hoek Brown Rock Mass Strength. Sampling of the completely weathered rock was difficult, as push tubes generally refused on the rock and drill core was disturbed by the drilling process. The selected relationship aimed to represent a material better than the residual soil, that was hard or very dense soil, however, not as good as a very weak rock. This strength was assigned to material which had visible rock fabric.

The strength of the rockfill material in the stockpile is based on rockfill friction angles using the method by Duncan (2014). It requires estimates of the uniformity coefficient and the relative density of the rockfill. A 16th percentile strength was taken to allow for potential weaker rockfill materials. The 16 percentile rockfill strength is shown in Figure B4.

Section B3.2 discusses the methodology of assigning the soil strength parameters and rock strength relationships to the geotechnical model for the stability analyses.

Table B1: HOEK Rock Mass Strength Relationship Parameters

Rock	Strength	Structure	Surface Condition	σ_c (MPa)	m_i	mb	s	a
Andesite	Extremely Weak	Intact or Massive	Fair	0.5	17	3.793	0.009	0.050
	Very Weak	Intact or Massive	Fair	2	17	3.793	0.009	0.050
	Very Weak	Intact or Massive	Fair	4	17	3.793	0.009	0.503
	Weak	Intact or Massive	Fair	7	17	6.254	0.045	0.501
	Mod.Strong	Intact or Massive	Good	20	17	8.322	0.108	0.501
	Strong	Intact or Massive	Very Good	50	17	9.949	0.189	0.500

σ_c – uniaxial compressive strength

TABLE B2: STATIC – DRAINED STRENGTH PARAMETER SET

Material	γ (kN/m^3)	Strength Parameters		Porewater Pressure
Rockfill	18.5	Duncan Gravel/Cobbles with Cu>4, 16%ile		Phreatic
Ash/Residual Soil	17.0	c' = 3 kPa	ϕ' = 34 deg	r_u = 0.1
EW Andesite 0.5MPa	18.0	Hoek – Andesite 0.5MPa		Phreatic
VW Andesite 2MPa	18.0	Hoek – Andesite 2MPa		
VW Andesite 4MPa	19.0	Hoek – Andesite 4MPa		
W Andesite 7MPa	20.0	Hoek – Andesite 7MPa		
S Andesite 20MPa	20.0	Hoek – Andesite 20MPa		

MS Andesite 50 MPa	21.0	Hoek – Andesite 50MPa	

TABLE B3: STATIC – UNDRAINED STRENGTH PARAMETER SET

Material	γ (kN/m^3)	Strength Parameters			Porewater Pressure
Rockfill	18.5	Duncan Gravel/Cobbles with Cu>4, 16%ile			Phreatic
Ash/Residual Soil	17.0	Vert. eff. Stress (kPa)	Su (kPa)	Su/σ_v'	r_u = 0.3
		0	34	-	
		75	34	0.45	
		250	93	0.37	
		500	165	0.33	
		1000	290	0.29	
		2000	460	0.23	
EW Andesite 0.5MPa	18.0	Hoek – Andesite 0.5MPa			Phreatic
VW Andesite 2MPa	18.0	Hoek – Andesite 2MPa			
VW Andesite 4MPa	19.0	Hoek – Andesite 4MPa			
W Andesite 7MPa	20.0	Hoek – Andesite 7MPa			
S Andesite 20MPa	20.0	Hoek – Andesite 20MPa			
MS Andesite 50 MPa	21.0	Hoek – Andesite 50MPa			

TABLE B4: POST-EARTHQUAKE STRENGTH SET

Material	γ (kN/m^3)	Strength Parameters	Porewater Pressure
Rockfill	18.5	Duncan Gravel/Cobbles with Cu>4, 16%ile	Phreatic
Ash/Residual Soil	17.0	Su/σ_v' = 0.25	r_u = 0.3
EW Andesite 0.5MPa	18.0	Hoek – Andesite 0.5MPa	Phreatic
VW Andesite 2MPa	18.0	Hoek – Andesite 2MPa	
VW Andesite 4MPa	19.0	Hoek – Andesite 4MPa	
W Andesite 7MPa	20.0	Hoek – Andesite 7MPa	
S Andesite 20MPa	20.0	Hoek – Andesite 20MPa	
MS Andesite 50 MPa	21.0	Hoek – Andesite 50MPa	

TABLE B5: DUNCAN FILL STRENGTH RELATIONSHIP PARAMETERS

Fill	Relative Density Dr	A	B	C	D	Std dev.	Percentile
Duncan Gravel/Cobbles with Cu>4 16%ile	0.6	44	10	7	2	3.1	16^{th}

B3.2. Development of geotechnical model for stability analyses

Geotechnical investigations show that the foundations below the WRS comprise a blanket of volcanic ash and residual soil (to depth of 4 to 9m), over a completely to moderately weathered rock profile (to depth of 15 to 19m), over slightly to unweathered andesite rock.

Boreholes in proximity to Sections 02, 03 and 04 were selected to inform the soil and rock depth profiles of the geotechnical model for stability analyses. The selected profiles along with the point-load-correlated UCS values and UCS test results were plotted against depth as shown on Figures B5 to B11 for WPN-BH2, WWS-102, WWS-103, WWS-104, WWS-105, WWS-106 and WWS-107. The borehole core photos were reviewed alongside Figures B5 to B11 to (1) develop the soil and rock depth profiles of the geotechnical model, (2) and then assign the soil and rock strength parameters to the appropriate soil and rock profile for stability modelling.

B3.3. Groundwater

Geotechnical investigations show that the groundwater table is approximately 12 m below the ground surface. This has been adopted in the stability analyses. A r_u factor of 0.1 has been assigned to the ash and residual soils for the drained strength analyses to account for potential perched groundwater table. A r_u factor of 0.3 has been assigned to the been assigned to the ash and residual soils for the peak and residual undrained loading condition analyses to account for excess pore water pressure generated during construction or in a seismic event.

B3.4. Stability results

The WRS has Factor of Safety (FoS) greater than the design criteria proposed in all three sections. The stability analyses indicate the proposed WRS is stable under the peak drained, peak undrained and residual undrained loading conditions.

To achieve the Factor of Safety (FoS) the following key engineering controls were required:

- The Section 02 analyses required additional rockfill in the gully at the toe of the WRS to achieve a FoS=1.5. Space is available within the proposed footprint for this material.
- The Section 03 and 04 include a shear key cut to intersect slide mechanism through the residual soil. This shear key requires backfill with specified engineered rockfill.
    - Preliminary shear key width on Section 3 is 25m
    - Preliminary shear key width on Section 4 is 15m

The stability analyses and results are shown in Figures B20 to B46 and summarised in the Tables B6, B7 and B8 below.

TABLE B6: GEOTECHNICAL STABILITY SUMMARY SECTION 2 – EAST SLOPE - STABILITY OF ROCK STACK PROFILE THROUGH GULLY

Stability Analyses	Strength Parameters	Figure	Slide Surface	Result	Comment
Static max operation – peak drained strength conditions	Rock stack and foundation Drained strength parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B20	Foundation – Circular	FOS = 2.55	Mechanisms within the rock stack = 1.3 Within the foundation =1.5 Above FOS = 1.5. Criteria met.
		B21	Foundation – Block slide	FOS = 2.27	
		B22	Rock Stack – Circular	FOS = 1.74	
Static max operation – peak undrained strength conditions	Rock stack and foundation Combination of drained and undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B23	Foundation – Circular	FOS = 1.94	Above FOS = 1.5. Criteria met.
		B24	Foundation – Block slide	FOS = 1.53	
Post-earthquake max operation – residual undrained conditions	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B25	Foundation – Circular	FOS = 1.69	Above FOS = 1.2. Criteria met.
		B26	Foundation – Block slide	FOS = 1.30	
EQ max operation 1 in 150 year rock stack response	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement. Post-earthquake strength applied from for assessment of yield acceleration	B27	Circular - Full rock stack $k_y = 0.2$	<0.5 cm	See Table B11 for seismic parameters used for determining co-seismic deformations. Displacements estimates indicate acceptable performance with minor displacement in the 150 year return period case. For the 2500 return period case the displacements of 6 to 23 cm for the maximum operation profile may result in minor damage to drains however the risk is limited as the stack is removed in closure profile.
		B28	Block - Full rock stack $k_y = 0.09$	<0.5 cm	
EQ max operation 1 in 2500 year rock stack response		B27	Circular - Full rock stack $k_y = 0.2$	<0.5 to 5 cm	
		B28	Block – Full rock stack $k_y = 0.09$	6 to 23 cm	

TABLE B7: GEOTECHNICAL STABILITY SUMMARY SECTION 3 – NORTH SLOPE - STABILITY OF ROCK STACK PROFILE OVER RIDGE

Stability Analyses	Strength Parameters	Figure	Slide Surface	Result	Comment
Static max operation – peak drained strength conditions	Rock stack and foundation Drained strength parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B29	Foundation – Circular	FOS = 2.17	Mechanisms within the rock stack = 1.3 Within the foundation =1.5 Above FOS = 1.5. Criteria met.
		B30	Foundation – Block slide	FOS = 2.11	
		B31	Rock Stack – Circular	FOS = 1.57	
Static max operation – peak undrained strength conditions	Rock stack and foundation Combination of drained and undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B32	Foundation – Circular	FOS = 1.72	Above FOS = 1.5. Criteria met.
		B33	Foundation – Block slide	FOS = 1.53	
Post-earthquake max operation – residual undrained conditions	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B34	Foundation – Circular	FOS = 1.53	Above FOS = 1.2. Criteria met.
		B35	Foundation – Block slide	FOS = 1.21	
EQ max operation 1 in 150 year rock stack response	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement. Post-earthquake strength applied from for assessment of yield acceleration	B36	Circular - Full rock stack k_y =0.15	<0.5 cm	See Table B11 for seismic parameters used for determining co-seismic deformations. Displacements estimates indicate acceptable performance with minor displacement in the 150 year return period case. For the 2500 return period case the displacements of 11 to 44 cm for the maximum operation profile may result in minor damage to drains however the risk is limited as the stack is removed in closure profile.
		B37	Block - Full rock stack k_y = 0.06	1 – 4 cm	
EQ max operation 1 in 2500 year rock stack response		B36	Circular - Full rock stack k_y = 0.15	<0.5 to 10 cm	
		B37	Block - Full rock stack k_y = 0.06	11 – 44 cm	

TABLE B8: GEOTECHNICAL STABILITY SUMMARY SECTION 4 – NORTH SLOPE - STABILITY OF ROCK STACK PROFILE ABOVE PORTAL CUT

Stability Analyses	Strength Parameters	Figure	Slide Surface	Result	Comment
Static max operation – peak drained strength conditions	Rock stack and foundation Drained strength parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B38	Foundation – Circular	FOS = 1.81	Mechanisms within the rock stack = 1.3 Within the foundation =1.5 Above FOS = 1.5. Criteria met.
		B39	Foundation – Block slide	FOS = 2.01	
		B40	Rock Stack – Circular	FOS = 1.79	
Static max operation – peak undrained strength conditions	Rock stack and foundation Combination of drained and undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B41	Foundation – Circular	FOS = 2.19	Above FOS = 1.5. Criteria met.
		B42	Foundation – Block slide	FOS = 1.90	
Post-earthquake max operation – residual undrained conditions	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement.	B43	Foundation – Circular	FOS = 1.26	Above FOS = 1.2. Criteria met.
		B44	Foundation – Block slide	FOS = 1.59	
EQ max operation 1 in 150 year rock stack response	Rock stack and foundation Combination of drained and post-earthquake softened undrained parameters applied using effective stresses based on excess porewater pressures due to rockfill placement. Post-earthquake strength applied from for assessment of yield acceleration	B45	Circular - Full rock stack $k_y = 0.09$	<0.5 cm	See Table B11 for seismic parameters used for determining co-seismic deformations. Displacements estimates indicate acceptable performance with minor displacement in the 150 year return period case. For the 2500 return period case the displacements of 4 to 14 cm for the maximum operation profile may result in minor damage to drains however the risk is limited as the stack is removed in closure profile.
		B46	Block - Full rock stack $k_y = 0.13$	<0.5 – 1 cm	
EQ max operation 1 in 2500 year rock stack response		B45	Circular - Full rock stack $k_y = 0.09$	3 – 15 cm	
		B46	Block - Full rock stack $k_y = 0.13$	4 – 14 cm	

WILLOWS ROCK STACK CO-SEISMIC DEFORMATION CALCULATIONS

B4. PURPOSE

Estimate the potential co-seismic deviatoric (shear) embankment deformations under earthquake loading for the WRS stockpile embankment.

B5. OBJECTIVES

1. Select design response spectra and mean moment magnitudes (Mw) for the stockpile site (Vs30 = 600m/s) for an:
    a. 150 year return period event
    b. 2,500 year return period event
2. Estimate the co-seismic deviatoric deformations induced by earthquake shaking using the Bray and Macedo (2019) calculation method.

B6. DESIGN RESPONSE SPECTRA

A seismic hazard study was undertaken by GNS Science in 2017 (Ref. 1) for the Waihi Operation site with a time average shear wave velocity over 30m, Vs30 = 600 m/s, representative of a soft rock site. The GNS study provided probabilistic uniform hazard spectra for the required:

- 150 year return period earthquake event
- 2,500 year return period earthquake event

B6.1. 150 year return period earthquake event

The 150 year return period uniform hazard spectrum is shown in Figure B12 and the associated deaggregation plots are shown in Figure B13, Figure B14 and Figure B15 for PGA, SA(0.5s) and SA(1.0s), respectively. The mean magnitude of the deaggregated earthquake sources for PGA (Peak Ground Acceleration) is provided by GNS (Ref. 1), however, not for SA(0.5s) and SA(1.0s). These have been visually estimated as summarised in Table B9 by EGL for use in estimating co-seismic displacement.

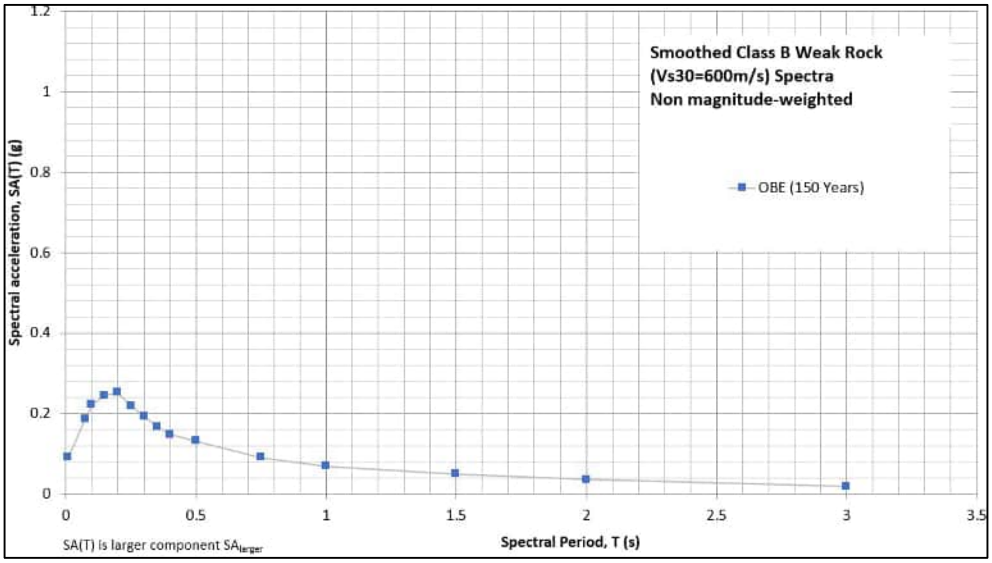


FIGURE B12: 150 YEAR RETURN RESPONSE SPECTRUM

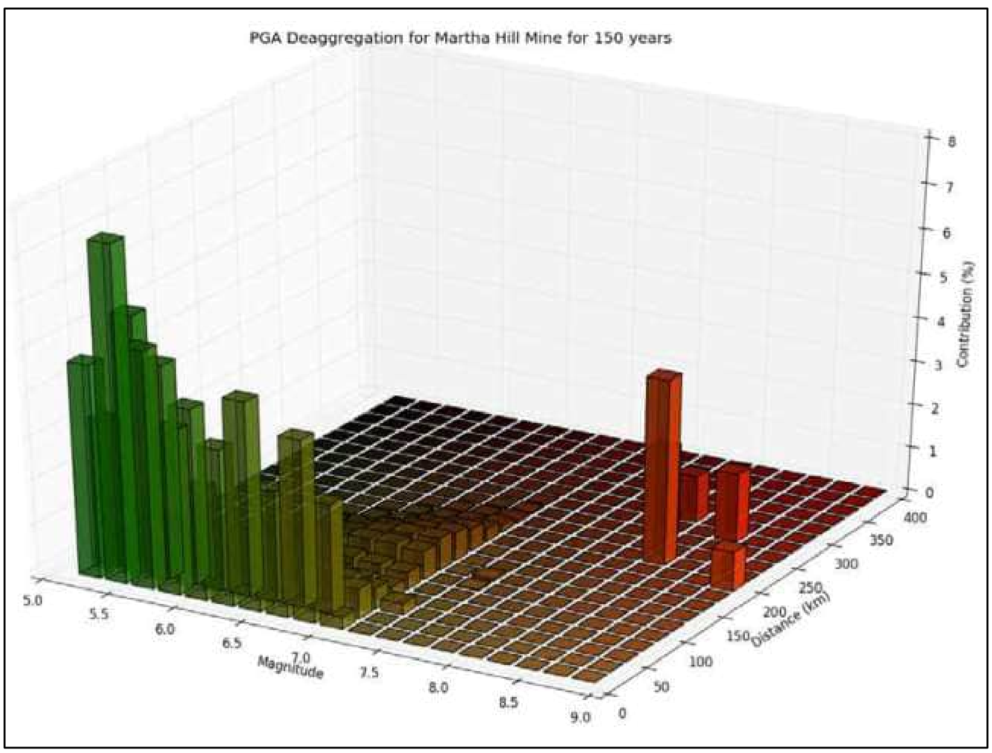


FIGURE B13: NON MAGNITUDE-WEIGHTED 150 YEAR PGA DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

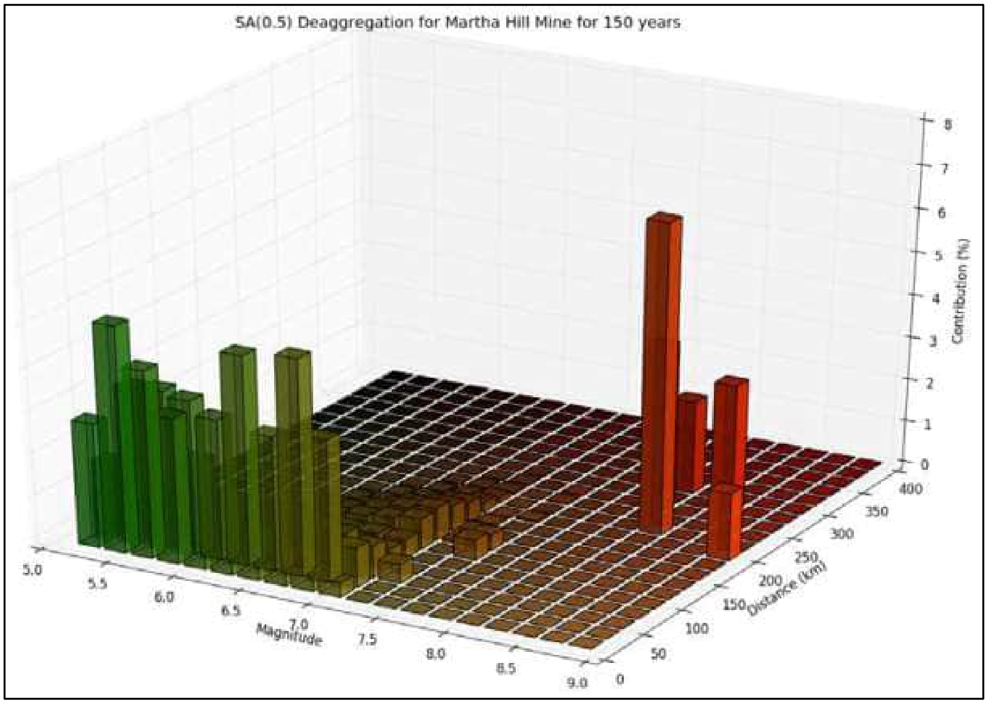


FIGURE B14: NON MAGNITUDE-WEIGHTED 150-YEAR SA (0.5S) DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

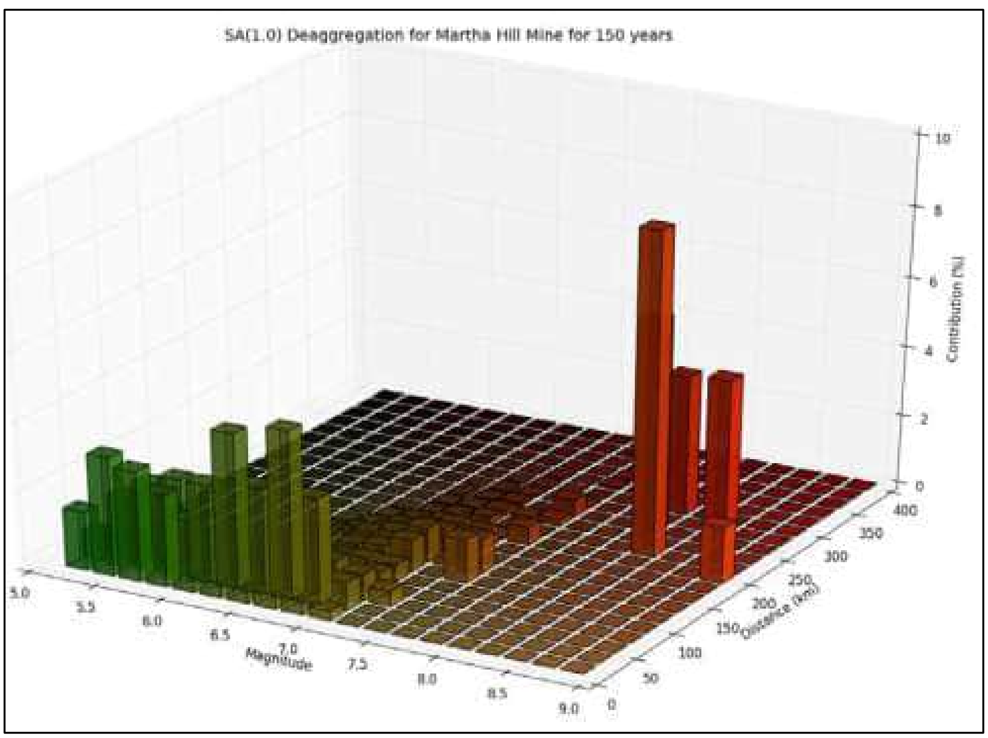


FIGURE B15: NON MAGNITUDE-WEIGHTED 150-YEAR SA (1.0 S) DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

TABLE B9: ESTIMATED MEAN MAGNITUDES FOR 150 YEAR RETURN PERIOD SPECTRAL ACCELERATIONS

Intensity Parameter	Mean Magnitude (Mw)
PGA	6.3
SA(0.5s)	6.4*
SA(1.0s)	6.7*

*Visually estimated from GNS 2017 deaggregation plots (Figures B13 and B14)

B6.2. 2,500 year return period earthquake event

The 2,500 year return period uniform hazard spectrum is shown in Figure B16 and the associated deaggregation plots are Figure B17, Figure B18 and Figure B19 for PGA, SA(0.5s) and SA(1.0s), respectively. The mean magnitude of the deaggregated earthquake sources for PGA (Peak Ground Acceleration) is provided by GNS (Ref. 1), however, not for SA(0.5s) and SA(1.0s). These have been visually estimated as summarised in Table B10 by EGL for use in estimating co-seismic displacement.

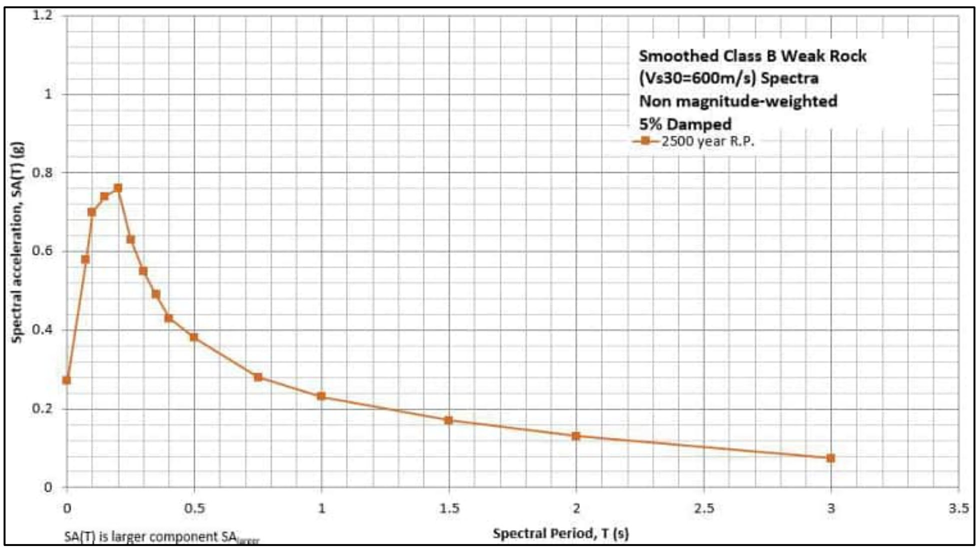


FIGURE B16: 2500 YEAR RETURN PERIOD RESPONSE SPECTRUM

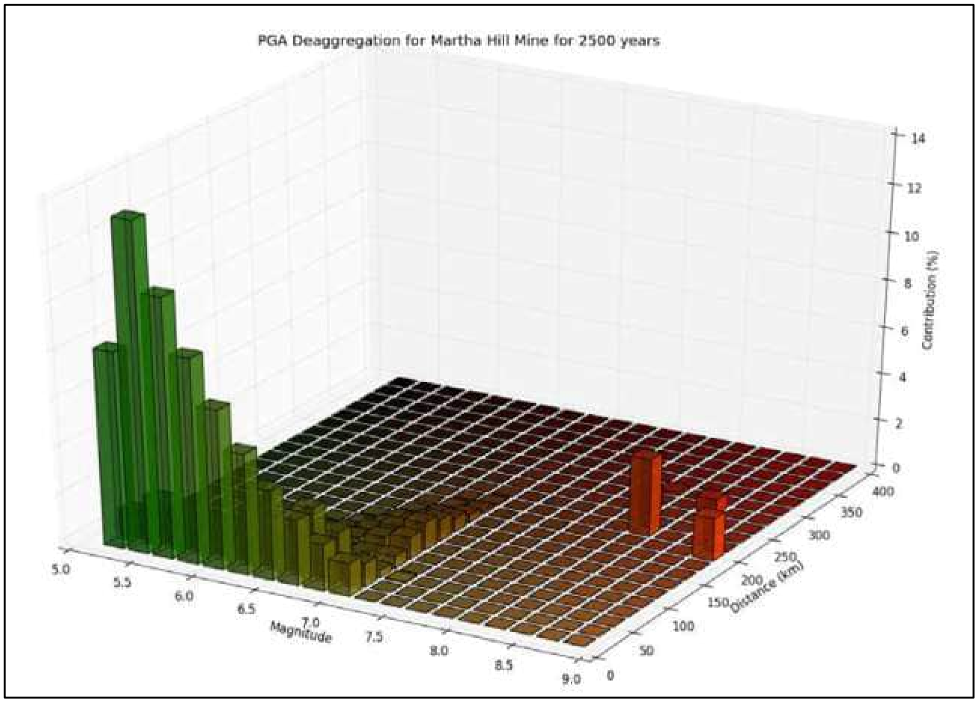


FIGURE B17: NON MAGNITUDE-WEIGHTED 2500 YEAR PGA DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

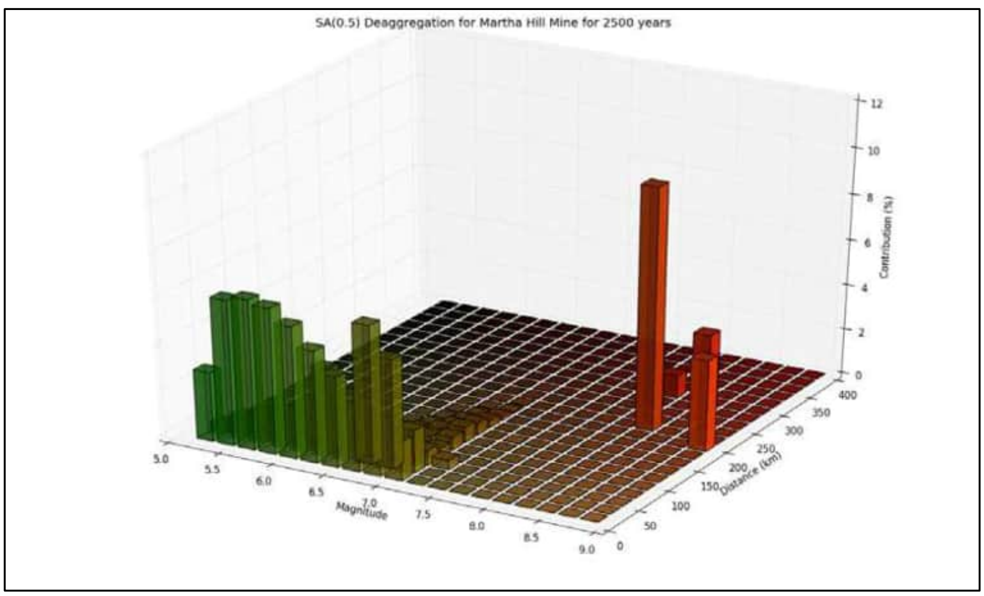


FIGURE B18: NON MAGNITUDE-WEIGHTED 2500-YEAR SA (0.5S) DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

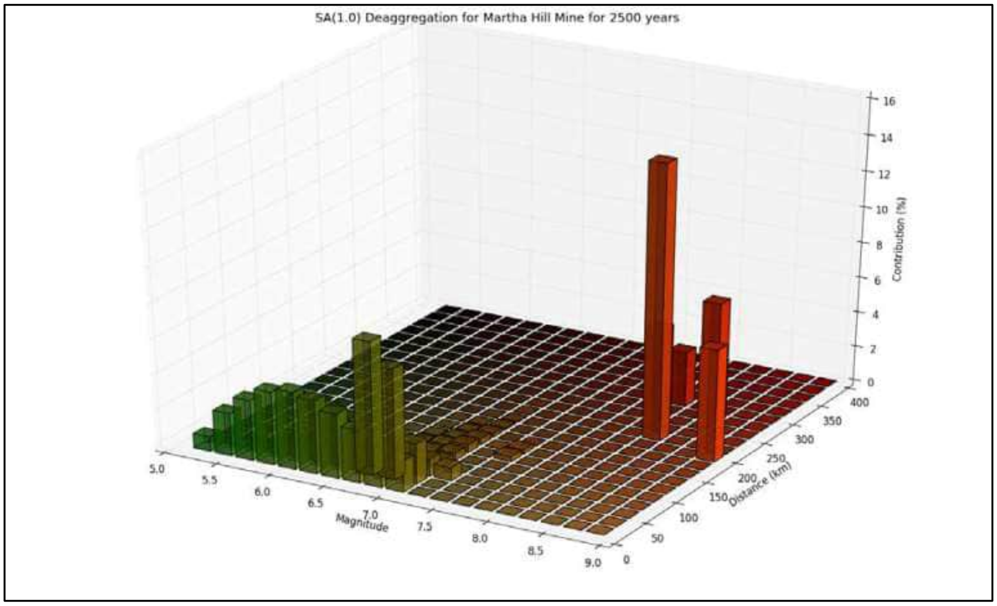


FIGURE B19: NON MAGNITUDE-WEIGHTED 2500-YEAR SA (1.0 S) DEAGGREGATION FOR MARTHA HILL MINE FOR CLASS B ROCK, VS30 = 600 M/S

TABLE B10: ESTIMATED MEAN MAGNITUDES FOR 2500 YEAR RETURN PERIOD SPECTRAL ACCELERATIONS

Intensity Parameter	Mean Magnitude (Mw)
PGA	6.9
SA(0.5s)	7.0*
SA(1.0s)	7.3*

*Visually estimated from GNS 2017 deaggregation plots (Figures B17 and B18)

B7. CO-SEISMIC DEVIATORIC DEFORMATIONS

Co-seismic deviatoric (shear) deformation of slide masses within the embankment are estimated using the method of Bray and Macedo (2019) "Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquake". The method is based on a fully coupled 1-dimension idealisation of slide mass response with displacement accumulated on the slide surface when the felt horizontal acceleration exceeds the pseudo-static yield acceleration of the slide mass. Estimation of the period (Ts) of the slide mass depends on the geometry of the mass and was assessed using the method in Bray, J. D., & Macedo, J. (2021).

Inputs and estimated potential displacements are summarised in Table B11. The estimated potential are generally in the same order of magnitude under the 150 year and 2,500 year return period respectively. As summarised in the comment section of Tables B6 to B8, potential displacements estimates indicate acceptable performance with minor displacement in the 150 year return period case. For the 2500 return period case the displacements for the maximum operation profile are also relatively minor. They may may result in minor damage to drains however the risk is limited as the stack is removed in closure profile.

TABLE B11: ESTIMATED CO-SEISMIC SLOPE DEFORMATION CALCULATION INPUTS SECTION 2, 3, AND 4

								150 year Return Period			2500 year Return Period		
Section	**Scenario Direction/ Profile**		**Slip Surface**	**Effective Height of Slip Surface[1] (m)**	**Slide mass velocity V_s (m/s)**	**T_s (s)**	**$1.3T_s$ (s)**	**k_y (g)**	**Sa ($1.3T_s$) (g)**	**Mw applied**	**Permanent Def. (cm)**	**Sa ($1.3T_s$)**	**Mw applied**	**Permanent Def.(cm)**
2	North Slope	Oper.	Circular - Full stack – Foundation	22.1	350	0.25	0.33	0.20	0.18	6.3	<0.5	0.52	6.9	<0.5 – 5
2	North Slope	Oper.	Block - Full stack	20.0	350	0.23	0.30	0.09	0.19	6.3	<0.5	0.55	6.9	6 – 23
3	North Slope	Oper.	Circular - Stack toe	3.9	350	0.04	0.06	0.15	0.16	6.3	<0.5	0.50	6.9	<0.5 – 10
3	North Slope	Oper.	Block - Full stack	18.6	350	0.21	0.28	0.06	0.21	6.3	1 – 4	0.59	6.9	11 – 44
4	East Slope	Oper.	Circular - Stack toe	1.9	350	0.02	0.03	0.09	0.12	6.3	<0.5	0.36	6.9	3 – 15
4	East Slope	Oper.	Block - Full stack	18.6	350	0.21	0.28	0.13	0.21	6.3	<0.5 – 1	0.59	6.9	4 – 14

Notes:

1) Effective height using sliding mass geometry “(f) MSW sidehill fill”, obtained from Bray, J. D., & Macedo, J. (2021). Closure to “Procedure for Estimating Shear-Induced Seismic Slope Displacement for Shallow Crustal Earthquakes” by Jonathan D. Bray and Jorge Macedo. Journal of Geotechnical and Geoenvironmental Engineering, 147(5), 7021007.

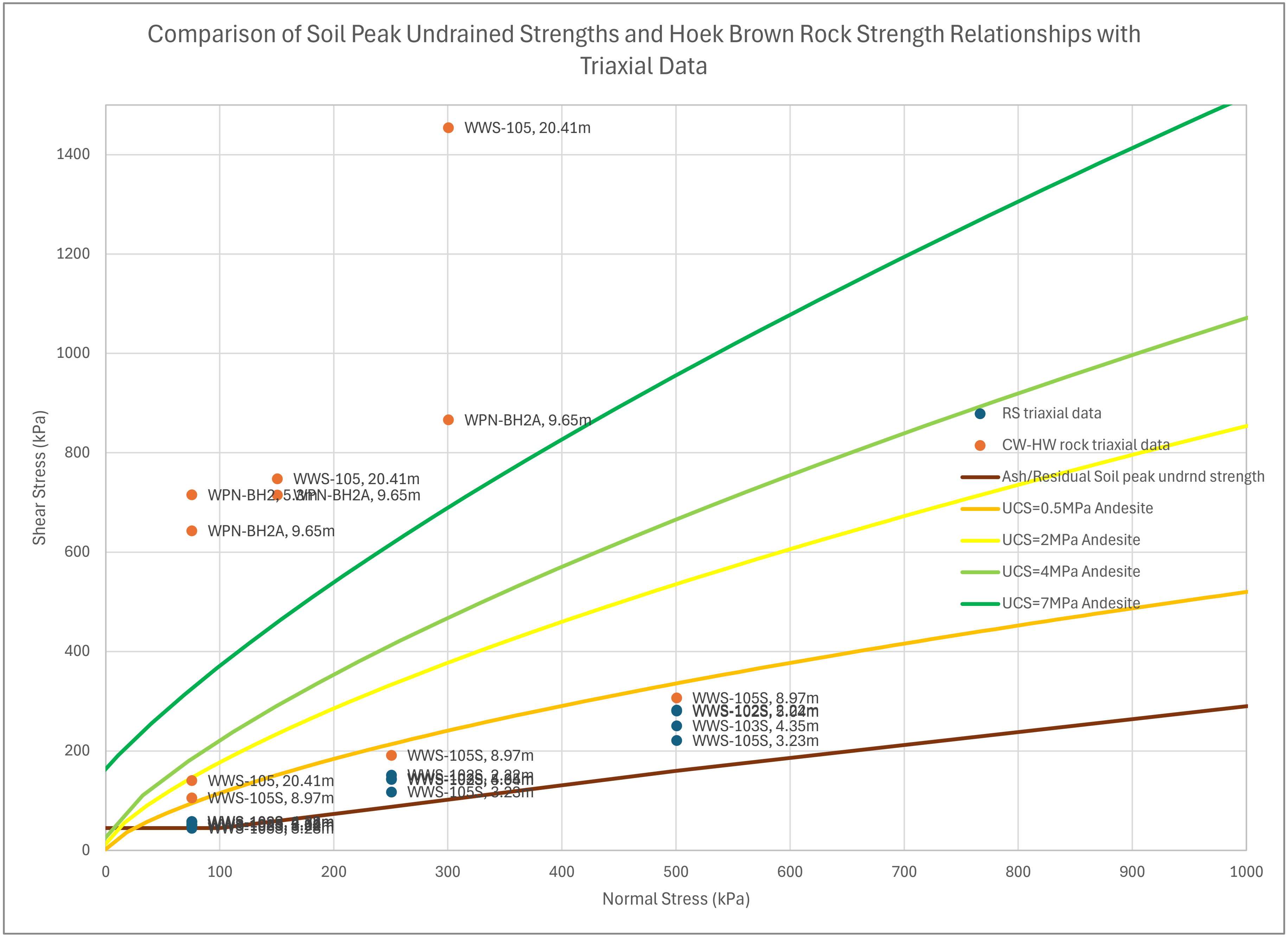


FIGURE B2: COMPARISON OF SOIL PEAK UNDRAINED STRENGTHS AND HOEK BROWN ROCK STRENGTH RELATIONSHIPS WITH TRIAXIAL DATA

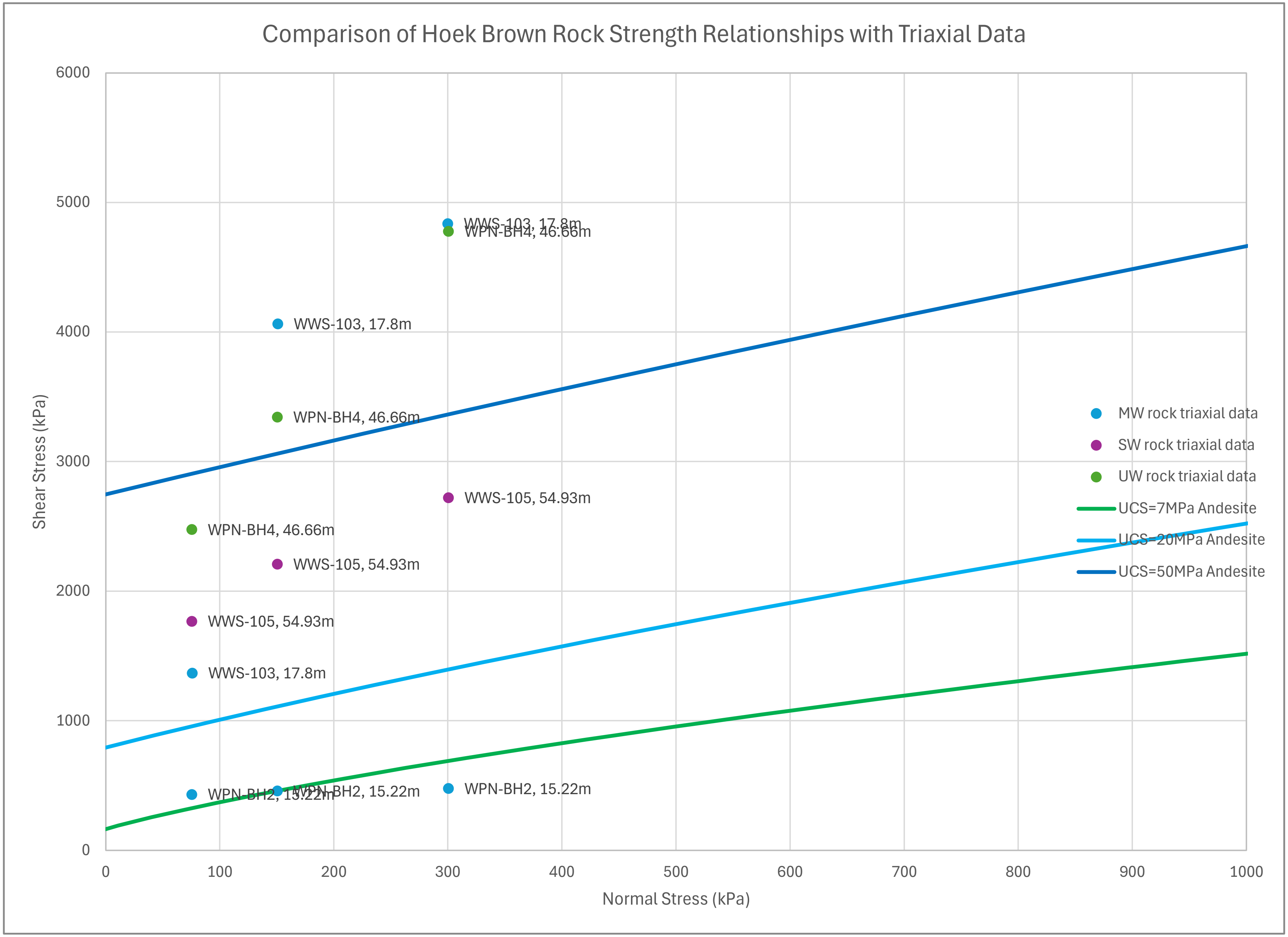


FIGURE B3: COMPARISON OF HOEK BROWN ROCK STRENGTH RELATIONSHIPS WITH TRIAXIAL DATA

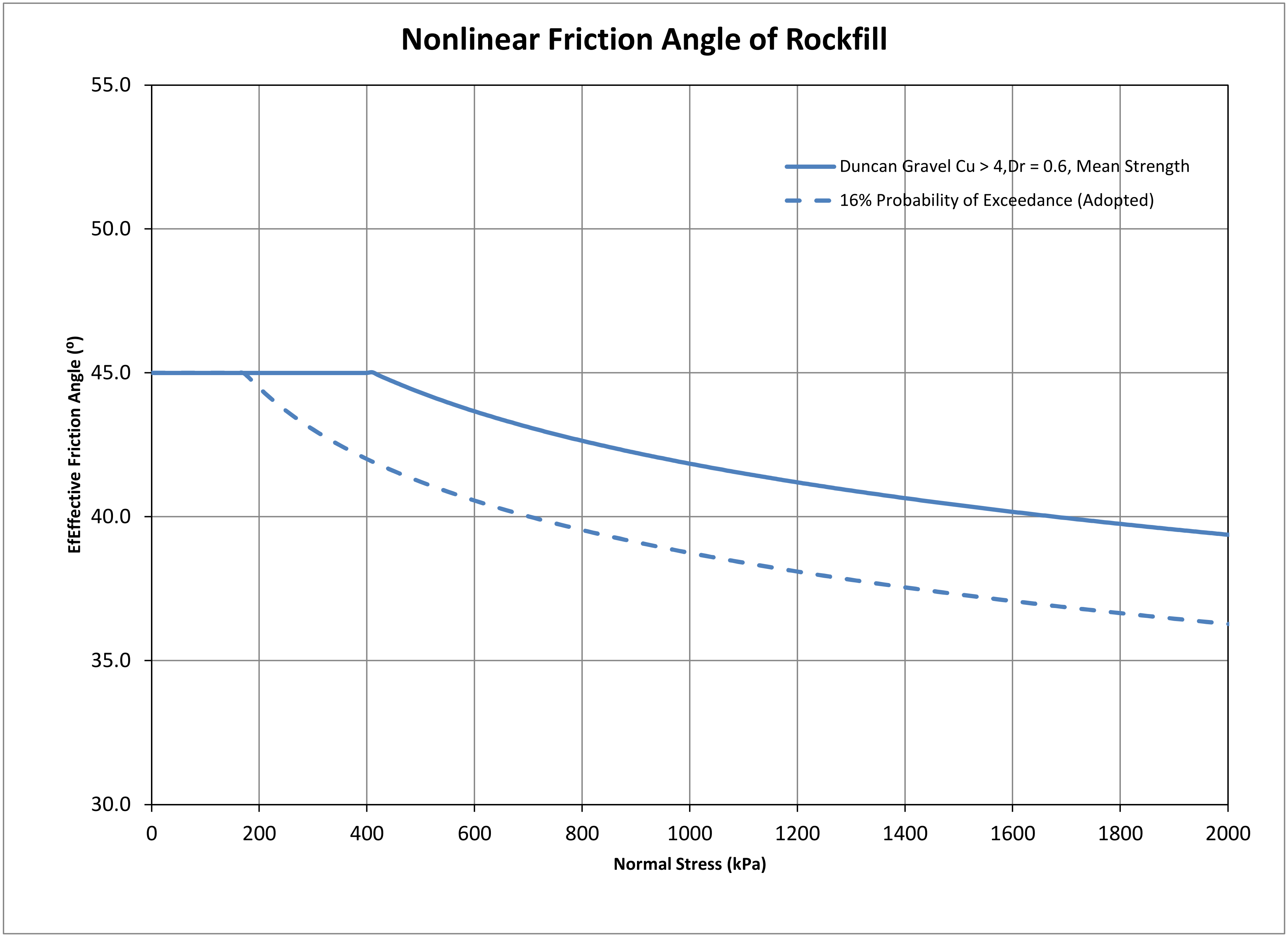


FIGURE B4: 16 PERCENTILE NONLINEAR FRICTION ANGLE OF ROCKFILL

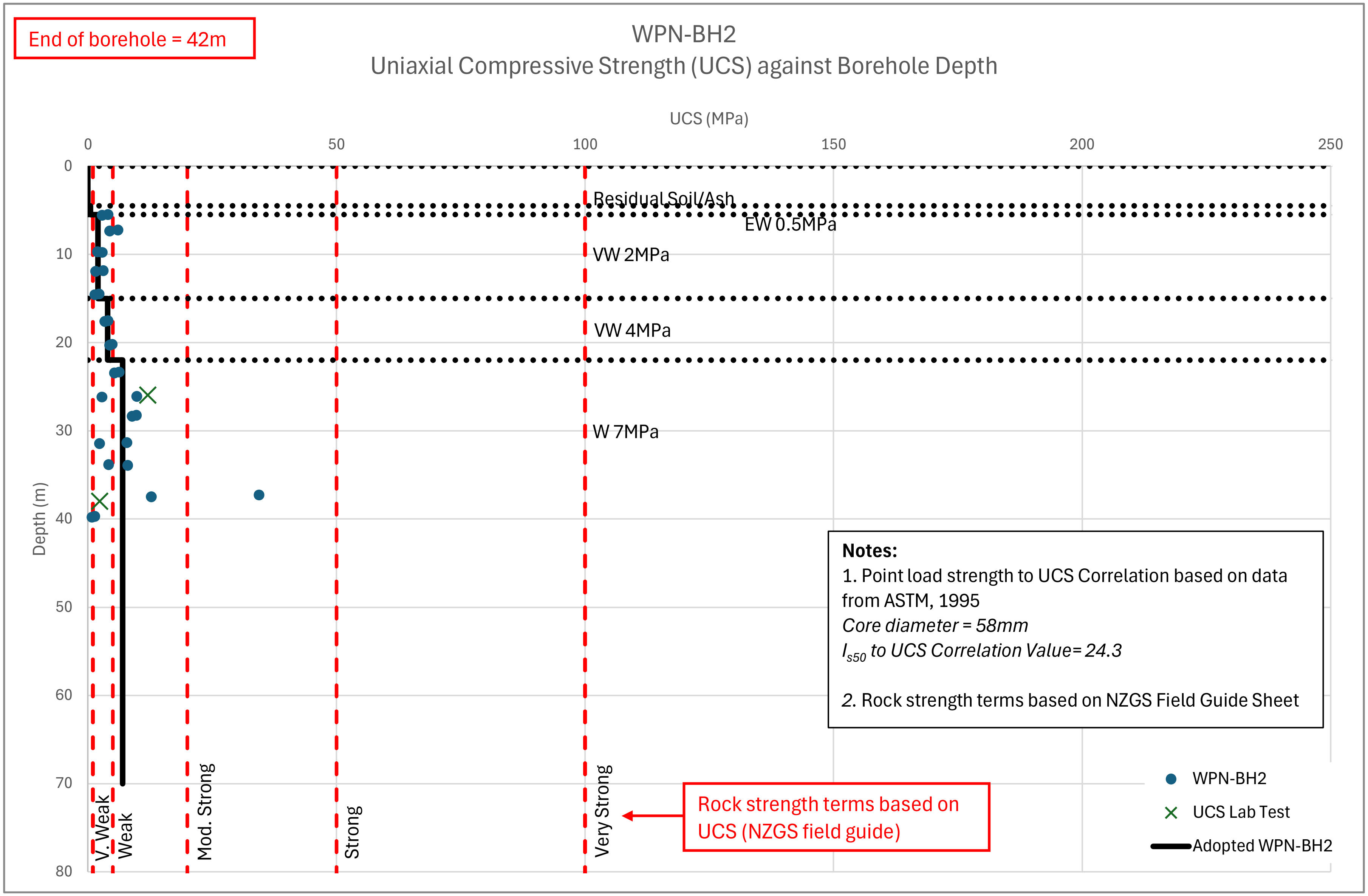


FIGURE B5: WPN-BH2 - UCS AGAINST BOREHOLE DEPTH

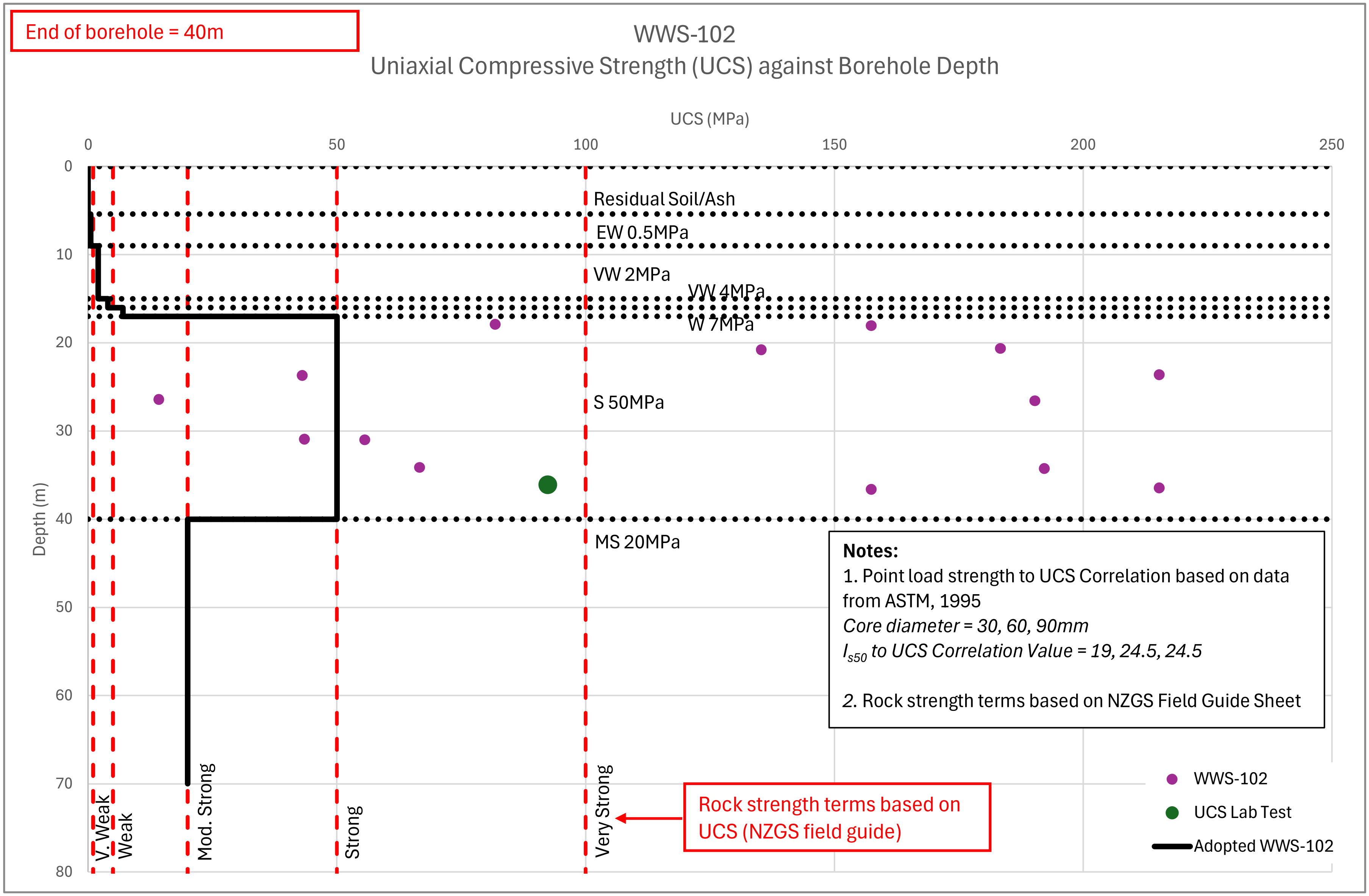


FIGURE B6: WWS-102 - UCS AGAINST BOREHOLE DEPTH

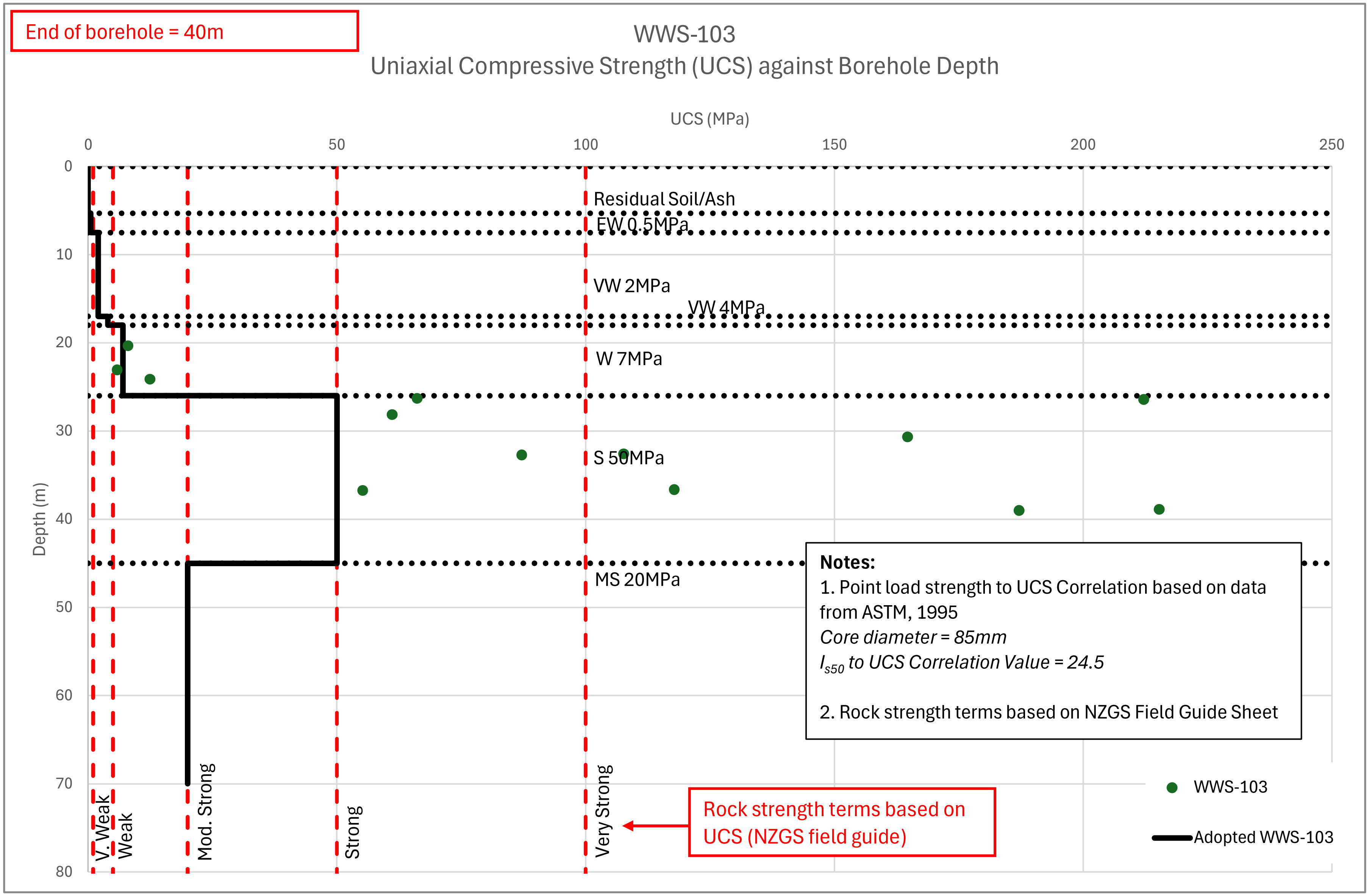


FIGURE B7: WWS-103 - UCS AGAINST BOREHOLE DEPTH

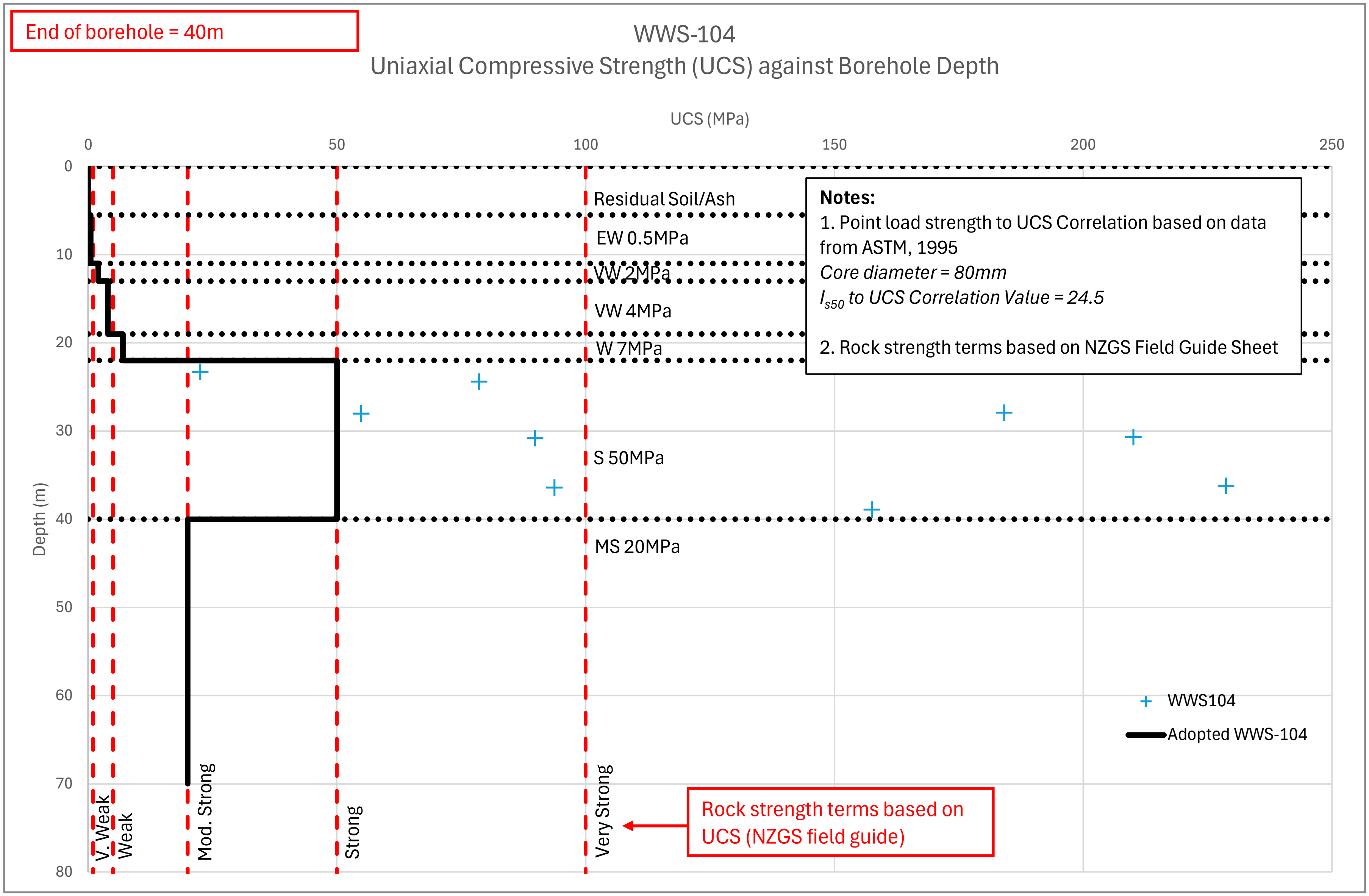


FIGURE B8: WWS-104 - UCS AGAINST BOREHOLE DEPTH

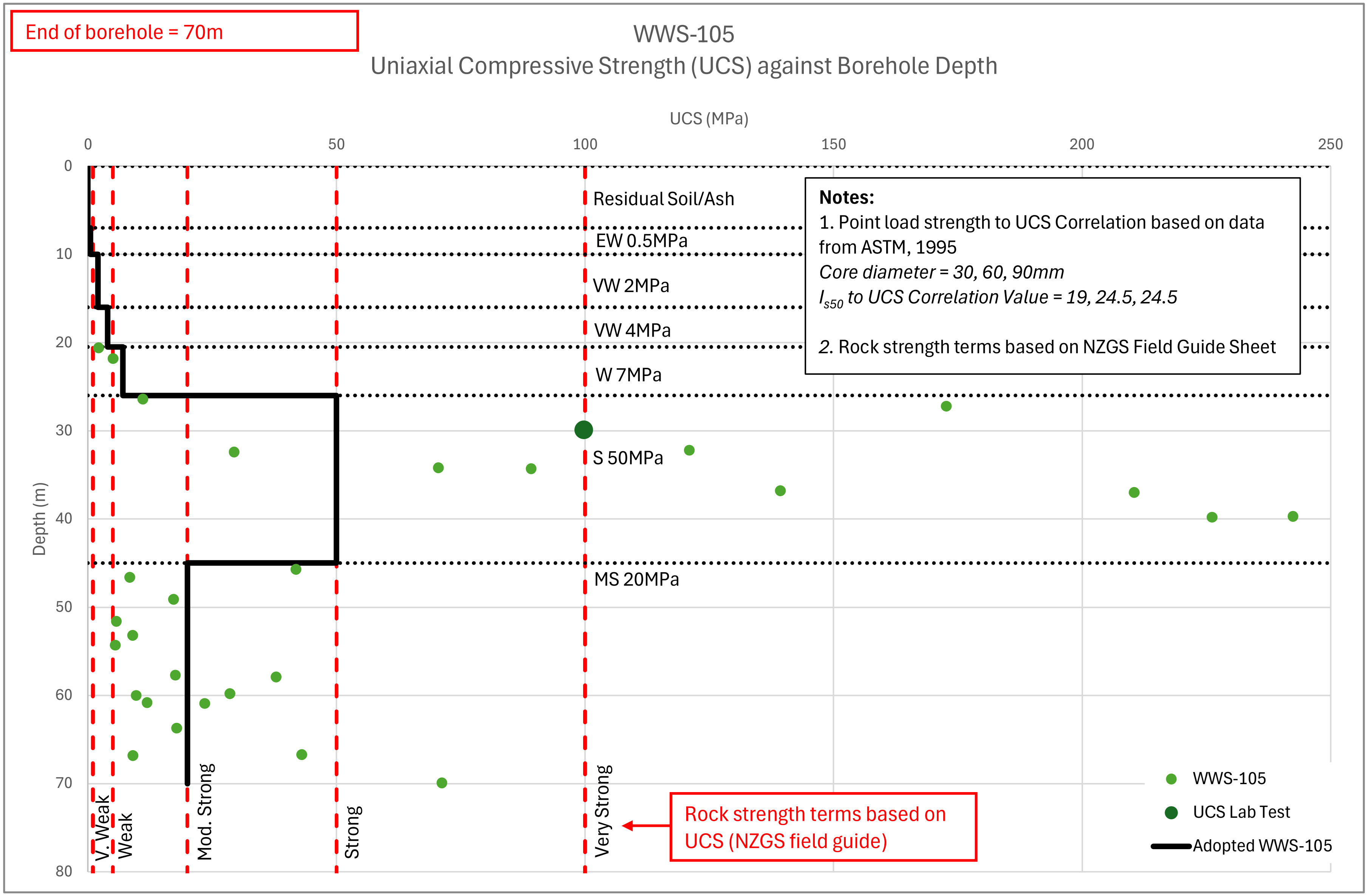


FIGURE B9: WWS-105 - UCS AGAINST BOREHOLE DEPTH

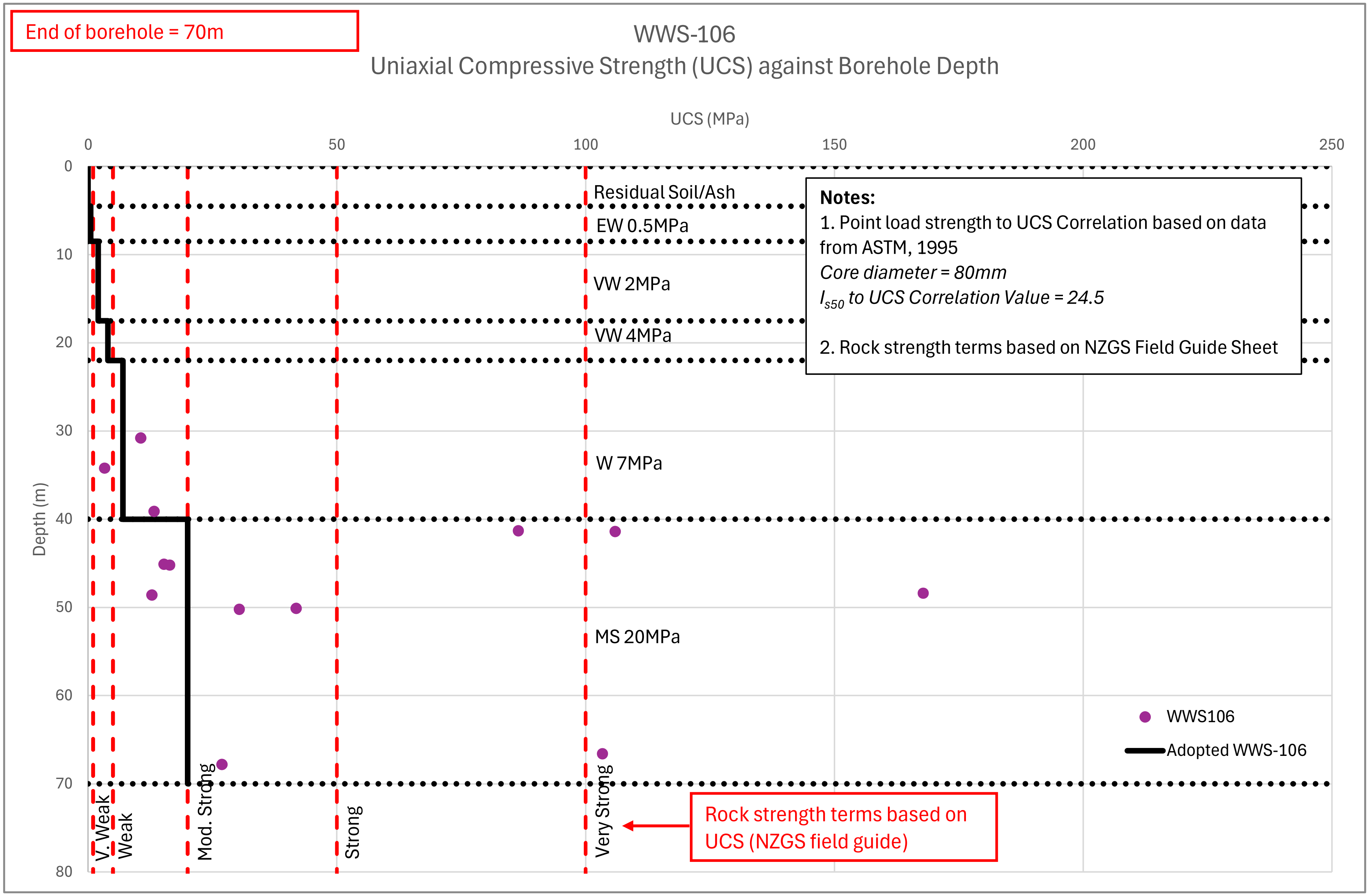


FIGURE B10: WWS-106 - UCS AGAINST BOREHOLE DEPTH

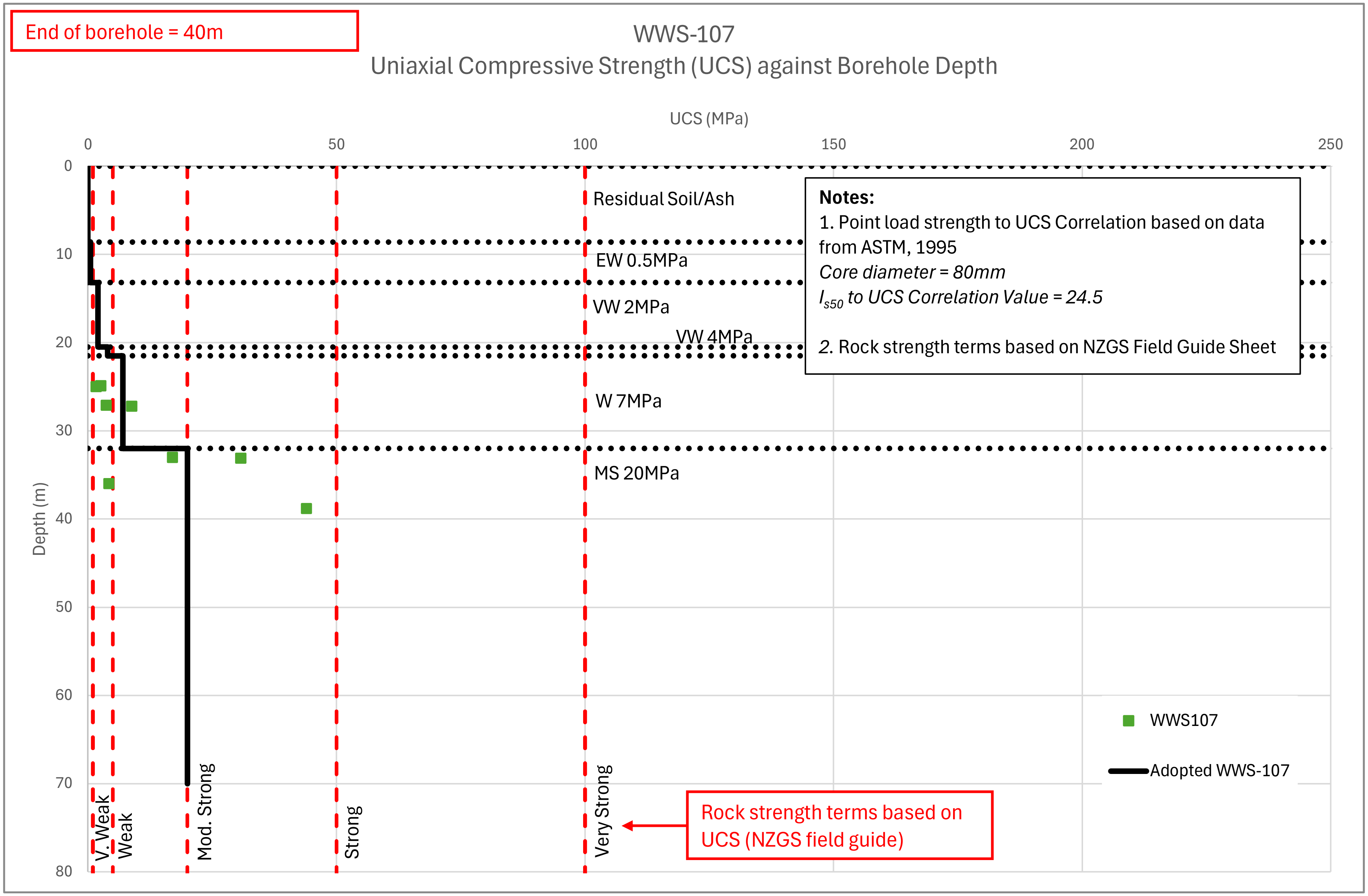


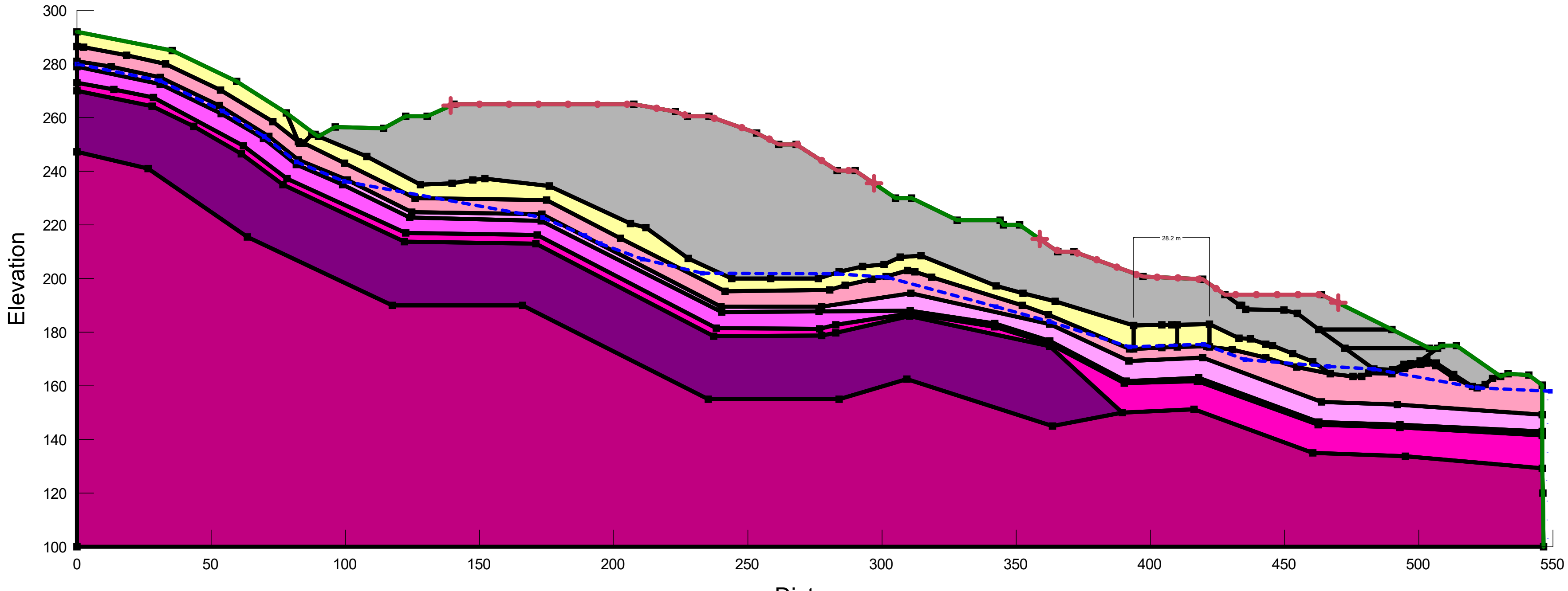
FIGURE B11: WWS-107 - UCS AGAINST BOREHOLE DEPTH

Section 2 - Stability Model Figures Showing
Geometry and Material Only

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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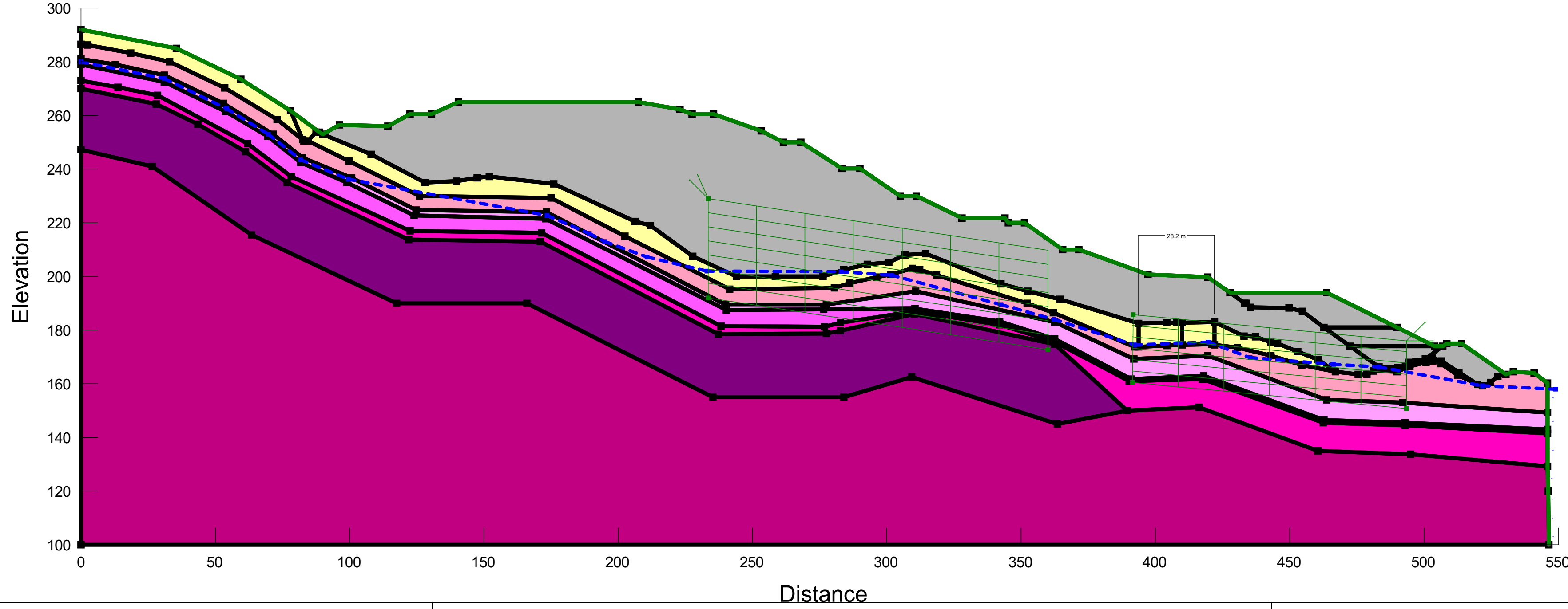
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B20 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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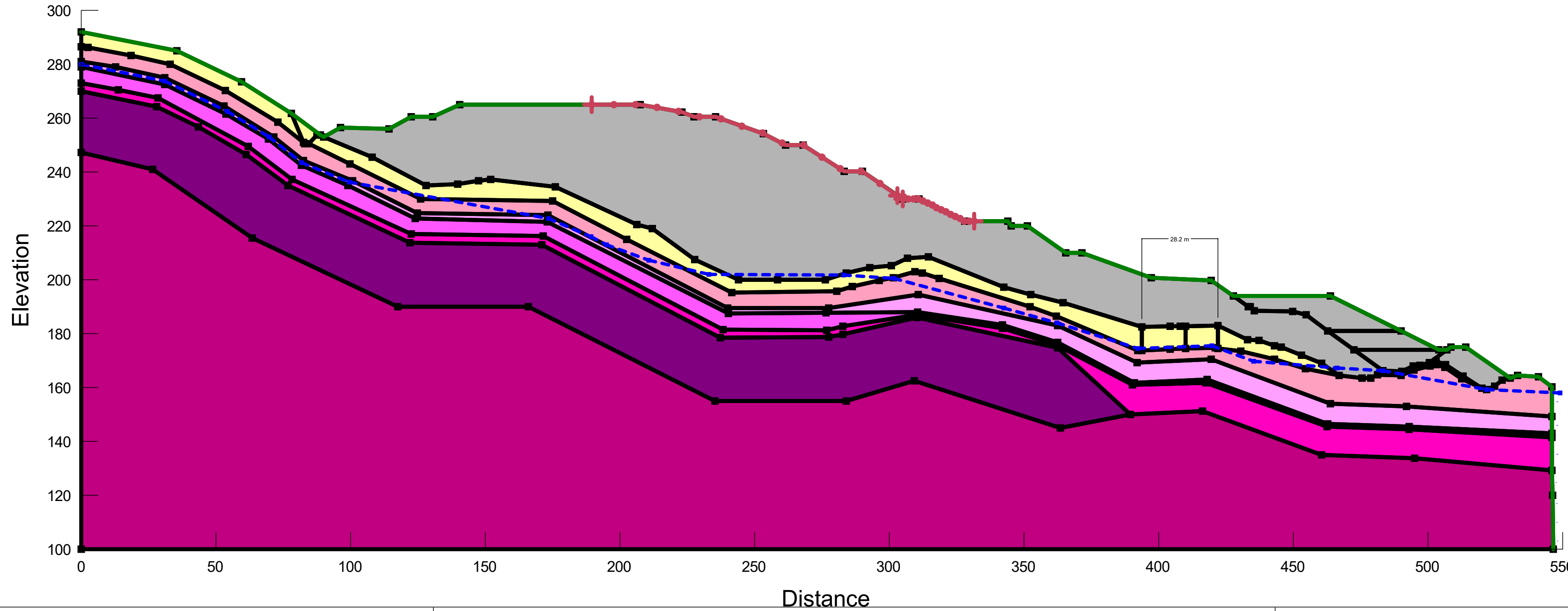
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B21 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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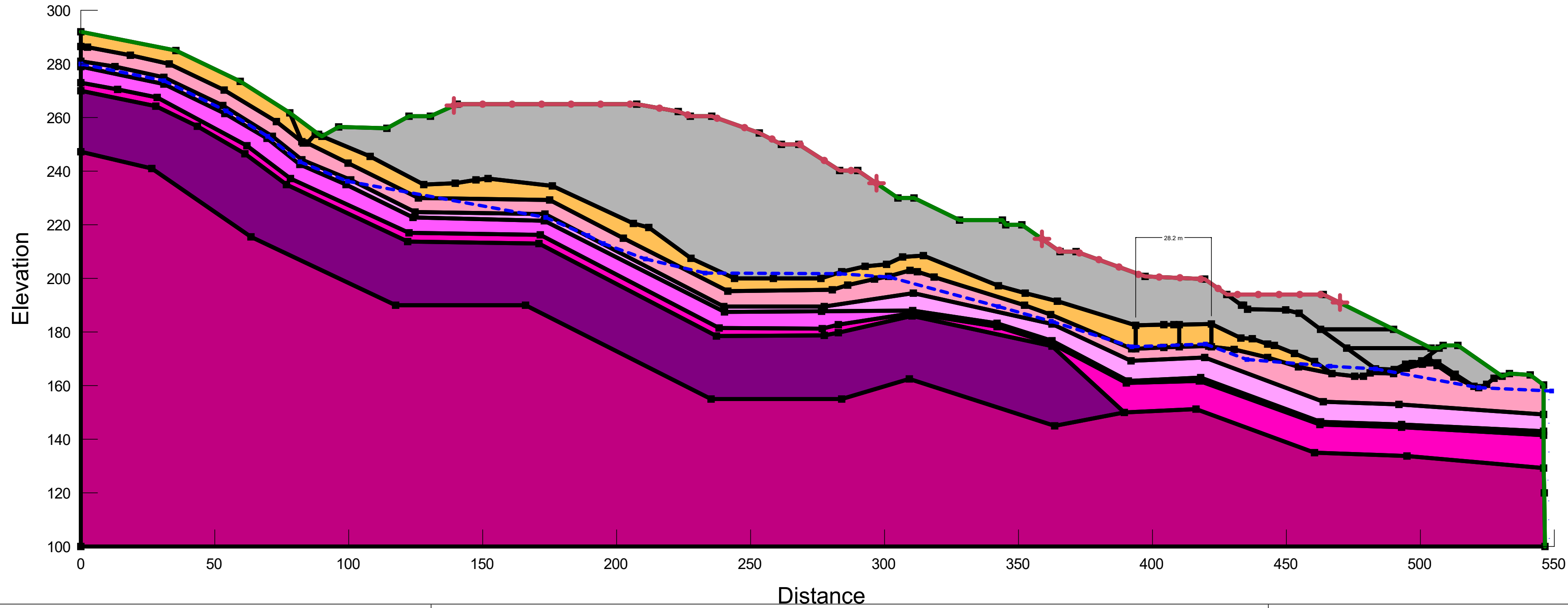
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B22 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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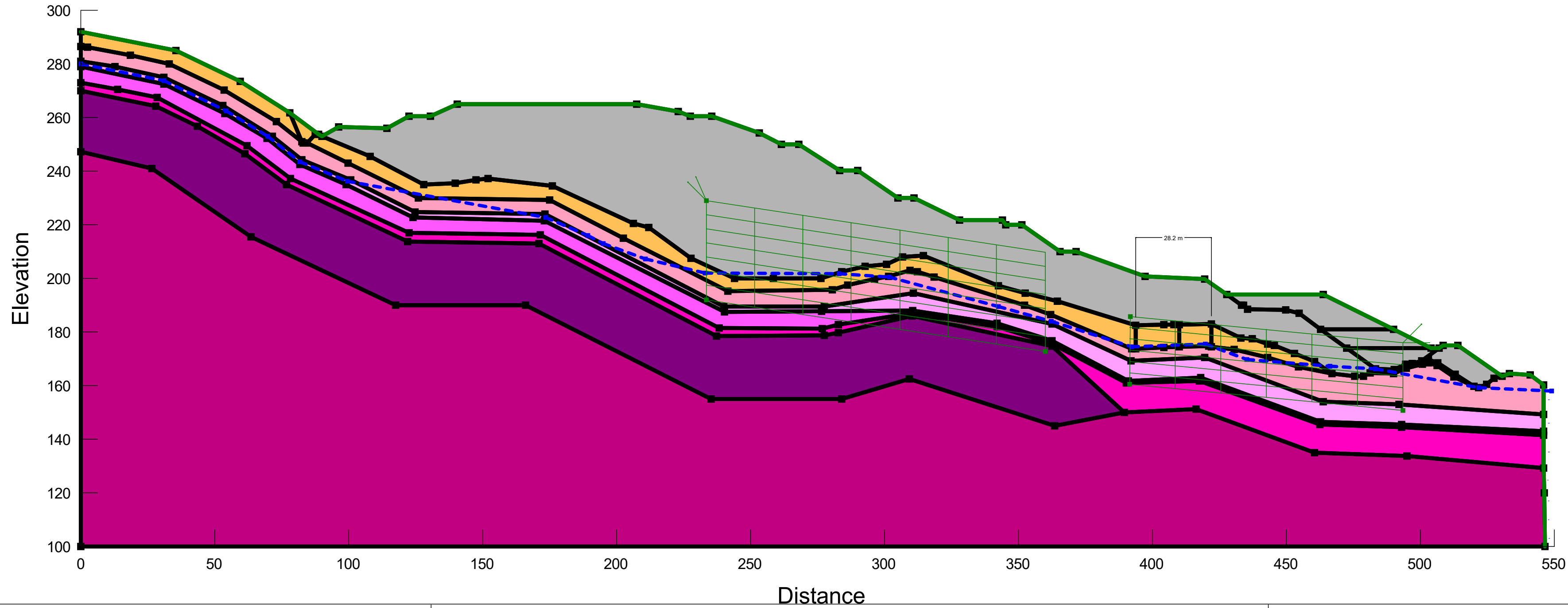
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B23 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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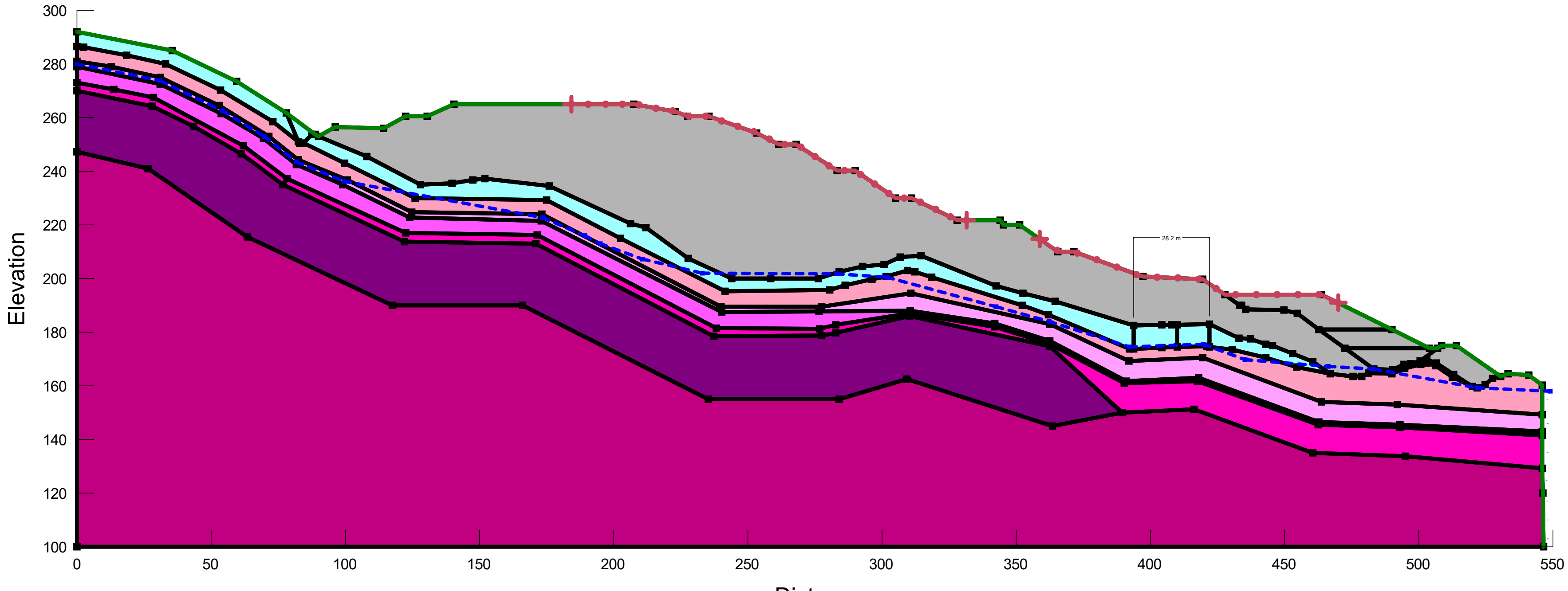
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B24 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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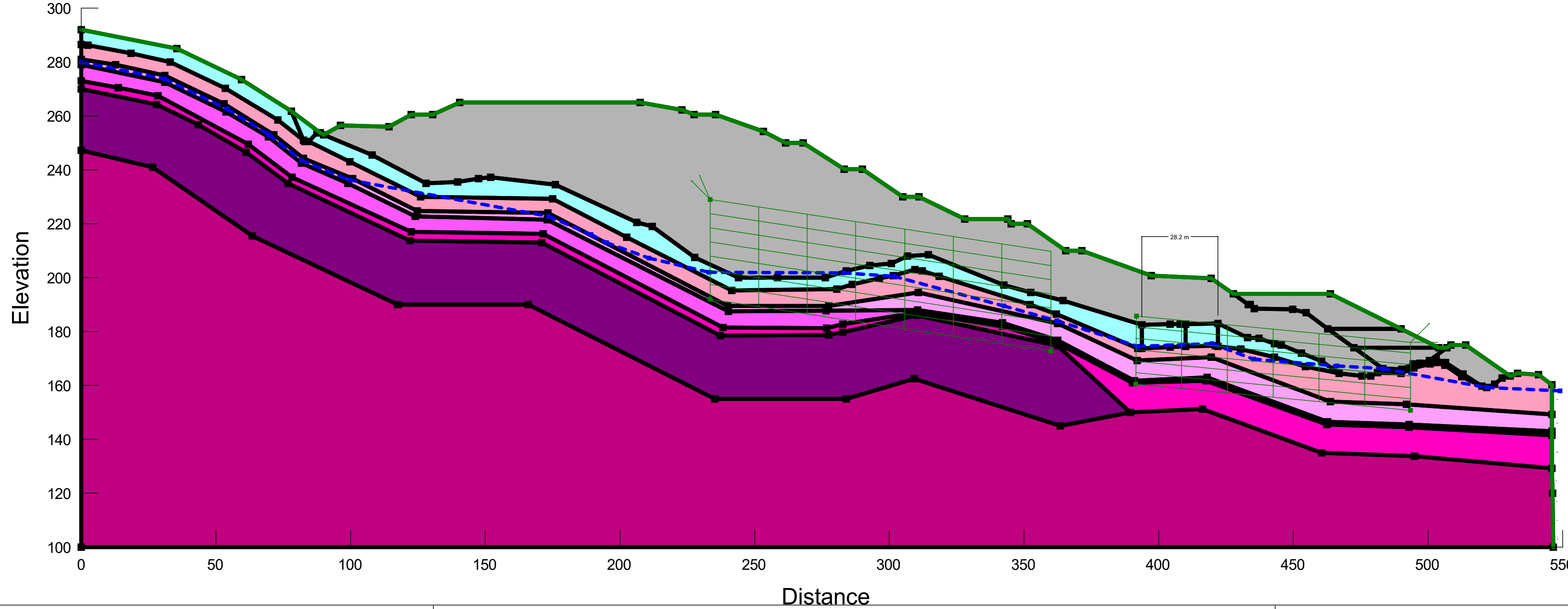
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B25 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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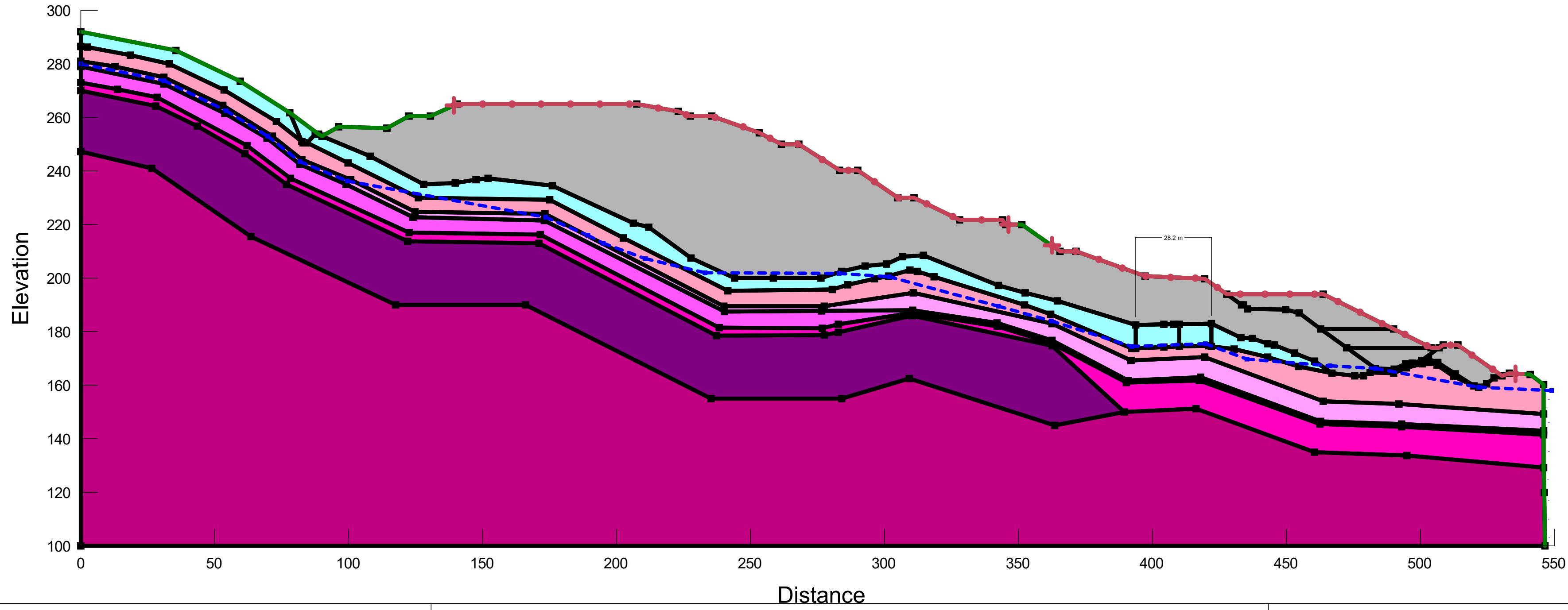
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B26 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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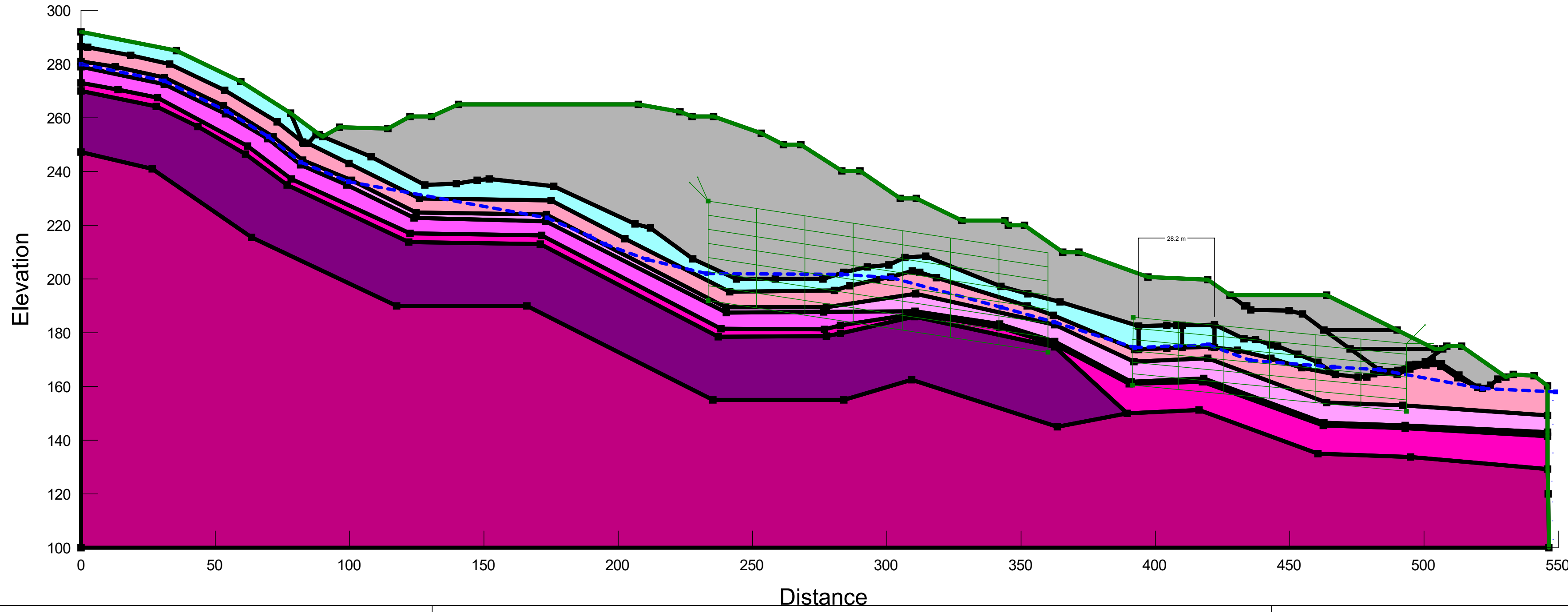
Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B27 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.09

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

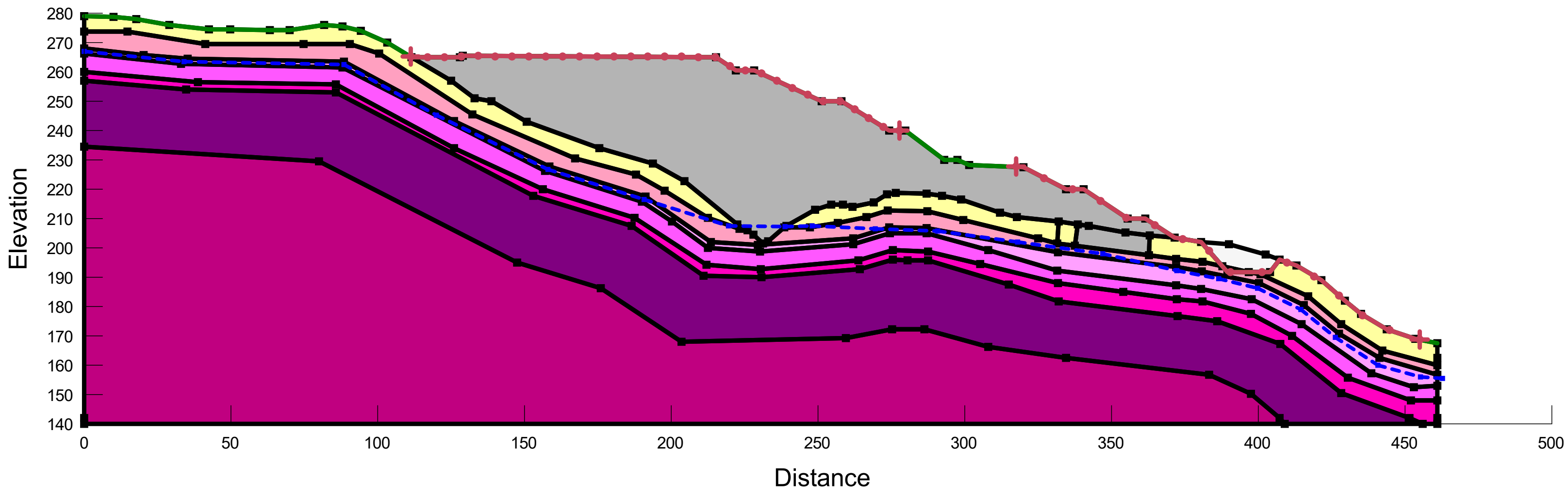
Date: 20/12/2024
Ref: 9169
Figure: B28 EQ_ky_Block
Scale: 1:2,500
Drawn: NT

Section 3 - Stability Model Figures Showing
Geometry and Material Only

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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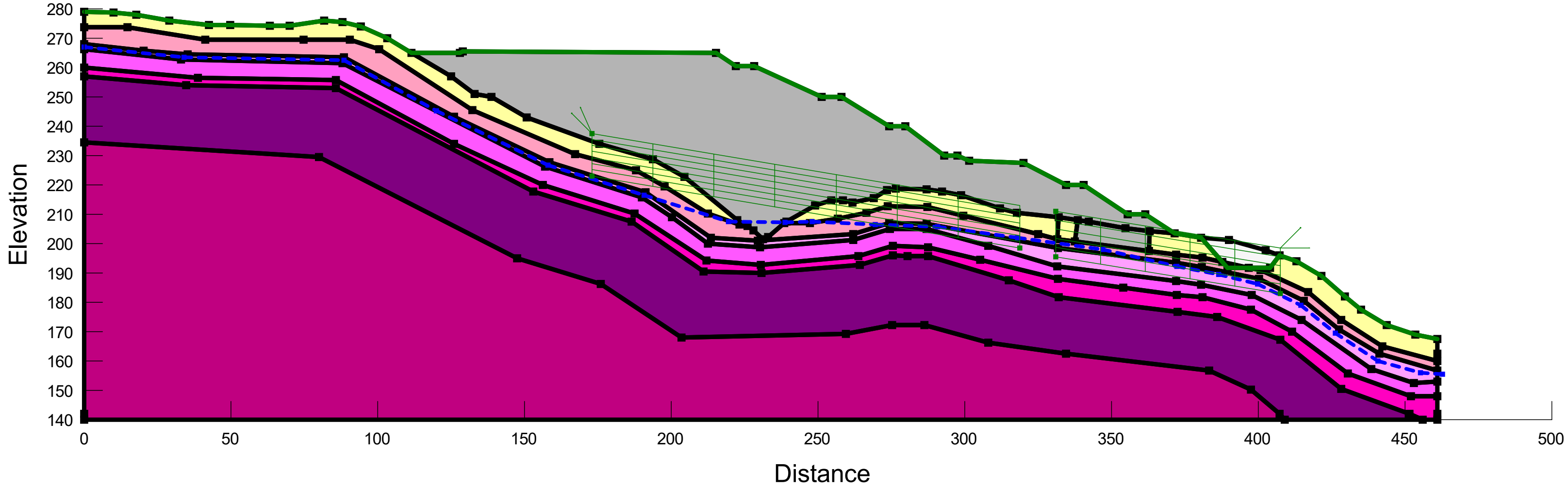
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B29 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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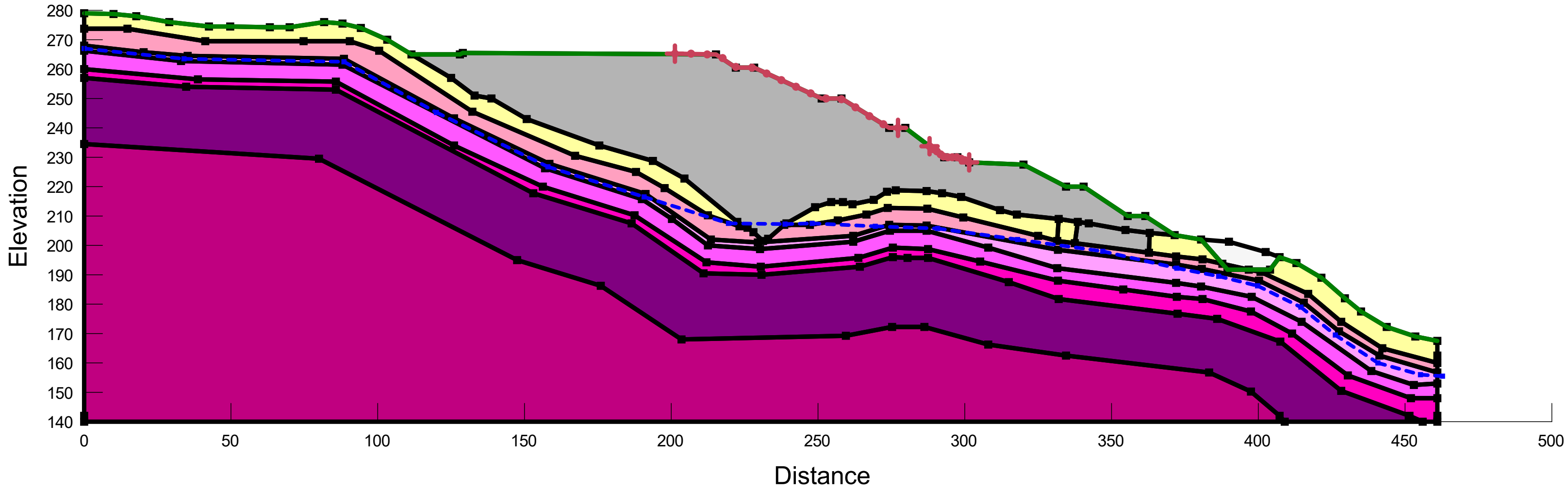
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B30 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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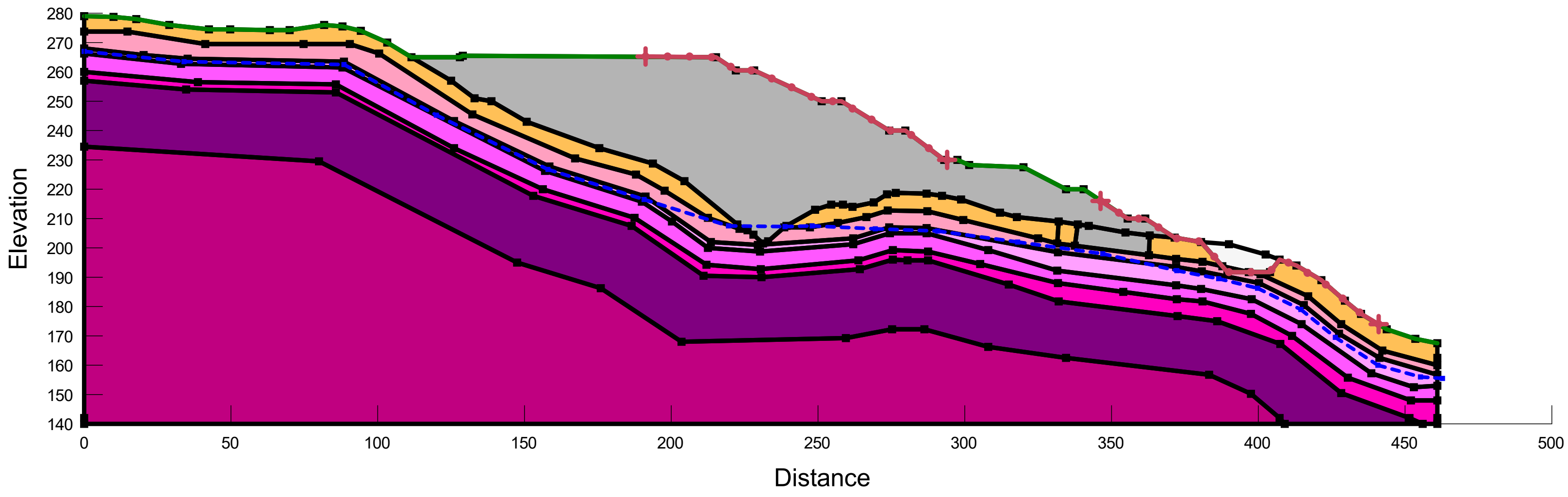
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B31 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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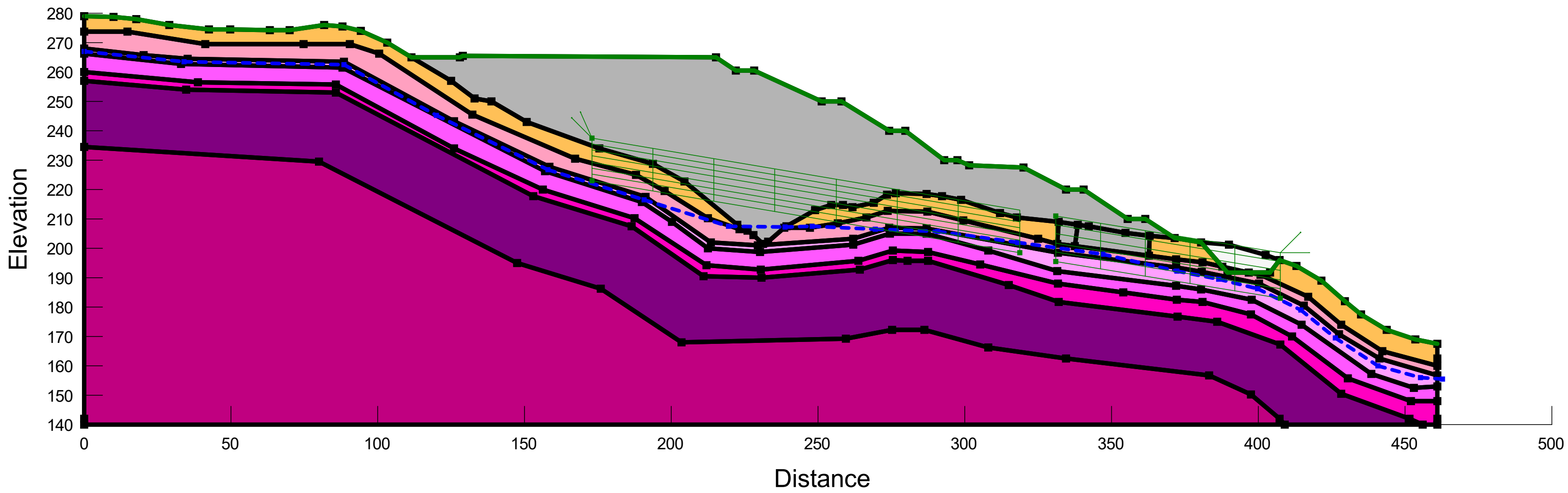
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B32 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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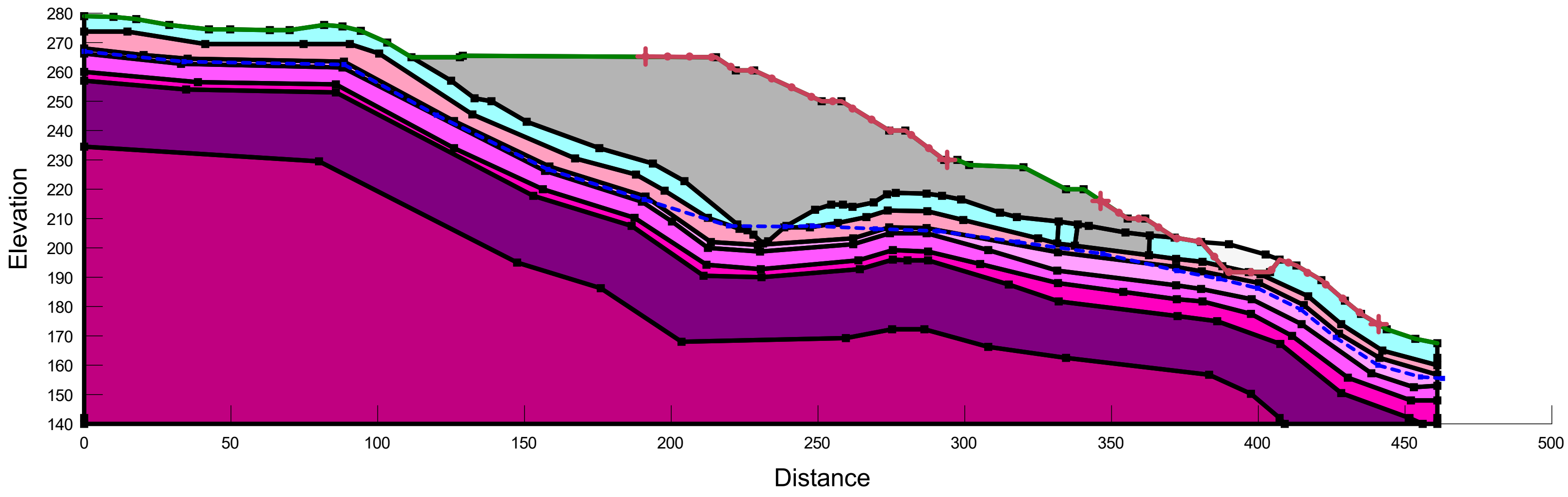
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B33 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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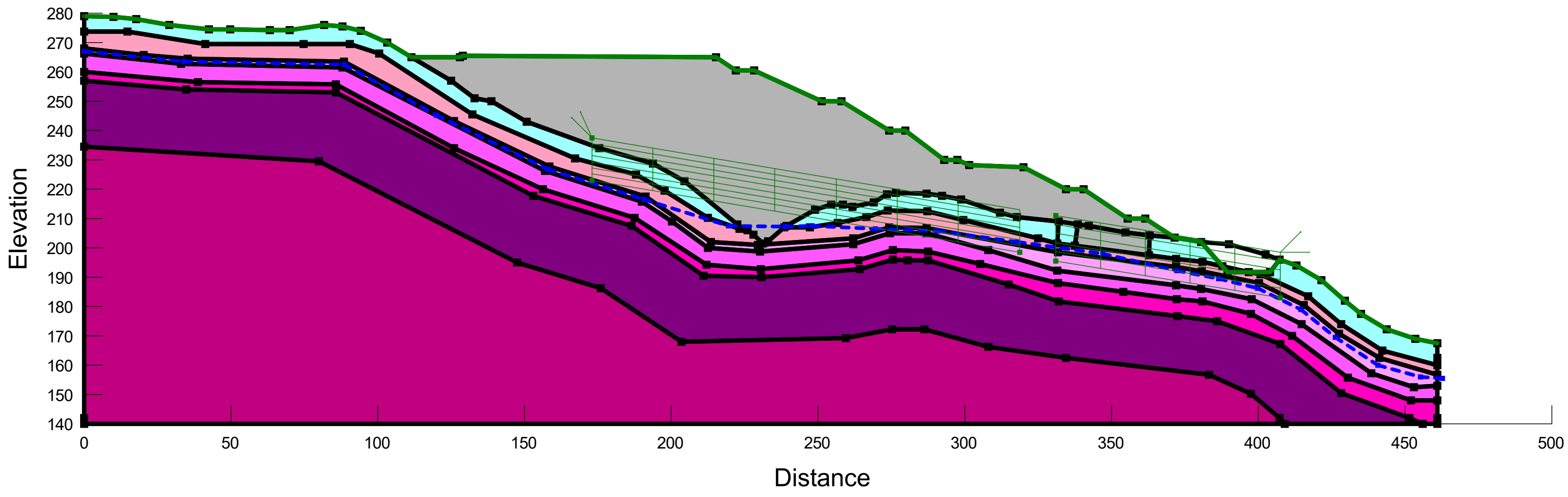
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B34 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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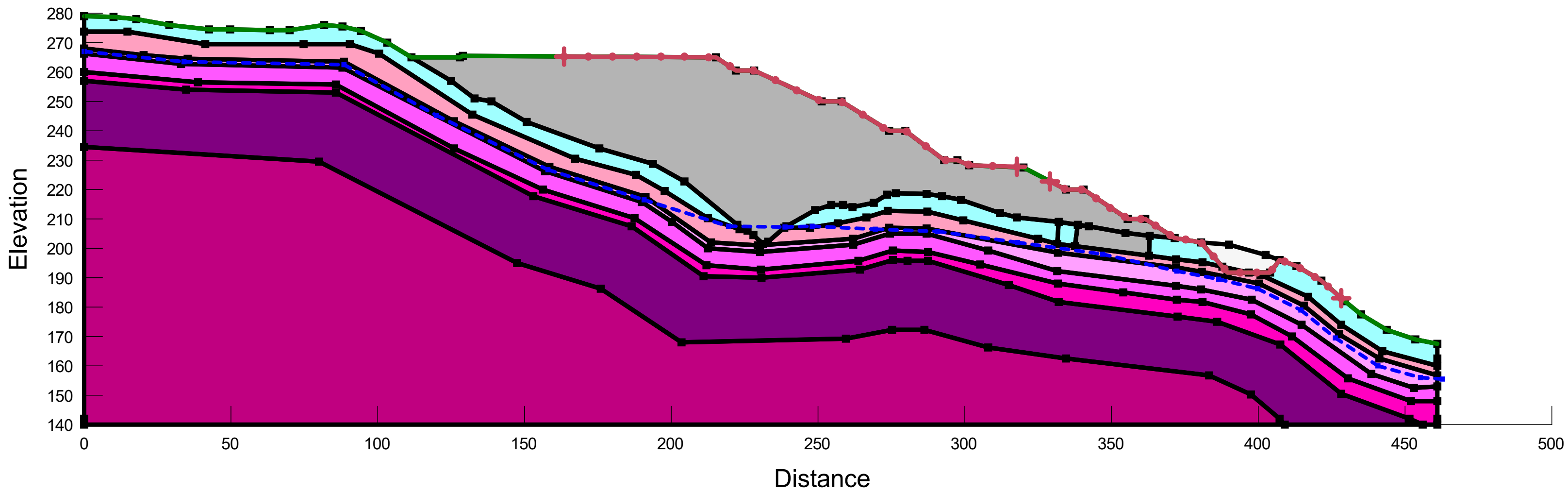
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B35 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.15

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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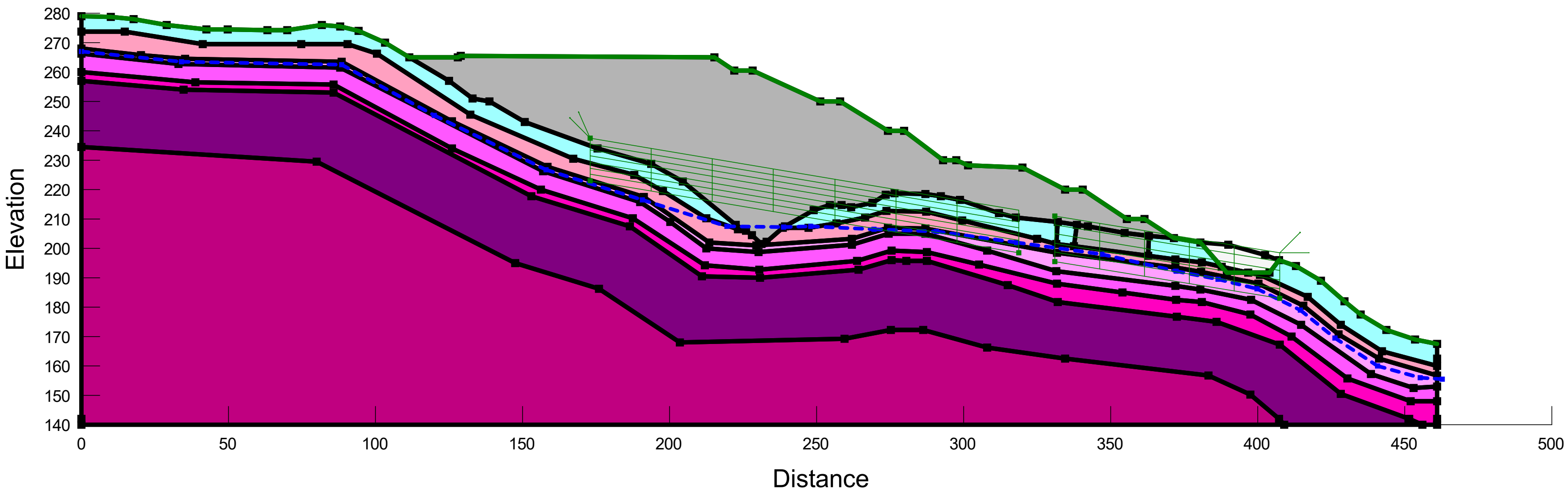
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B36 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.06

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

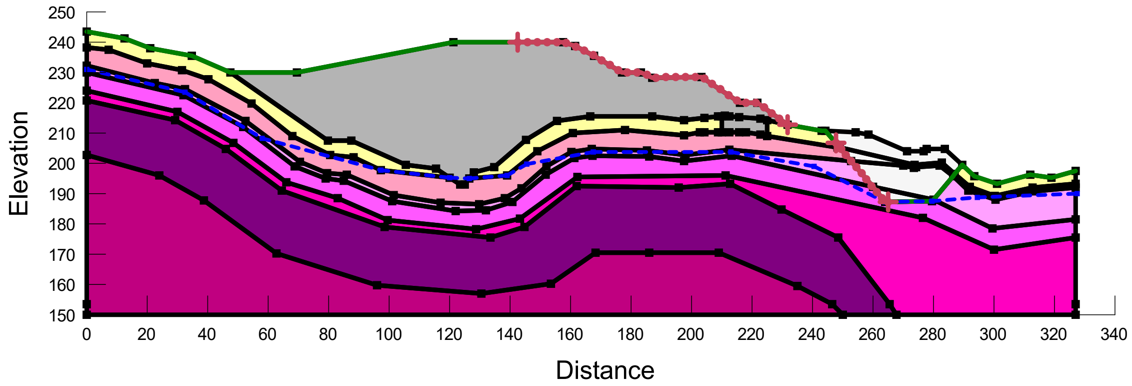
Date: 20/12/2024
Ref: 9169
Figure: B37 EQ_ky_Block
Scale: 1:2,500
Drawn: NT

Section 4 - Stability Model Figures Showing Geometry and Material Only

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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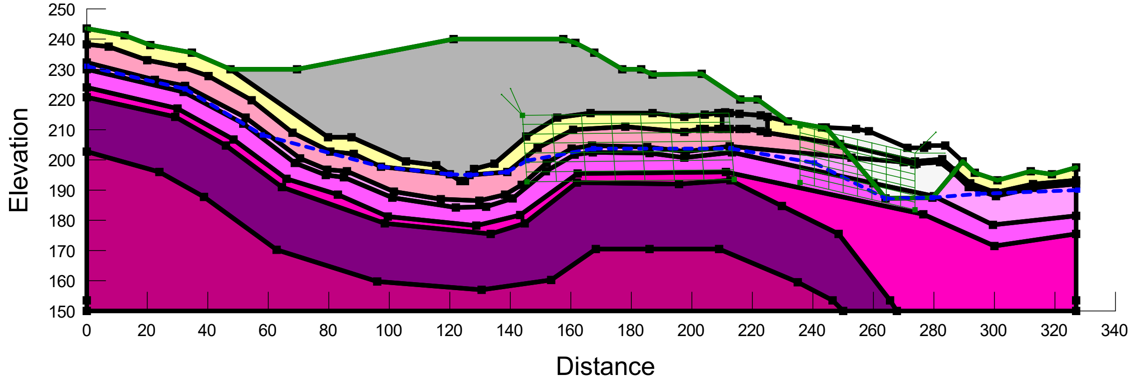
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B38 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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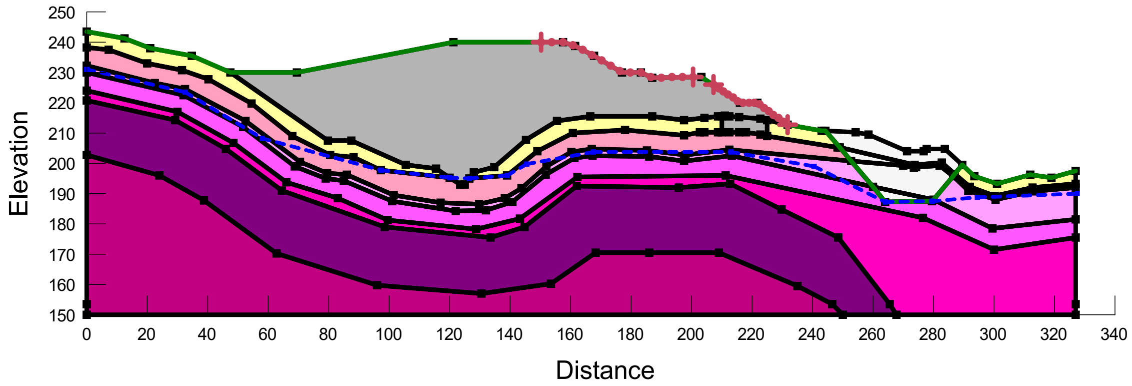
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B39 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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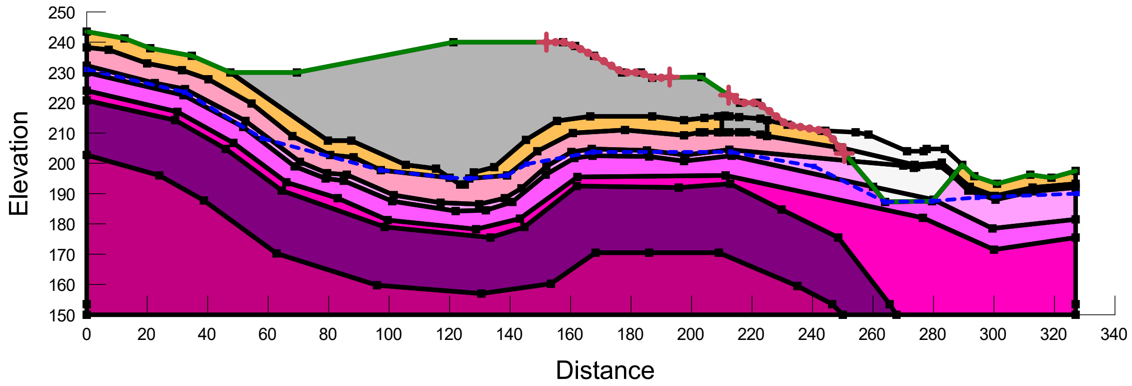
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B40 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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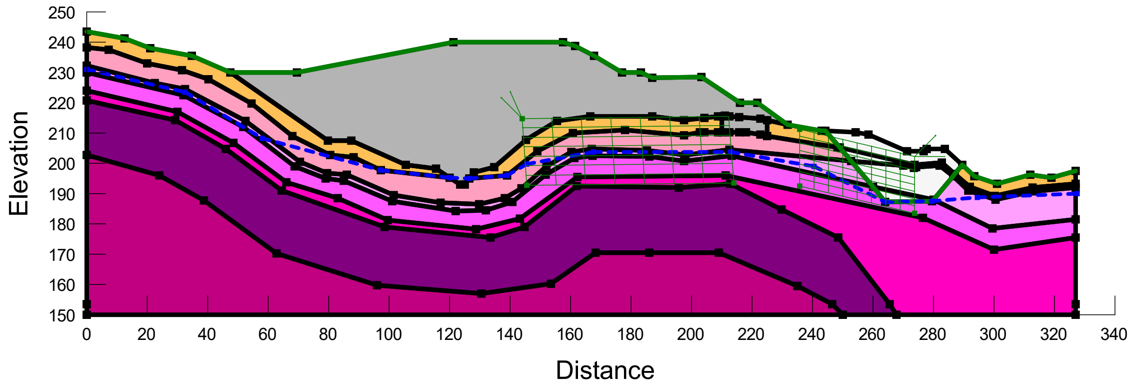
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B41 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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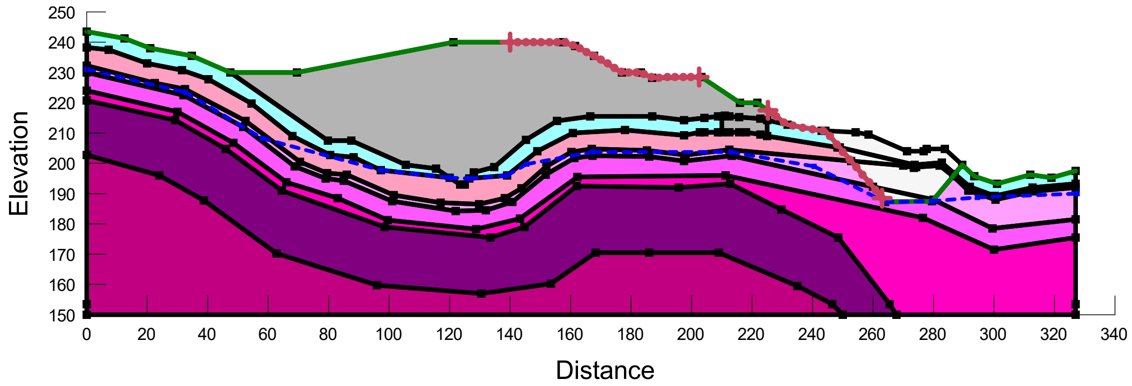
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B42 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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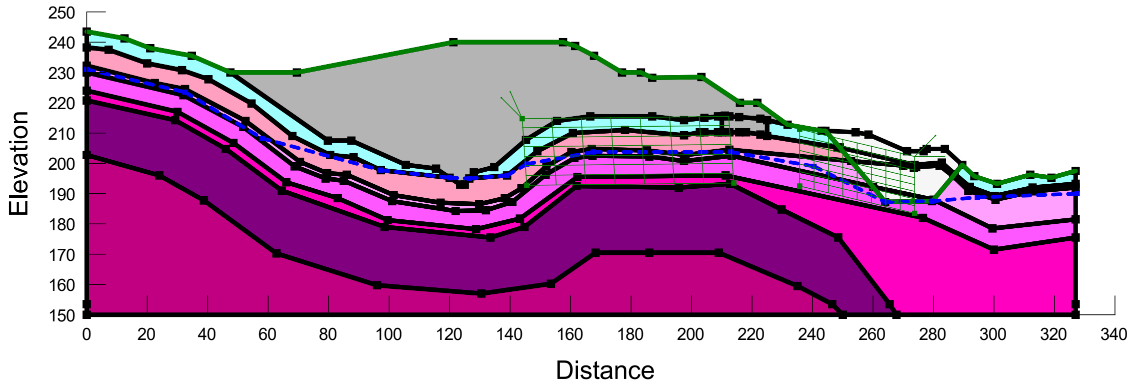
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B43 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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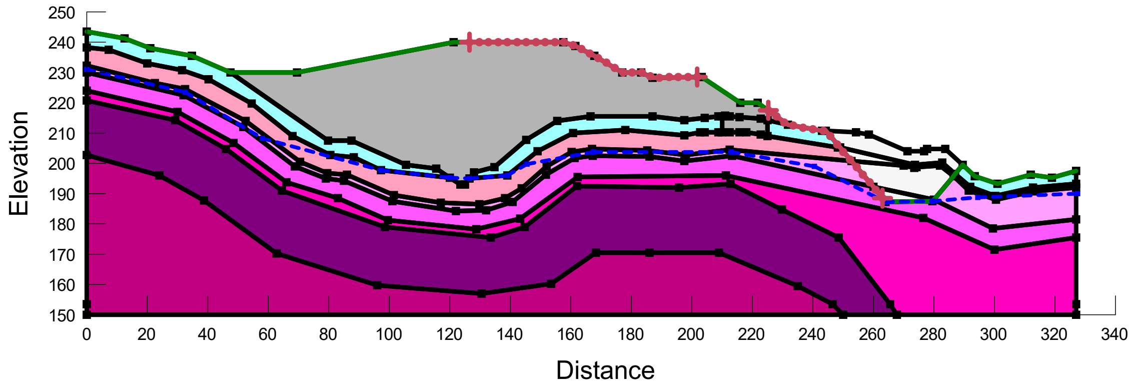
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B44 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.09

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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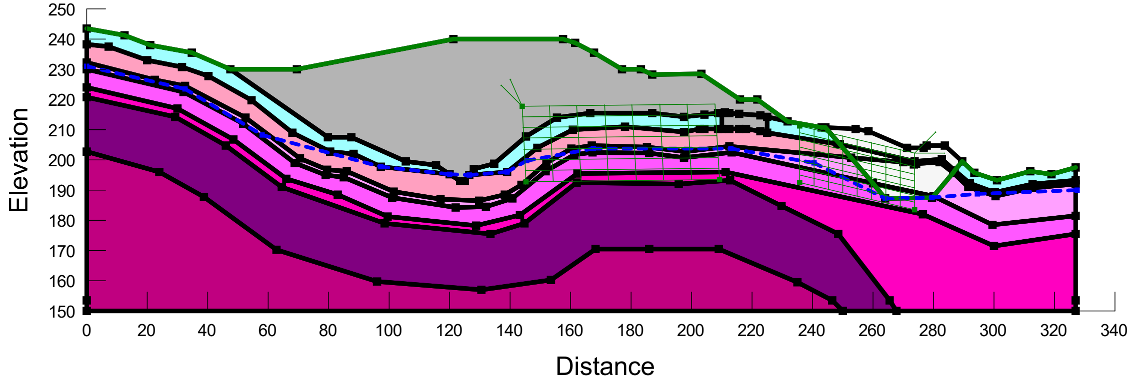
Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B45 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.13

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B46 EQ_ky_Block
Scale: 1:2,500
Drawn: NT

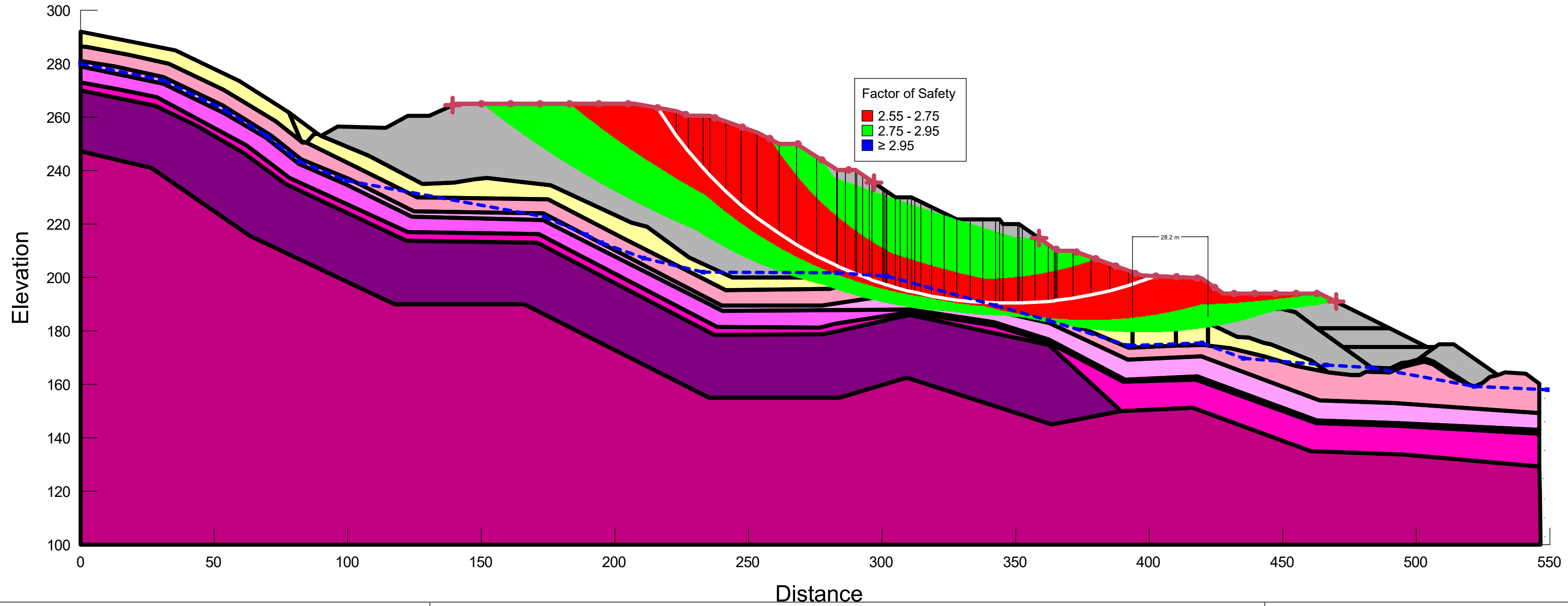
Section 2 - Stability Model Figures Showing Results

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.55

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B20 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

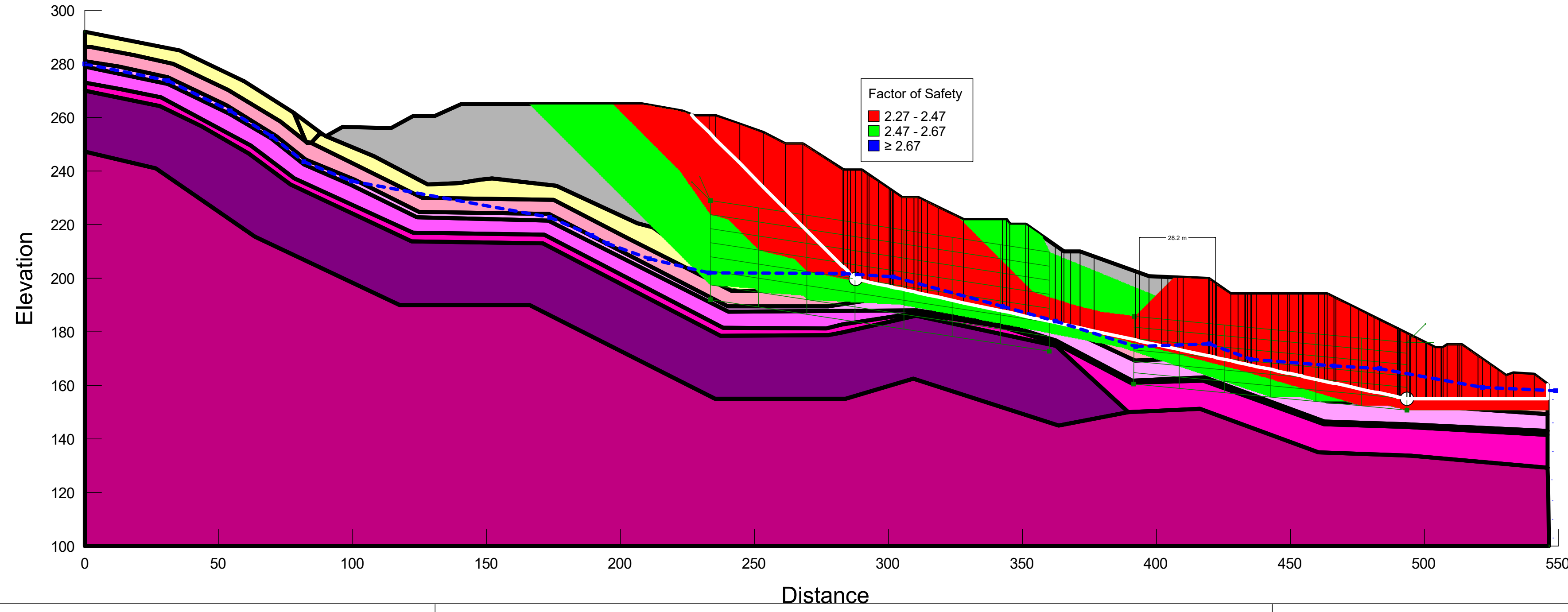
Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.27

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No

2.27



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Willows WRS Stability Analyses - Section 02

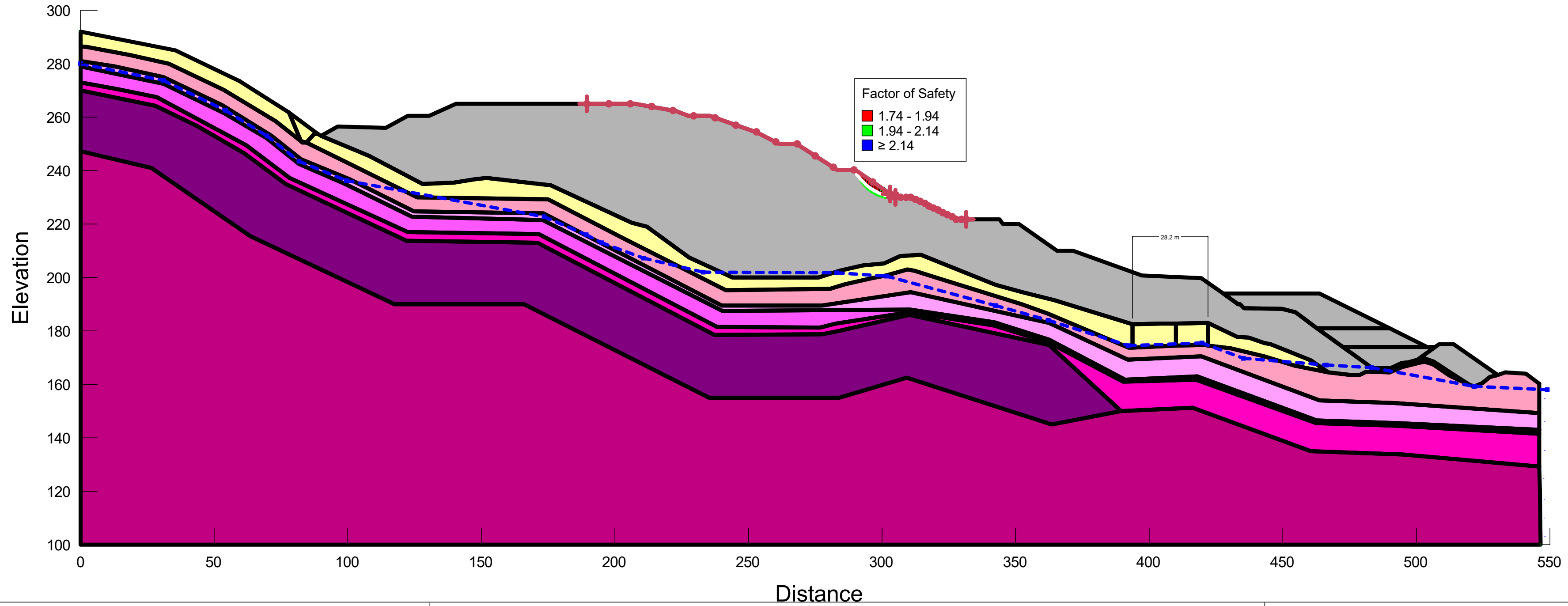
Date: 20/12/2024
Ref: 9169
Figure: B21 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.74

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

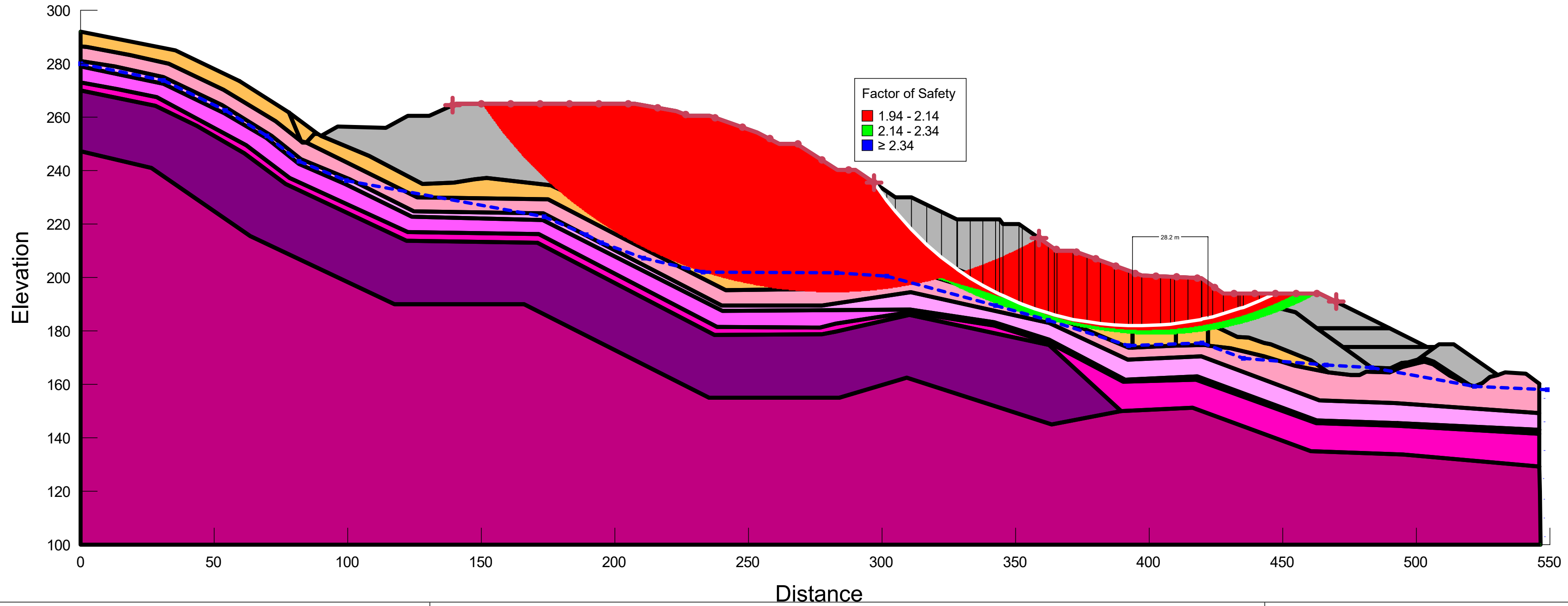
Date: 20/12/2024
Ref: 9169
Figure: B22 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.94

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

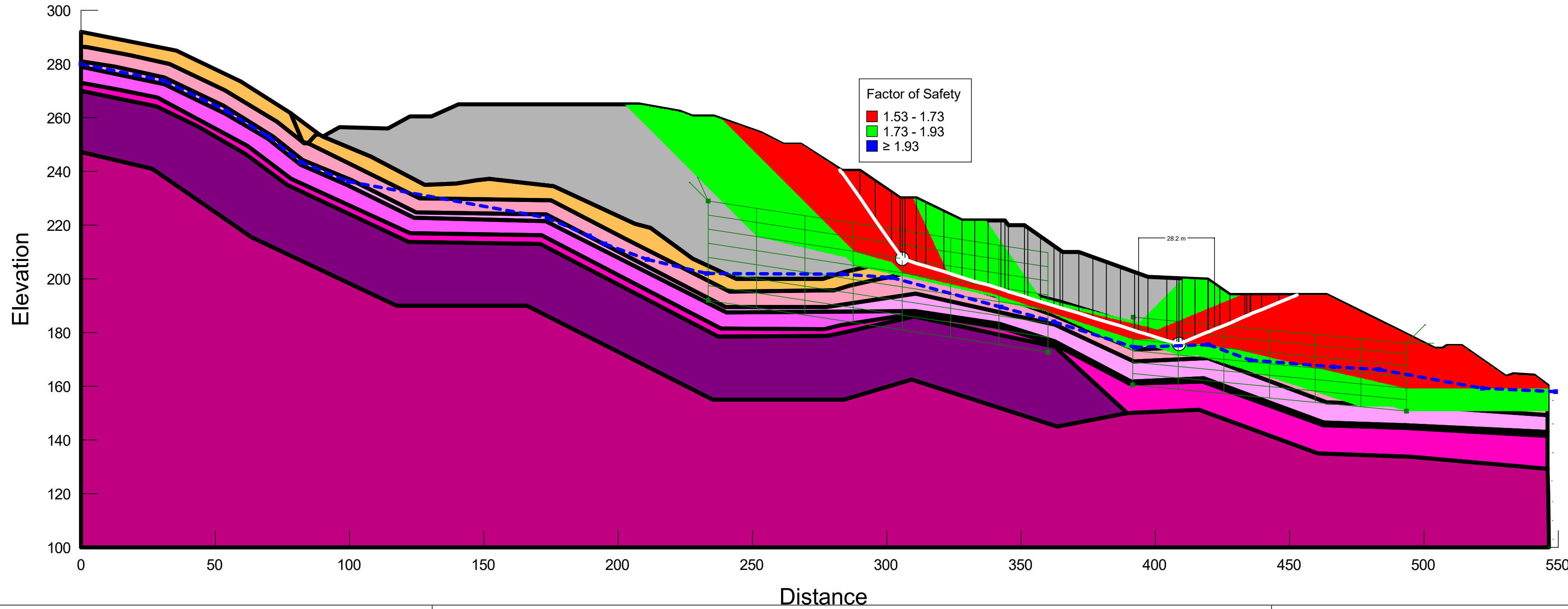
Date: 20/12/2024
Ref: 9169
Figure: B23 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.53

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

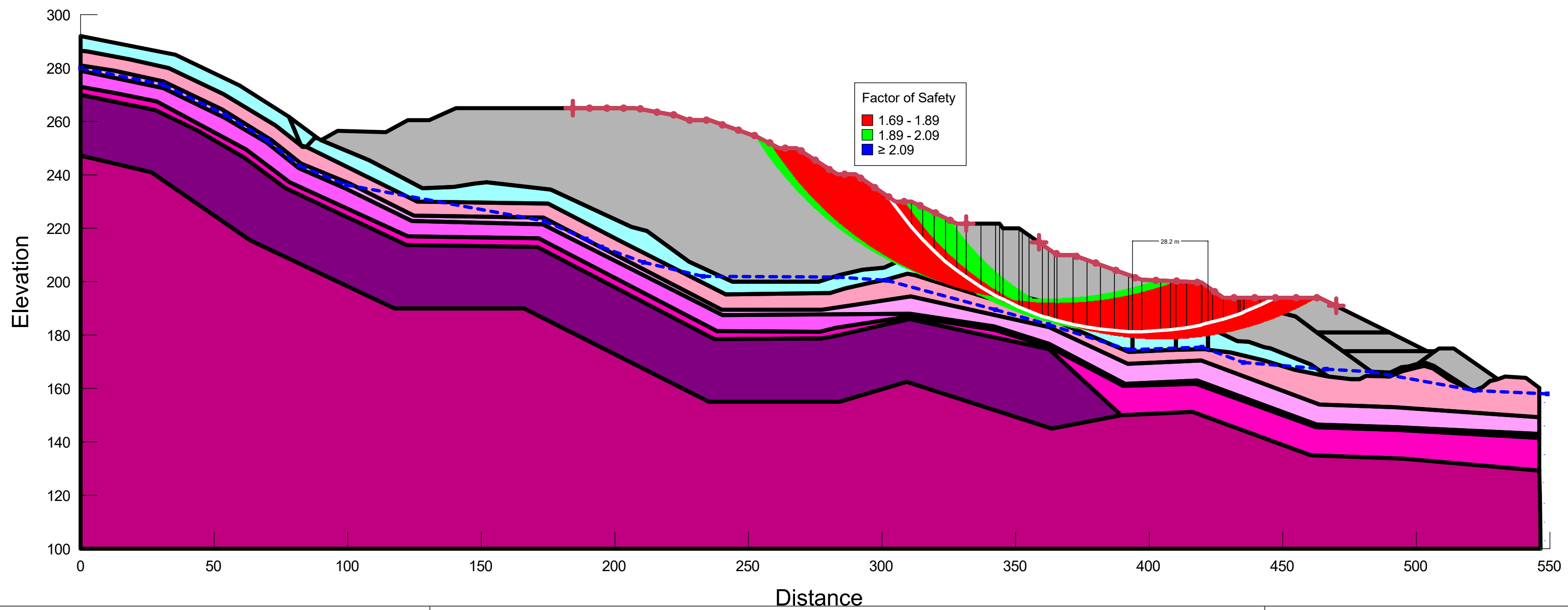
Date: 20/12/2024
Ref: 9169
Figure: B24 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.69

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

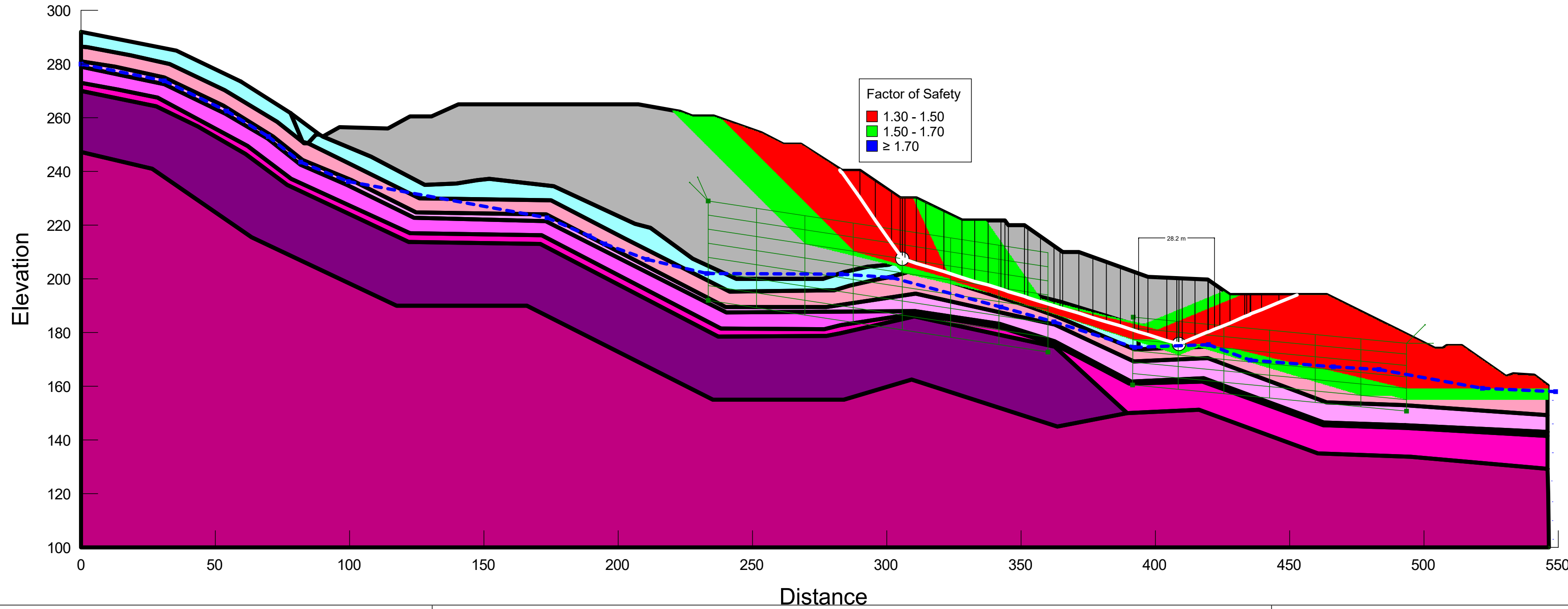
Date: 20/12/2024
Ref: 9169
Figure: B25 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.30

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

Date: 20/12/2024
Ref: 9169
Figure: B26 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Section 3 - Stability Model Figures Showing Results

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.2

Factor of Safety: 0.99

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No

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Willows WRS Stability Analyses - Section 02

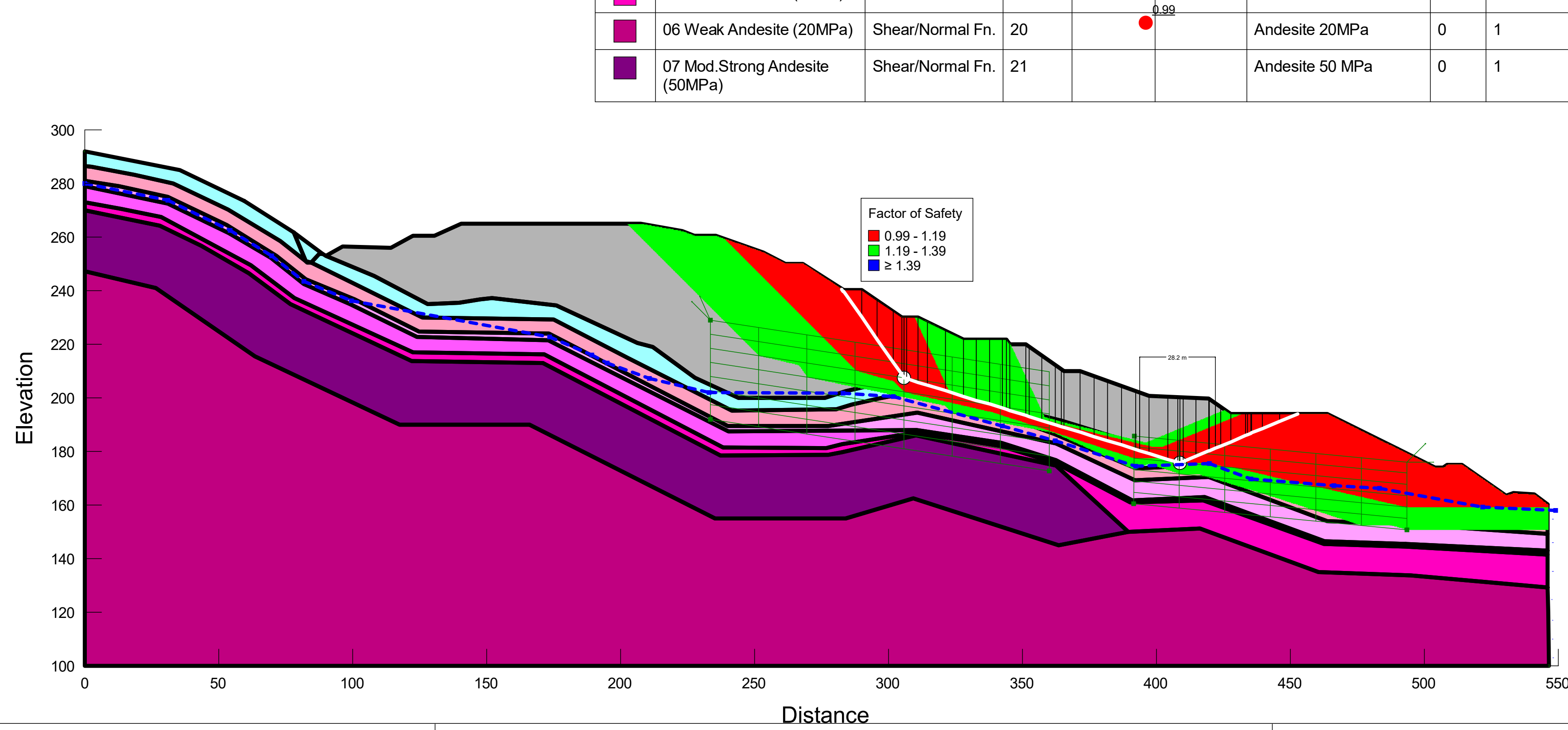
Date: 20/12/2024
Ref: 9169
Figure: B27 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.09

Factor of Safety: 0.99

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 02

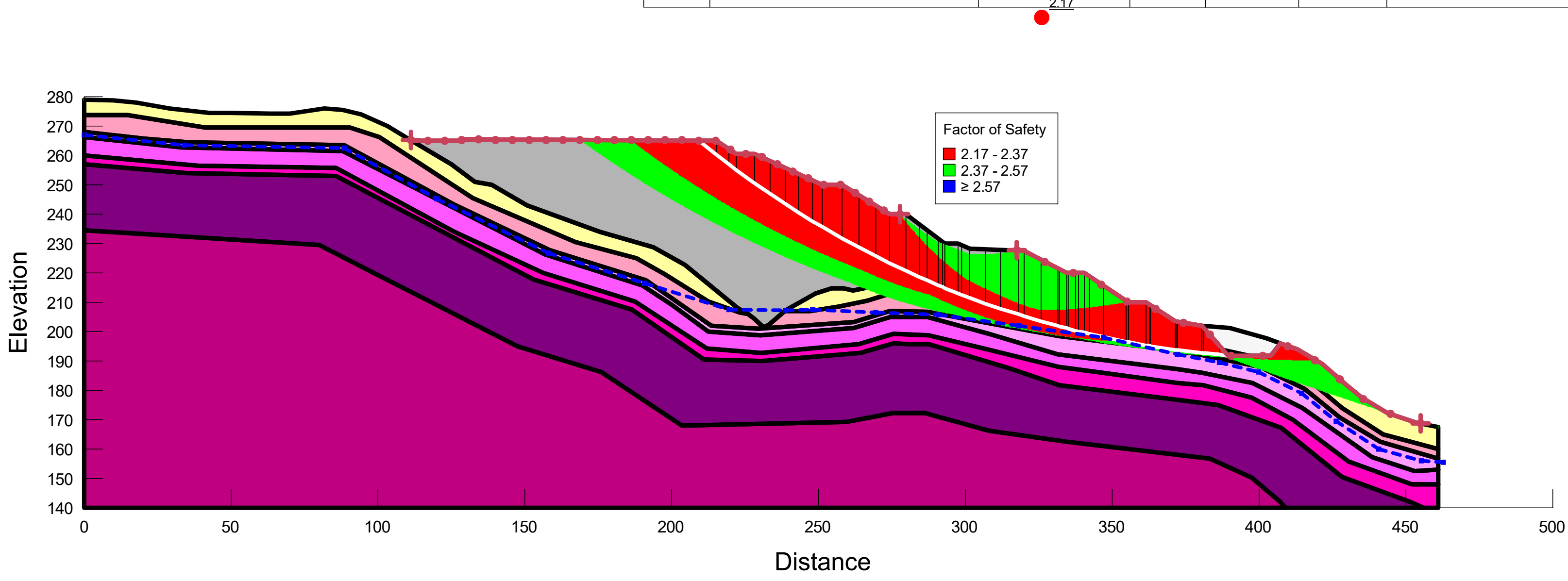
Date: 20/12/2024
Ref: 9169
Figure: B28 EQ_ky_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.17

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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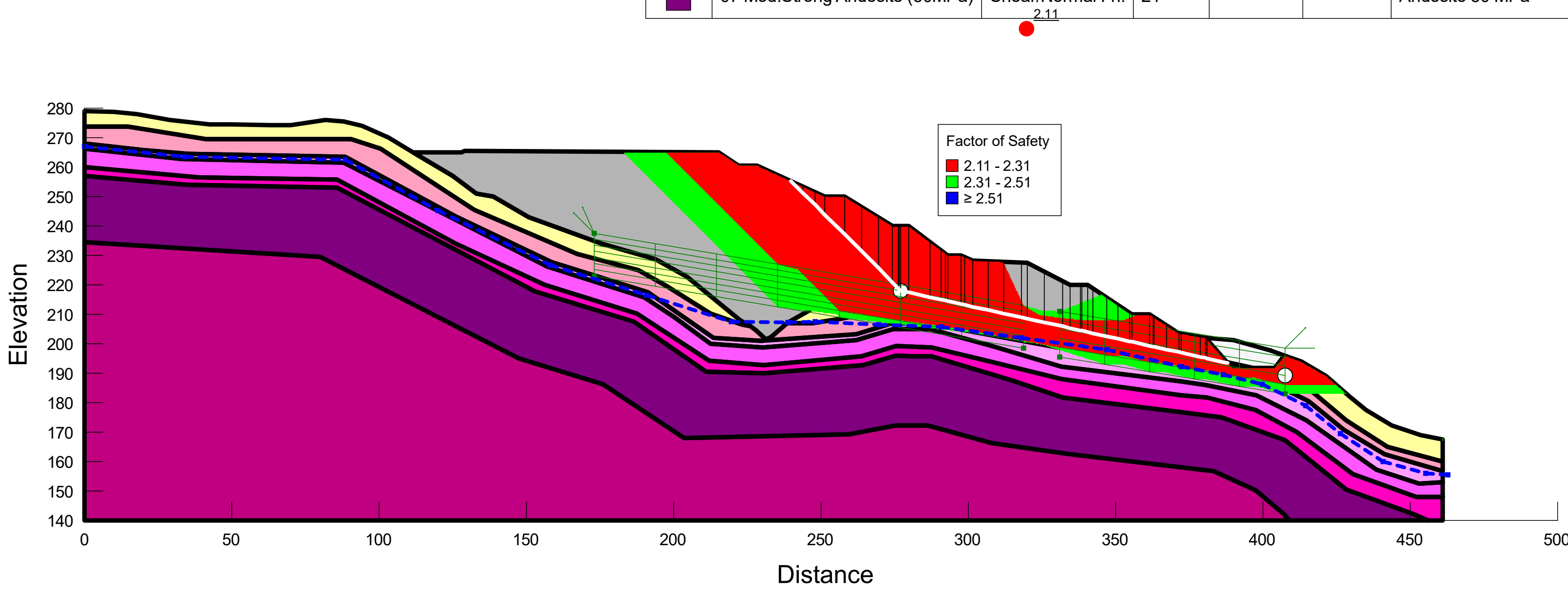
Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B29 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters
Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.11

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

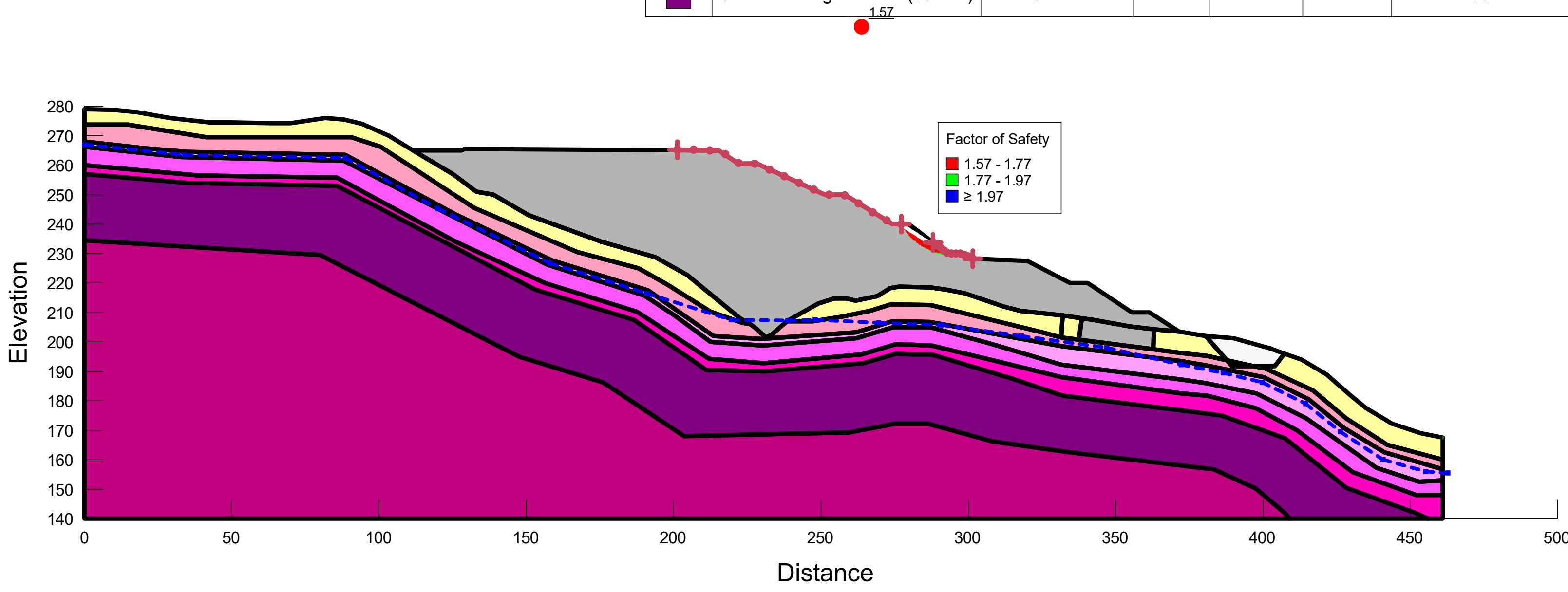
Date: 20/12/2024
Ref: 9169
Figure: B30 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.57

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

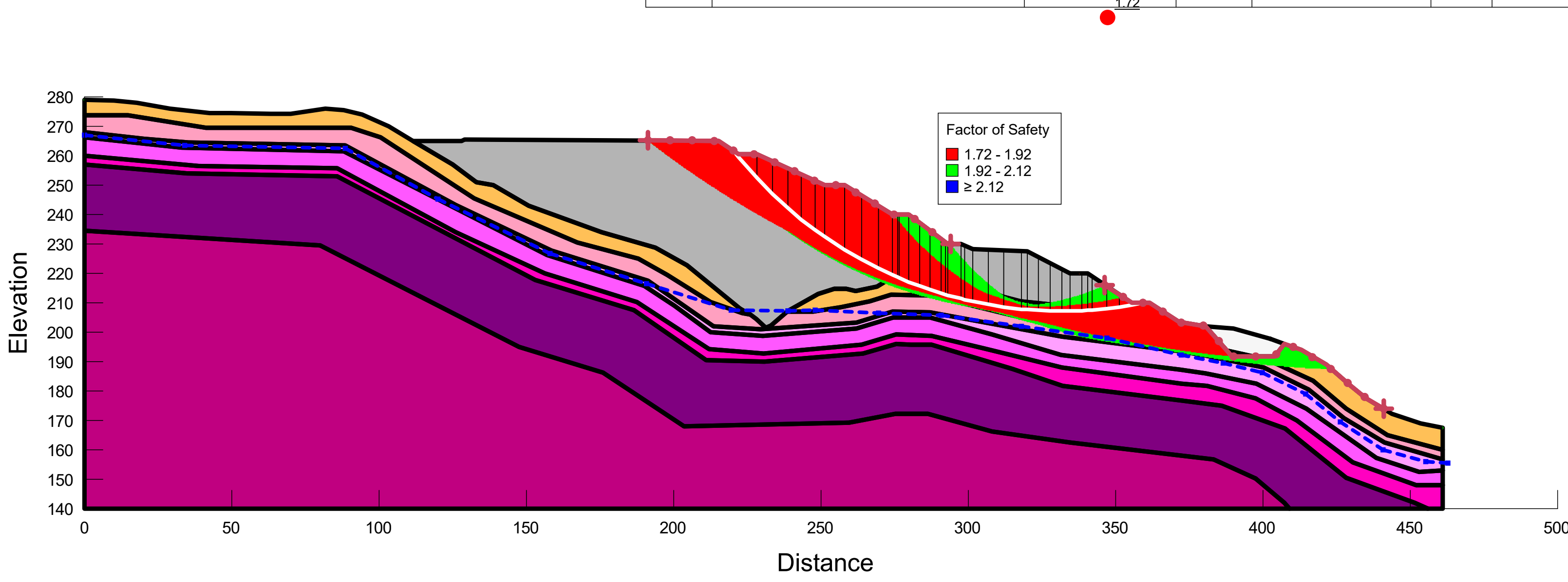
Date: 20/12/2024
Ref: 9169
Figure: B31 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.72

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

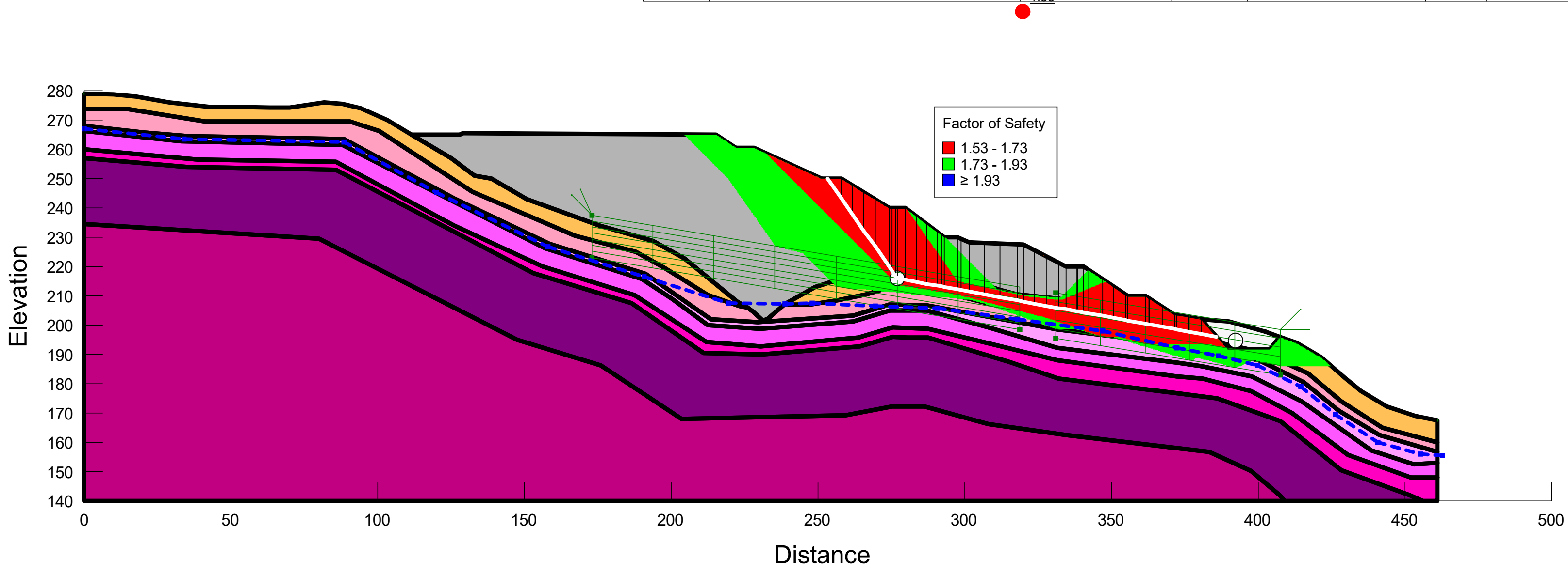
Date: 20/12/2024
Ref: 9169
Figure: B32 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.53

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

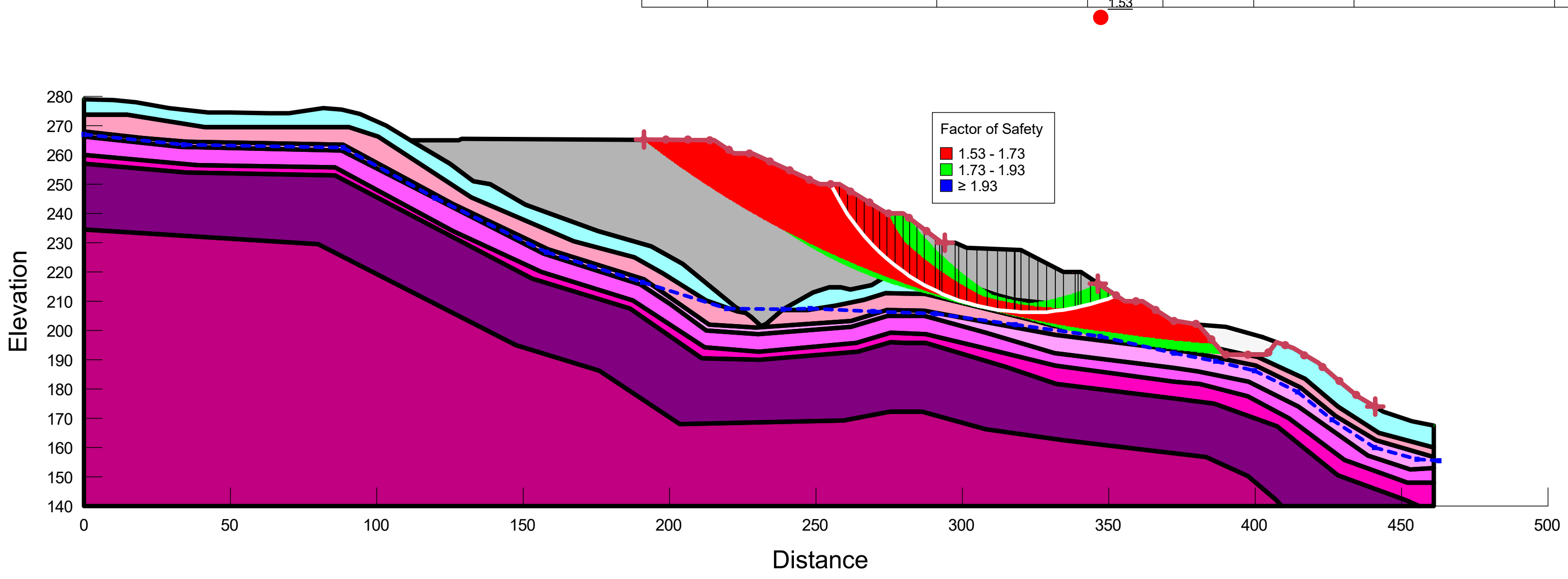
Date: 20/12/2024
Ref: 9169
Figure: B33 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.53

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

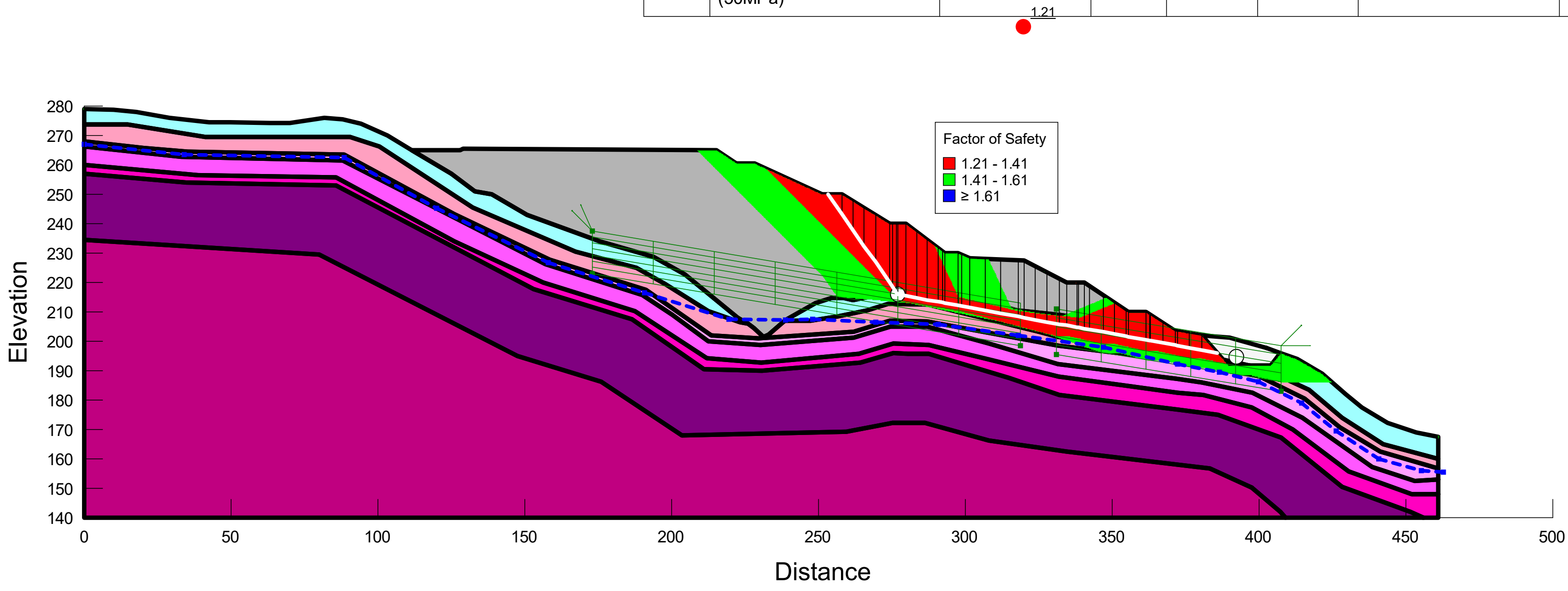
Date: 20/12/2024
Ref: 9169
Figure: B34 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.21

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

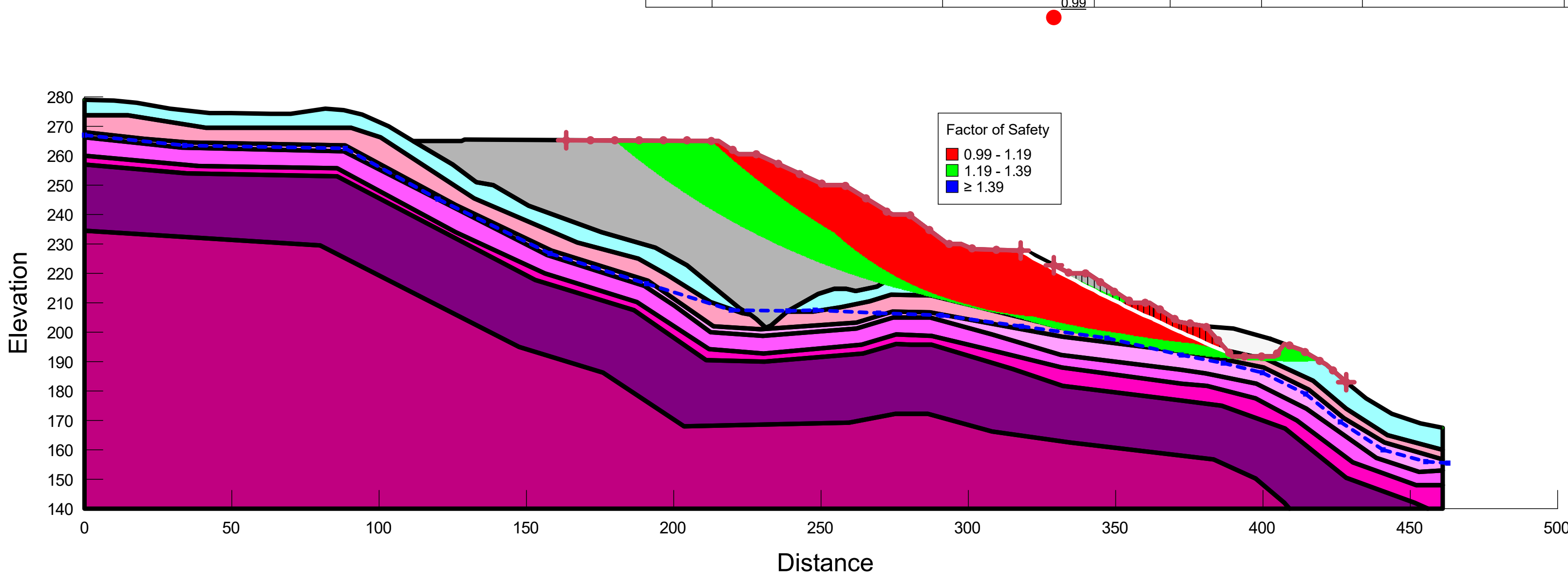
Date: 20/12/2024
Ref: 9169
Figure: B35 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.15

Factor of Safety: 0.99

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

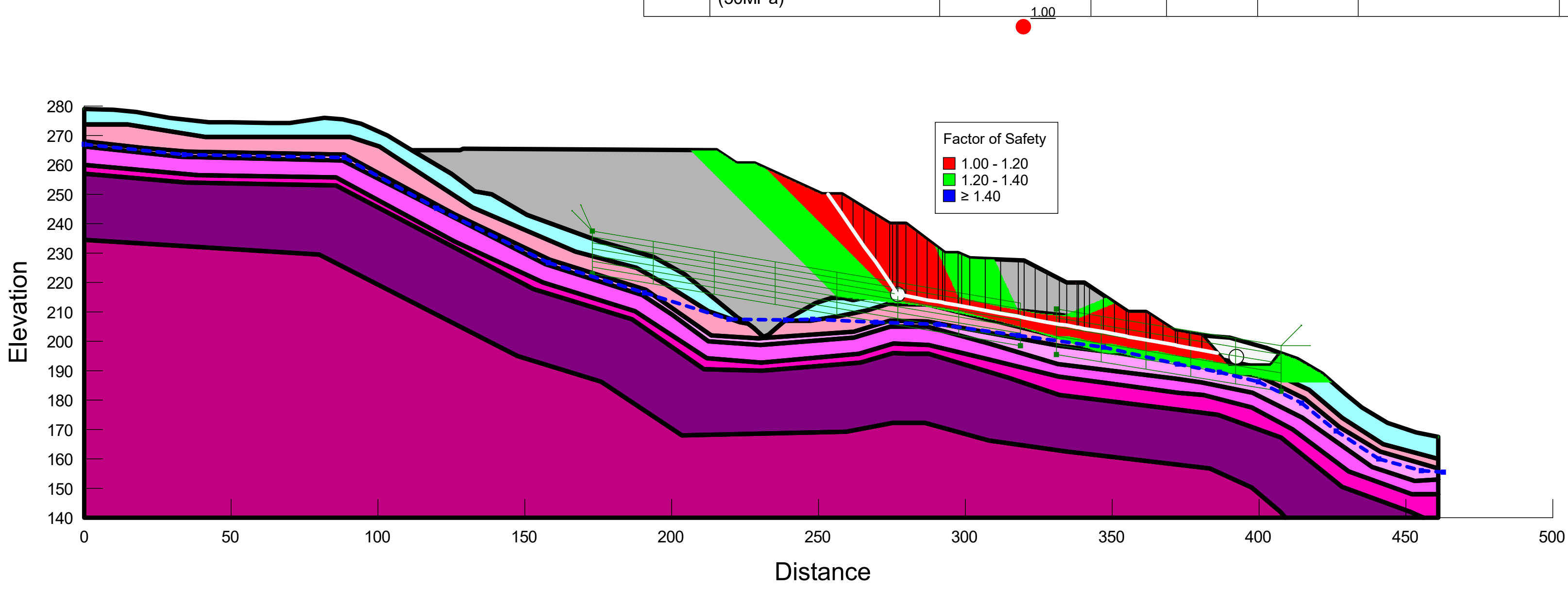
Date: 20/12/2024
Ref: 9169
Figure: B36 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.06

Factor of Safety: 1.00

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 03

Date: 20/12/2024
Ref: 9169
Figure: B37 EQ_ky_Block
Scale: 1:2,500
Drawn: NT

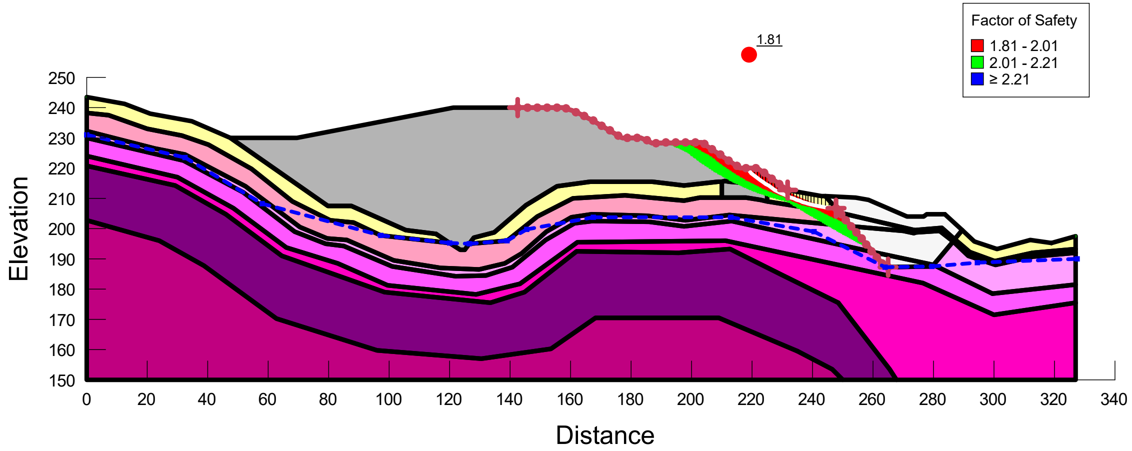
Section 4 - Stability Model Figures Showing Results

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.81

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

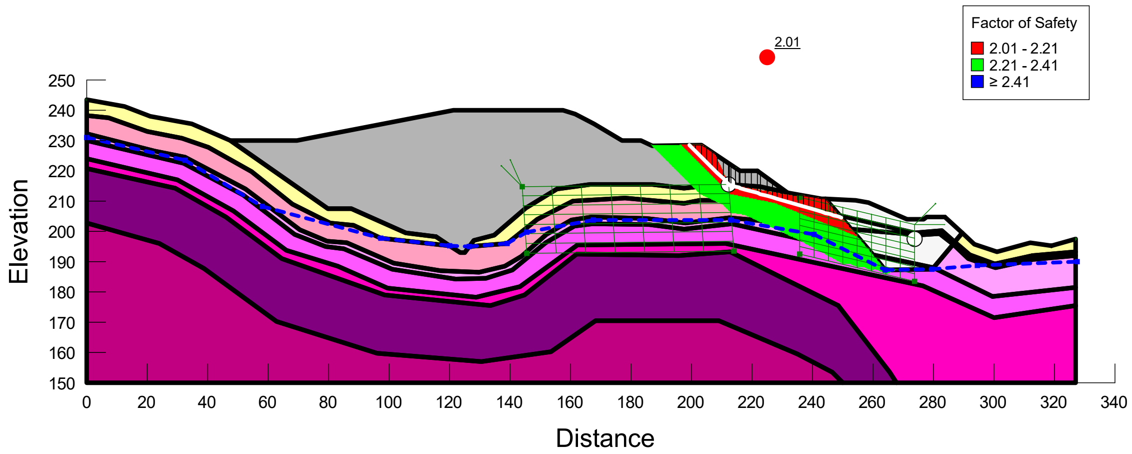
Date: 20/12/2024
Ref: 9169
Figure: B38 Static_Drnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.01

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

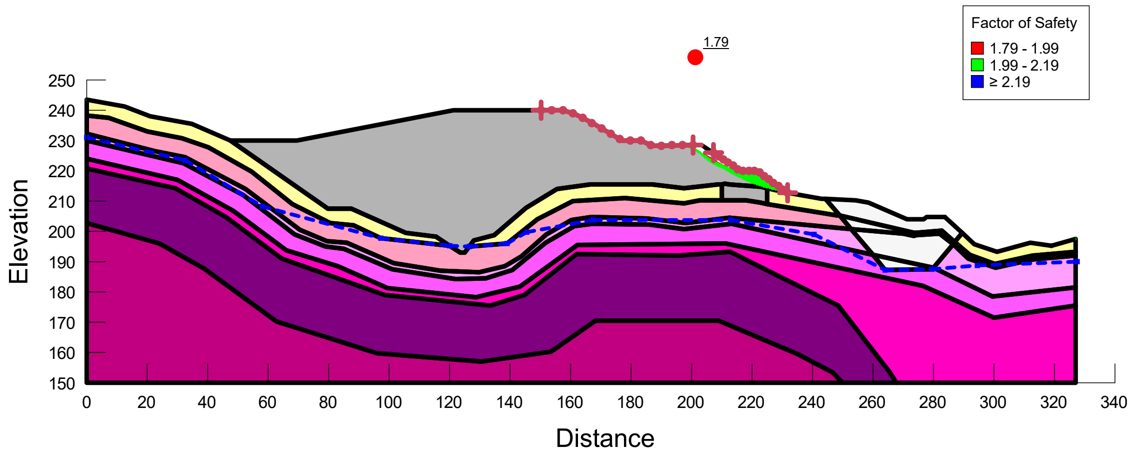
Date: 20/12/2024
Ref: 9169
Figure: B39 Static_Drnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.79

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01a Ash/Residual Soil_Drained	Mohr-Coulomb	17	3	34		0	1	0.1	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

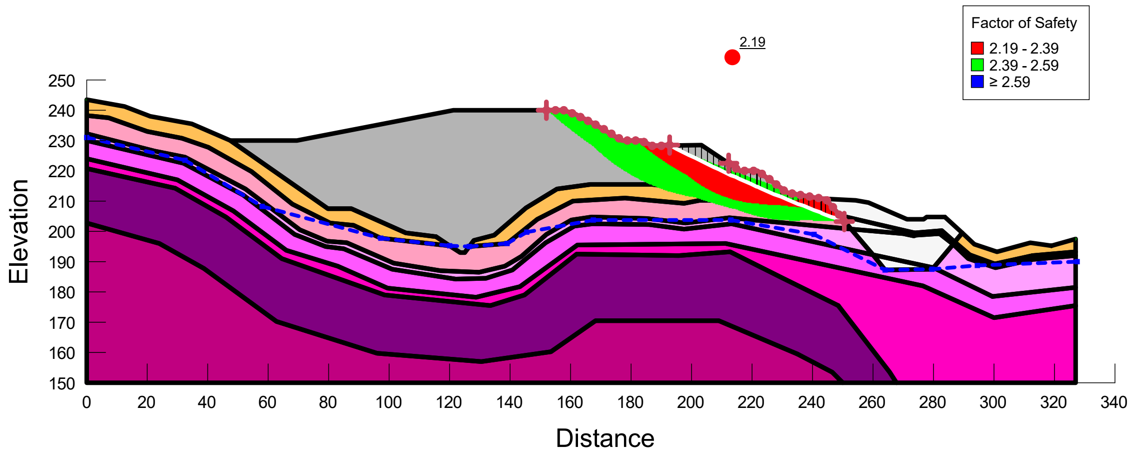
Date: 20/12/2024
Ref: 9169
Figure: B40 Static_Drnd_Circ_RockStack
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 2.19

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

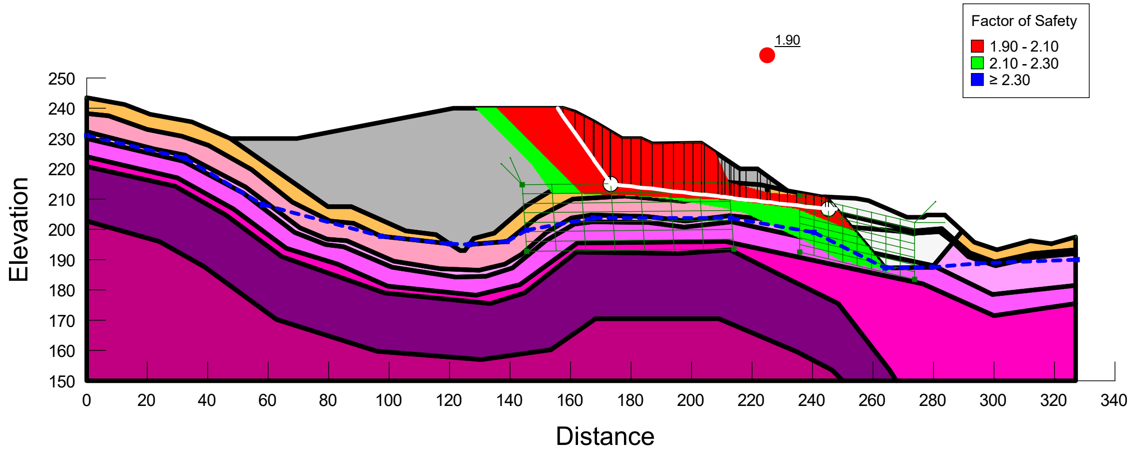
Date: 20/12/2024
Ref: 9169
Figure: B41 Static_Undrnd_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.90

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5	Rockfill (16th Percentile)	0	1		No
	01b Ash/Residual Soil_PeakUndrained	Shear/Normal Fn.	17	Ash/Residual Soil Peak Undrained	0	1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18	EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18	Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19	Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20	Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20	Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21	Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

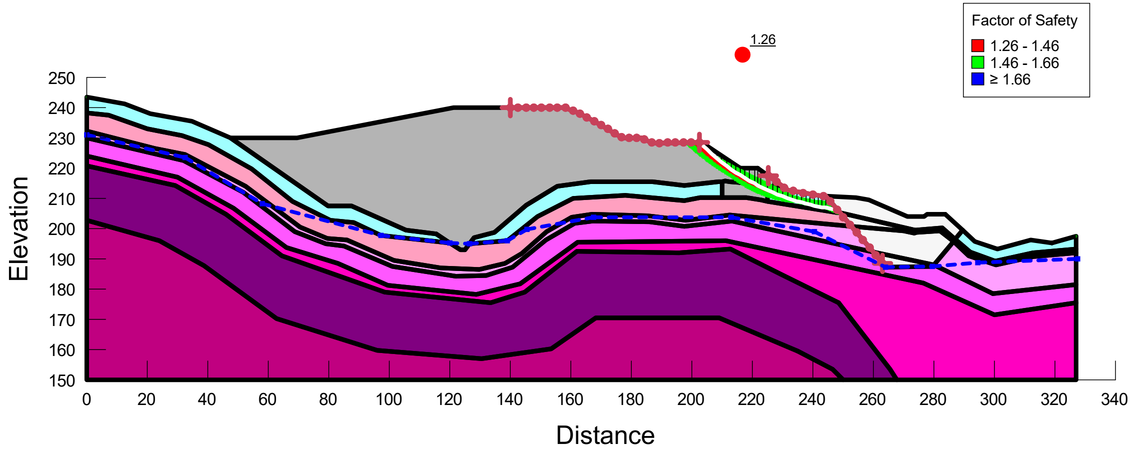
Date: 20/12/2024
Ref: 9169
Figure: B42 Static_Undrnd_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.26

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

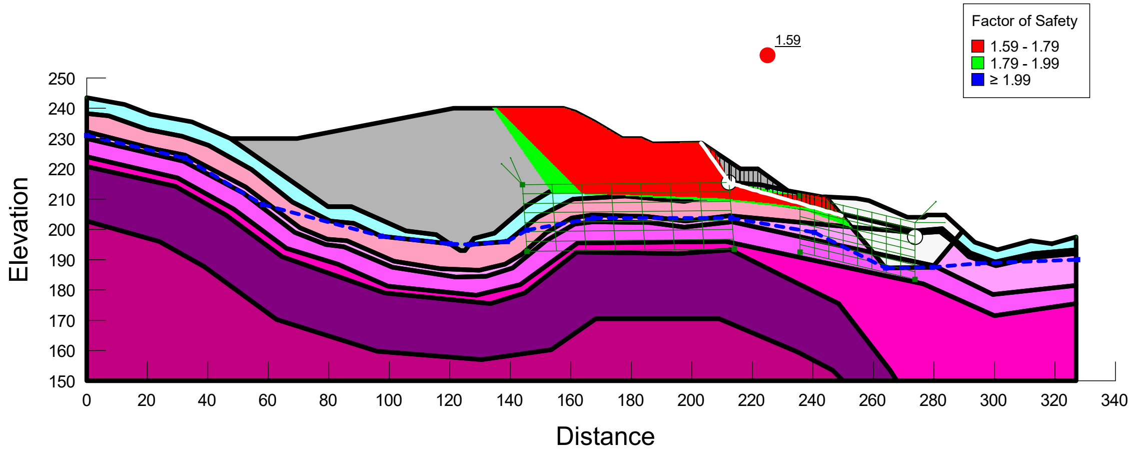
Date: 20/12/2024
Ref: 9169
Figure: B43 PostEQ_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.:

Factor of Safety: 1.59

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

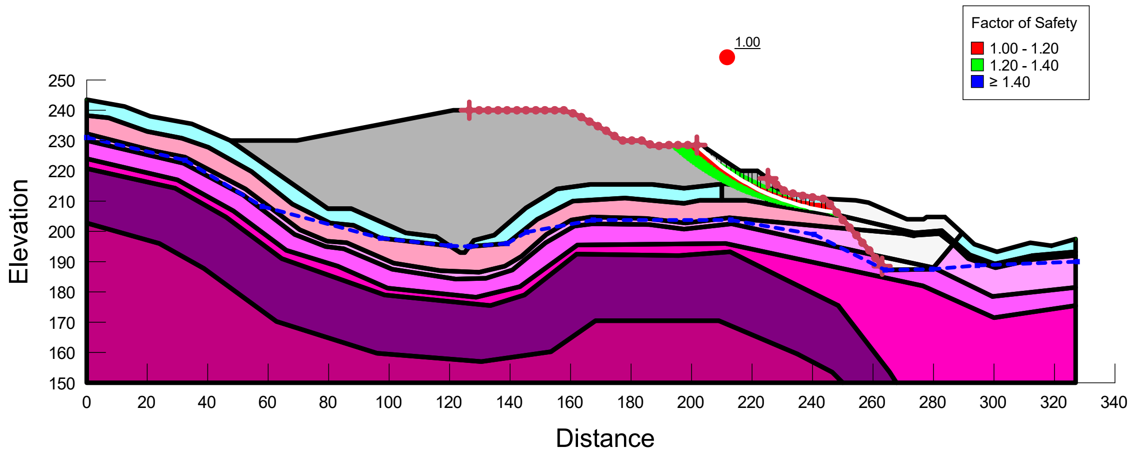
Date: 20/12/2024
Ref: 9169
Figure: B44 PostEQ_Block
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Spencer
Direction of movement: Left to Right
Slip Surface Option: Entry and Exit
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.09

Factor of Safety: 1.00

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

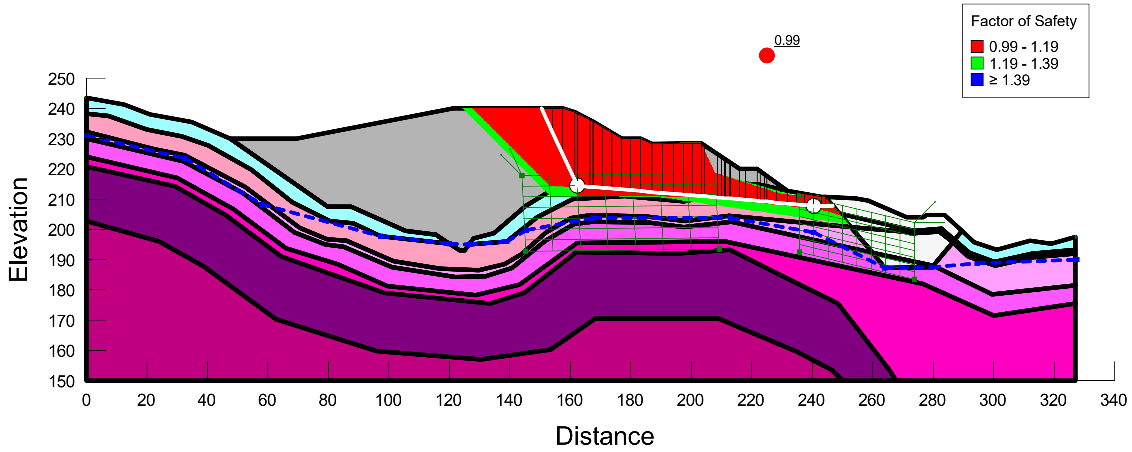
Date: 20/12/2024
Ref: 9169
Figure: B45 EQ_ky_Circular
Scale: 1:2,500
Drawn: NT

Analysis Parameters

Method: Janbu
Direction of movement: Left to Right
Slip Surface Option: Block
Unit Weight of Water: 9.807 kN/m³
Horz Seismic Coef.: 0.13

Factor of Safety: 0.99

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Minimum Strength (kPa)	Tau/Sigma Ratio	Strength Function	Phi-B (°)	Piezometric Line	Ru	Include Ru in PWP
	00 WRS Rockfill (16th)	Shear/Normal Fn.	18.5			Rockfill (16th Percentile)	0	1		No
	01c Ash/Residual Soil_ResidualUndrained	SHANSEP	17	0	0.25			1	0.3	Yes
	02 E.Weak Andesite (0.5MPa)	Shear/Normal Fn.	18			EW Andesite 0.5MPa	0	1		No
	03 V.Weak Andesite (2MPa)	Shear/Normal Fn.	18			Andesite 2MPa	0	1		No
	04 V.Weak Andesite (4MPa)	Shear/Normal Fn.	19			Andesite 4MPa	0	1		No
	05 Weak Andesite (7MPa)	Shear/Normal Fn.	20			Andesite 7MPa	0	1		No
	06 Weak Andesite (20MPa)	Shear/Normal Fn.	20			Andesite 20MPa	0	1		No
	07 Mod.Strong Andesite (50MPa)	Shear/Normal Fn.	21			Andesite 50 MPa	0	1		No



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Willows WRS Stability Analyses - Section 04

Date: 20/12/2024
Ref: 9169
Figure: B46 EQ_ky_Block
Scale: 1:2,500
Drawn: NT