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Ground Control Management Plan

Lang Lang Sand Resources Pty Ltd

09 February 2023

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1. Introduction

1.1 Purpose

The purpose of this document is to provide a Ground Control Management Plan (GCMP) for Lang Lang Sand Resources Pty Ltd (the Client), owned by Aurora Construction Materials (ACM), who wish to develop sand resources at Work Authority 7541 (WA7541), located at 5575 South Gippsland Highway (SGH) in the Lang region of Victoria (the site; see Figure 1. Primarily, the GCMP aims to identify the risks associated with quarrying operations at the South Gippsland site and to provide a framework for risk management. It is understood the Client's work plan application must satisfy any requirements prescribed by the Department of Jobs, Precincts and Regions (DJPR) - Earth Resources Regulation (ERR) division.

To assist the client with this application, GHD was engaged by Mr Kelvin Sargent of ACM to undertake a geotechnical assessment of the site, with outcomes detailed in the GHD (2022) draft report *'5575 South Gippsland Highway Geotechnical Assessment'* dated 30 March 2022 (GHD Ref: 12527040-45542-13), and develop a ground control management plan (GCMP) (this report) which identifies potential geotechnical risks and suitable risk treatment protocols.

GCMPs are a tool that provide the necessary framework to recognise, identify and address pertinent geotechnical issues for the purpose of creating a safe, stable, and sustainable site, as defined in Section 1.2, during quarry operations all the way through to closure and rehabilitation phases. Accordingly, a key part of the GCMP is the geotechnical risk assessment. The risk assessment is used to identify and address any perceived or known threats to the:

– Safety of people – including the public and site personnel
– Environment
– Risk to quarry employees
– Key infrastructure within and around the quarry
– Nearby public infrastructure (where applicable)

The findings of the risk assessment help tailor management protocols to the site for which the GCMP is being developed with the aim of mitigating risks to tolerable thresholds.

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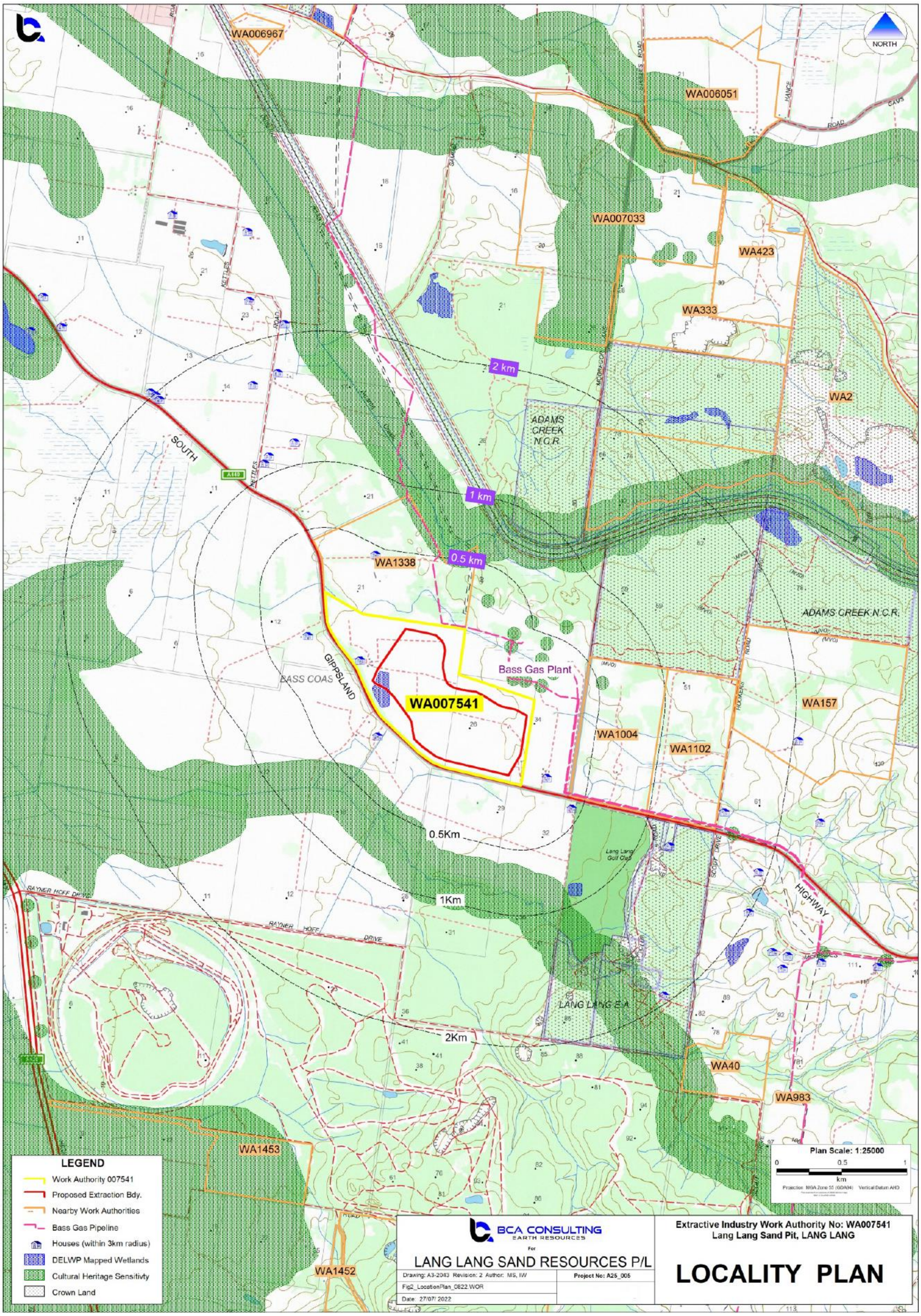

Figure 1 Plan view of WA7541 Boundary and adjacent work authorities.

1.2 Definitions

Safe

The interim and final landforms should present the lowest reasonably achievable risk to public health and safety and the environment, both within and beyond the quarry boundaries. A range of possible hazards will need to be addressed including fire, dust, and contamination of air, soil, and water, and detrimental or uncontrolled water flows or the development of weak or dangerous ground. Suitable controls which are necessary to maintain safe conditions should be implemented, e.g., ground movement monitoring. This document focuses specifically on stability related controls.

Stable

Anticipated ground movements should be minimised as far as reasonably practicable and those movements that will occur should be understood, predictable and controllable. Controls necessary to maintain stability within and beyond the site boundary should be in place with appropriate monitoring. The risk of rapid, adverse ground movements leading to damage to infrastructure, property, or the environment should be as low as reasonably achievable. Any risk to human life will also be identified and addressed.

Sustainable

The quarry pit geometry including any water bodies, should be feasible from long term stability, environmental, social, and economic perspectives, and capable of beneficial use post quarrying.

1.3 Scope and limitations

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

1.4 Legislative Environment

ACM is subject to the following key licences and legislative instruments:

- The Mineral Resources (Sustainable Development) Act 1990 (Vic) and associated Mineral Resources (Sustainable Development) (Mineral Industries) Regulations 2019 (Vic) provide a legal framework for quarrying / mining.
- Planning and Environment Act 1987.
- The Occupational Health and Safety Act 2004 (Vic) and associated Occupational Health and Safety Regulations (2017) (Vic) which address the health, safety and welfare of employees in the workplace, and of the general public, in connection with the operation of the site.
- The Environment Protection Act 2017 (Vic), Water Act 1989 (Vic), Environmental Protection and Biodiversity Conservation Act 1999 and the Flora and Fauna Guarantee Act (1988) (Vic).
- State Planning Policy Framework (SPPF).

WorkSafe, the Victorian Environment Protection Agency (EPA) and the Department of Jobs, Precincts and Regions (DJPR) are the key State Government Regulatory bodies that oversee mining and quarrying operations in Victoria. These bodies enforce the policies listed in the acts above to ensure that the WA7541 site operates within the legislative requirements.

1.5 Stability and Ground Control Context

The formulation of a comprehensive GCMP particularly in a quarry setting requires the consideration of a number of factors, such as the rock mass strength and mechanical characteristics, surface and groundwater considerations, quarrying equipment and development methodology. Outlined below in Figure 2 is a design process map, after the CSIRO guidelines (2009), which forms the framework for this GCMP.

In developing the GCMP for WA7541 site, consideration is given to:

- The depth and operating life of the quarry
- The potential for changes in expected ground conditions associated with the expansion of the quarry (i.e. groundwater fluctuations, bedding and planes of weakness)
- The location of working benches and transportation routes
- The potential for surface and ground water problems
- The equipment to be used, excavation methods, and handling of the resource and waste
- The presence of nearby surface features (e.g. public roads, railways, pipelines, natural drainage channels or public buildings)
- The potential for the general public to inadvertently gain access to the quarry void during operation
- Geotechnical risk assessments and associated Trigger Action Response Plan (TARP)

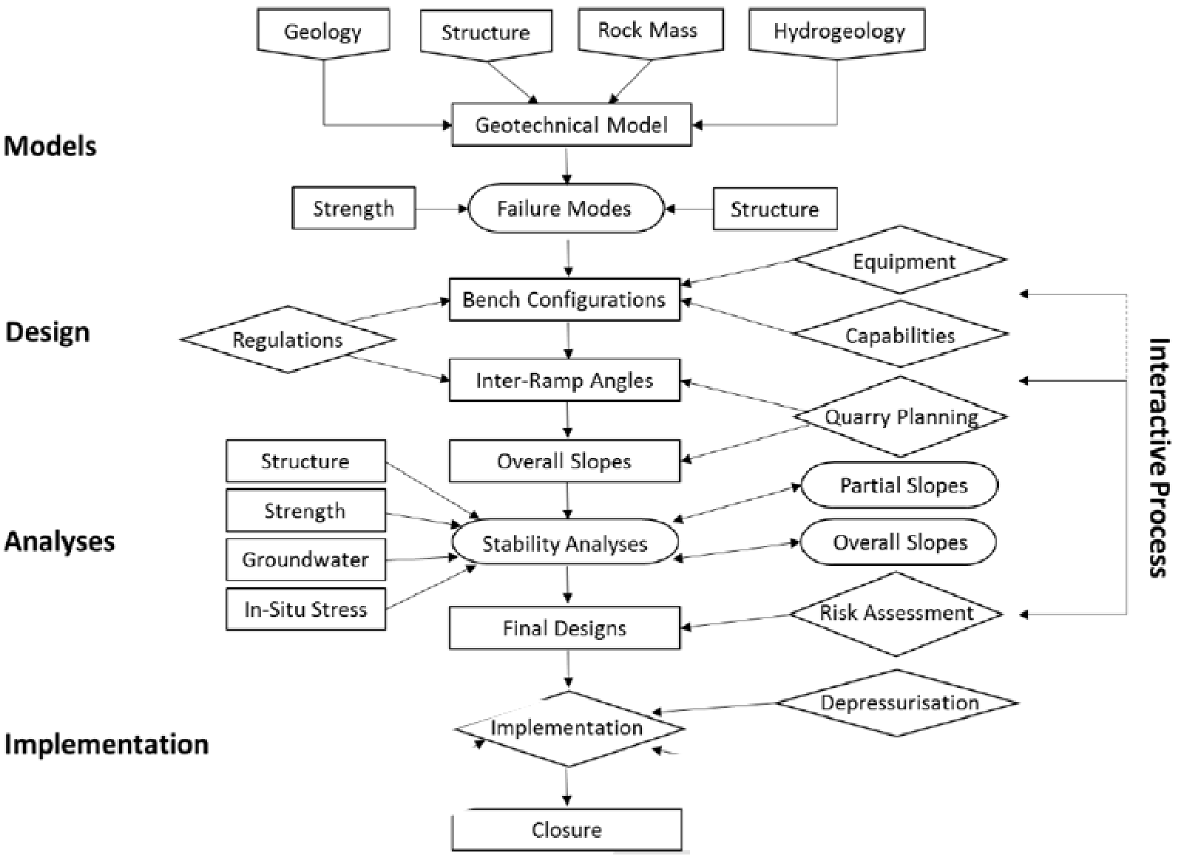

Figure 2 Design process flowchart

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2. Quarry Setting

2.1 General

The proposed quarry extraction site, WA7541, is situated in Lang Lang, Victoria, an area containing multiple sand extraction quarries. The site is currently an undeveloped greenfield site, located approximately 7 km southeast of the Lang Lang township, and 80 km southeast of Melbourne (Figure 3).

Figure 3 Site Location within the regional plan

The WA7541 boundary covers an area of just under 118 Ha. The resource will likely be used for the production of construction materials such as concrete and road surfacing material.

2.1.1 Development History

The WA7541 site, at 5575 South Gippsland Highway, Lang Lang, is currently an undeveloped greenfield site, with no past mining operations.

2.1.2 Proposed Quarry Development

Based on the provided information, excavation of the pit will be undertaken using a staged approach (see Figure 4) from east to west. The pit geometry is likely to be formed as follows:

- Total depth of extraction is expected to be approximately 30 m below current surface level.
- Working and rehabilitated profiles of 1V:3H (approx. 18°) above groundwater and 1V:2H (approx. 26°) below.
- A 10 m wide beaching bench will be established at the water level.

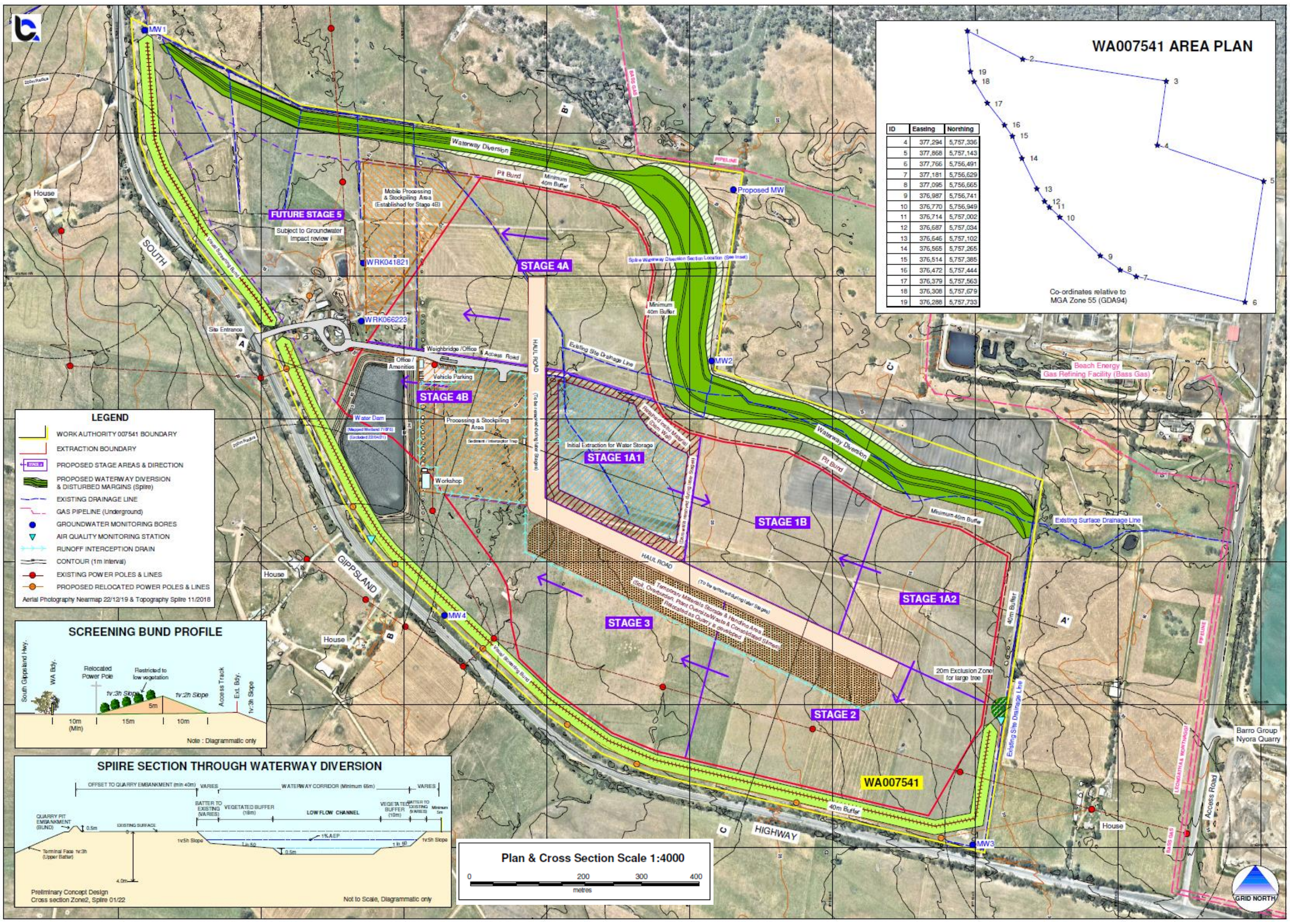

Figure 4 *Pit Development Plan*

GHD understand that the client is proposing to excavate the resource using a sequenced process, as follows:

- Removal of overburden material (varies between 2 and 6 m in thickness)
- Dry extraction above the groundwater table
- Mechanical dredging to remove sand resources below the groundwater table

2.2 Quarry Infrastructure and Local Surroundings

This WA7541 site is bounded to the west and south by the South Gippsland Highway, to the northwest by WA1338 (Len Huxtable), to the northeast by Bass Gas Plant and to the east by private farmland. Four other existing WA tenements can be found within 3 km of the proposed site: WA2 (Holcim), WA157 (Metro Quarry Group), WA1004 (Railway Sand Supplies) and WA1102 (Metro Quarry Group), as shown in Figure 5.

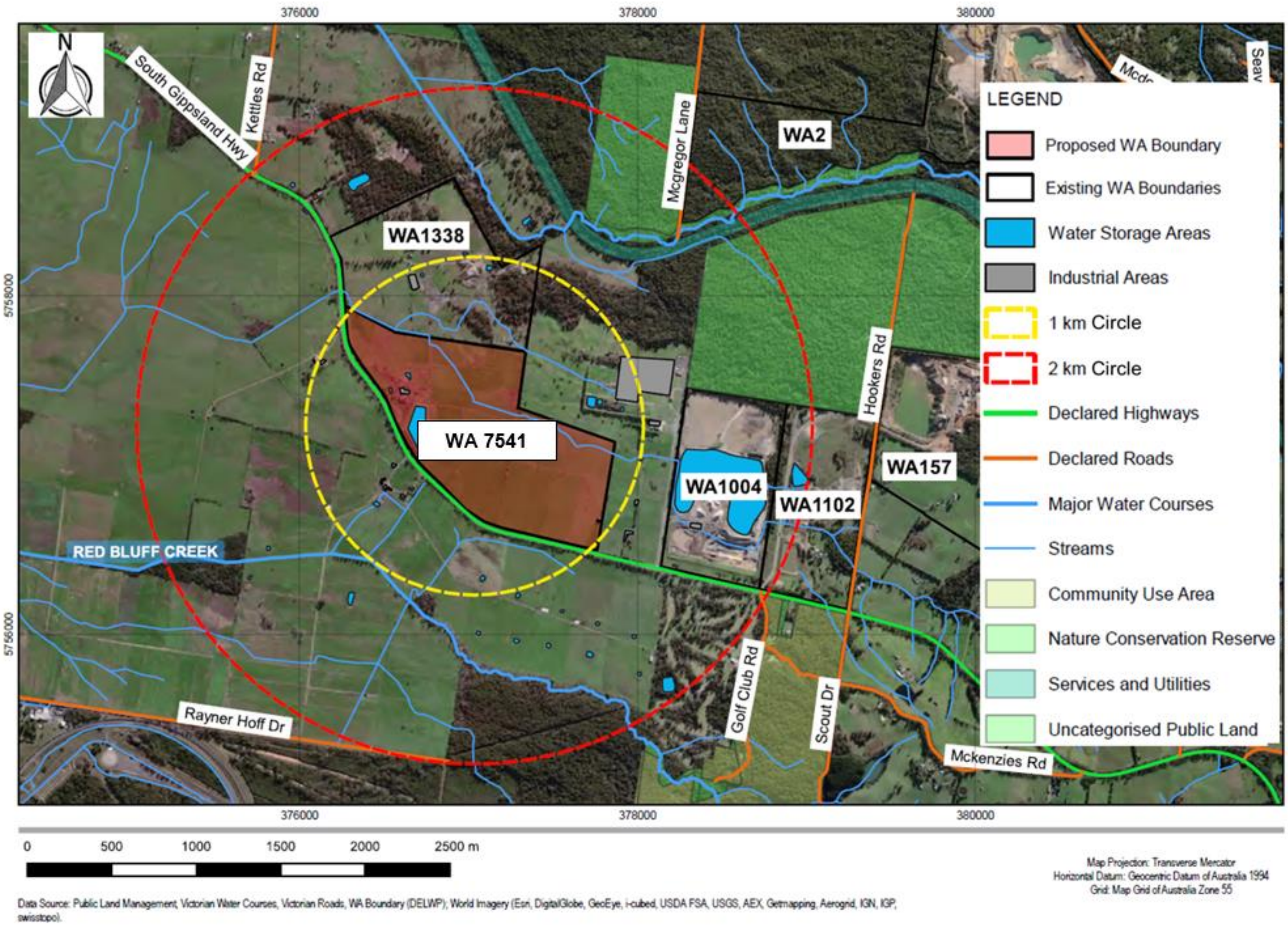

Figure 5 Plan View of the Proposed Quarry Location Depicting Nearby Receptors

3. Geotechnical Performance and Considerations

3.1 Geotechnical Model Considerations

The geotechnical domain model forms the basis for any quarry pit slope design. The geotechnical domain model facilitates the segregation of a quarry pit into sectors or zones which have similar geological, structural and material property characteristics, thus modes of instability. In principle, the act of geotechnical domaining allows for multiple optimisation techniques to apply, where the slope design is optimised, in terms of safety and economics, for a given sector rather than applying a single slope design across the entire pit. In essence, geotechnical domaining a quarry pit can be used inform quarry owners/operators where to focus their time and effort.

The geotechnical domain model is compiled from four component models:

– Geological model
– Structural model
– Hydrogeological model
– Material properties model

Geotechnical domaining of the Client's site has relied upon the philosophy set out by Read and Stacey (2009). Outlined in the Figure 6 are the considerations that are taken into account when formulating site specific geotechnical domains.

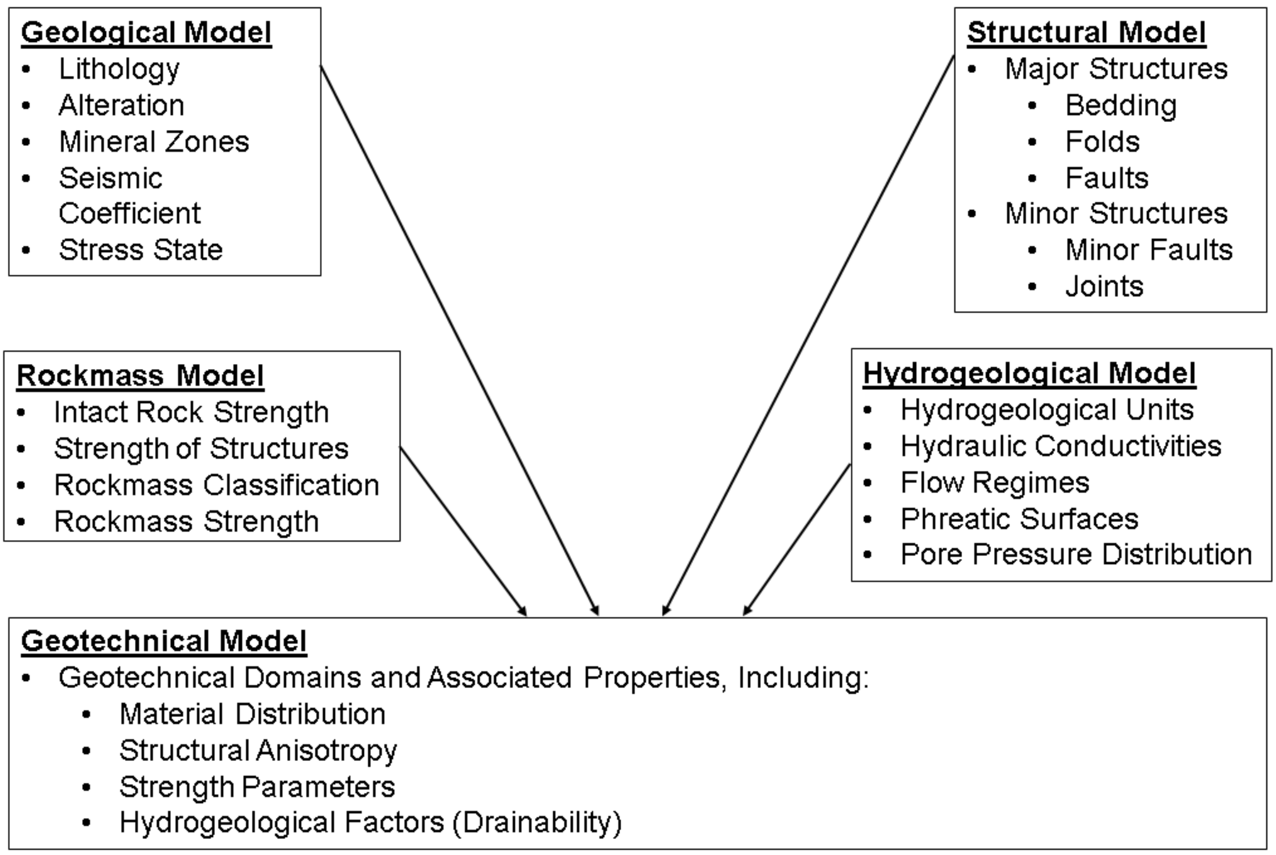

Figure 6 Development of Geotechnical Domain Model after Read and Stacey (2009)

3.2 Regional and Site Geology

3.2.1 Regional Geology

The proposed quarry site lies approximately 7 km inland from the eastern shores of Western Port Bay. The area is situated within a tectonic depression, known as the Western Port Sunklands. The sunklands are bounded to the west by the Tyabb Fault, and to the east by the Bass and Heath Hill Faults (GeoVic, 2014; Geoscience Australia, 2020), forming a horst (Mornington Peninsula bedrock ridge) and graben (Port Phillip Sunkland, Western Port Sunkland) sequence (McAndrew & Marsden, 1968).

3.2.2 Regional Structural Geology

The proposed quarry site is situated on a graben (Western Port Sunklands), downthrown relative to the Mornington Peninsula bedrock to the west and the South Gippsland Highlands to the east. The extents of the sunklands are defined by the Tyabb Fault to the west, and the Heath Hill Fault to the east (GeoVic, 2014). Within the sunklands, the quarry site sits in a slightly elevated zone known as the Lang Lang Lowlands, delineated by the Lang Lang Fault as shown in Figure 7 (Carillo-Rivera, 1975).

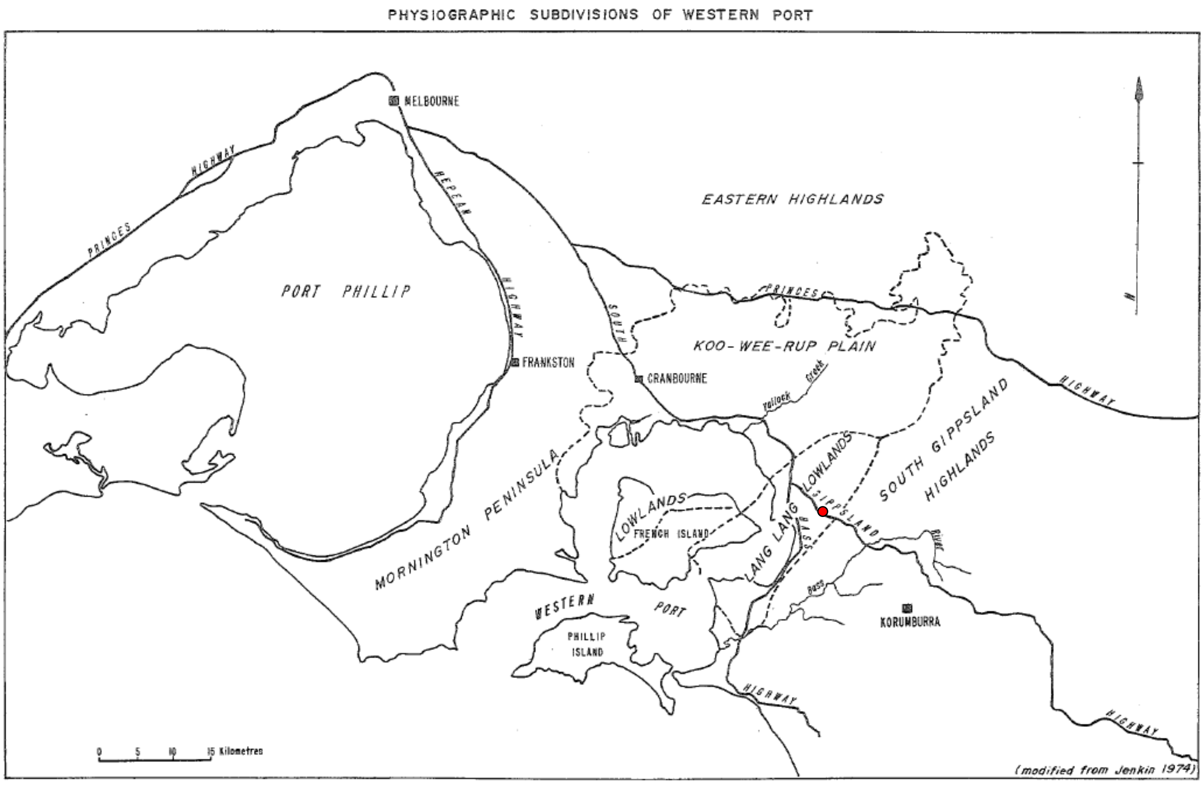

Figure 7 Physiographic Sub-Divisions of Western Port (Carillo-Rivera, 1975, modified from Jenkin, 1974). Proposed quarry shown in red.

3.2.3 Stratigraphy

The area in the vicinity of the proposed quarry site consists of 3 main stratigraphic units Figure 8, as follows (from oldest to youngest):

- Wonthaggi Formation (*Ksw*)
- Sandringham Sandstone, formerly known as Brighton Group (*Nb*)
- Unconsolidated Quaternary Deposits (Qg, *Qa2* and *Qa1*)

A geological map of the proposed quarry site and the surrounding region is presented in Figure 8.

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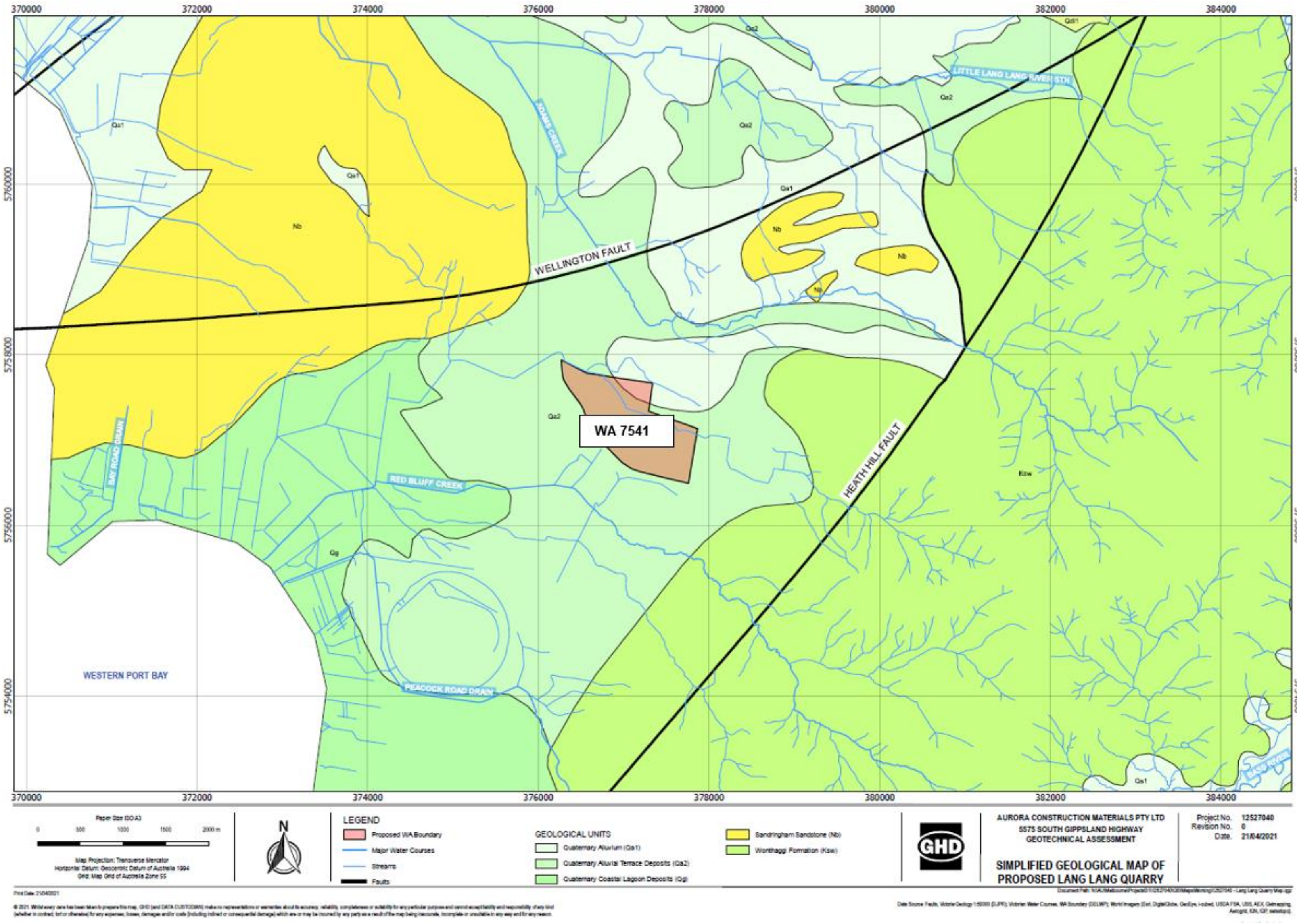

Figure 8 ***Simplified Geological Map of the Lang Lang Region***

Wonthaggi Formation (*Ksw*)

The oldest rocks found around the proposed quarry area is the sedimentary Wonthaggi Formation (*Ksw*). The Wonthaggi Formation is part of the Strzelecki Group, which were the first sediments deposited within the Gippsland Basin (Mehin & Bock, 1998). The overall thickness of the Strzelecki Group is at least 3000 m and consists of interbedded non-marine greywackes, mudstones, sandstones, conglomerates, minor coals and volcanics deposited in lacustrine, swamp or floodplain environments (Mehin & Bock, 1998). The Wonthaggi Formation is defined by Welch *et al*. (2011) as a lithic volcaniclastic sandstone, arkose and siltstone, with minor conglomerate and coal. Bryan *et al*. (1997) assigns an age of 129.5 – 100.5 Ma for the Wonthaggi Formation.

Sandringham Sandstone, formerly known as Brighton Group (*Nb*)

The Sandringham Sandstone (*Nb*) is a newly redescribed unit, grouping together the following units: Hanson Plain Sand, Moorabool Viaduct Sands, Baxter Sandstone, Marina Cove Sand, Black Rock Sandstone, Red Bluff Sandstone, Beaumaris Sandstone and the Brighton Group (VandenBerg, 2016).

Within the Port Phillip Bay region, exposures of Neogene sandstone are widely distributed and are often of variable quality (VandenBerg, 2016). Therefore, these exposures have been studied in isolation from each other, resulting in many outcrops being given their own rock unit name. VandenBerg (2016) conducted a re-examination of the various type sections of these units and concluded that all name Neogene units in this region are shallow marine in origin and contain sedimentary structures such as planar bedding and swaley cross-stratification. As such, he interpreted that these units were deposited as a continuous sheet on an extensive strandplain, which has been subsequently eroded into the scattered exposures that we see today. Because of these similarities, VandenBerg (2016) proposes that these late-Neogene sediments be unified under the Sandringham Sandstone name.

In the Lang Lang area, the Sandringham Sandstone is described as a paralic (interbedded marine and non-marine) silt, sand and gravel deposit. The unit is variably calcareous and ferruginised, with sections of limestone (GeoVic, 2014). Elsewhere, the Sandringham Sandstone also exists as sandy silt, fine sandstone, sandy conglomerate to pebbly sandstone and clayey sand. The sandstone also contains carbonaceous bands (with plant fossils), lag deposits, horizontal and swaley cross-lamination, and preserved burrows (VandenBerg, 2016).

The Sandringham Sandstone has been dated as Pliocene to Miocene in age, with a minimum age of 4.6 Ma constrained by the overlying basalts of the Newer Volcanic Group and a maximum age of 5.8 (±0.2) Ma determined by Sr/Sr isotope ratios within mollusc fossils (Hare *et al*., 2005; Wallace *et al*., 2005).

Due to its widespread distribution, the Sandringham Sandstone is overlain by multiple units. In the Lang Lang Lowlands area, the Sandringham Sandstone is overlain by unconsolidated Quaternary sediments.

Unconsolidated Quaternary Deposits (*Qa2, Qa1, Qg*)

The youngest units found within the proposed quarry area are a series of Quaternary aged unconsolidated sediments (GeoVic, 2014). There are two distinct phases of alluvial sedimentation (*Qa2* and *Qa1*) and a series of coastal lagoon deposits (*Qg*). Both phases of alluvial sedimentation are defined as generally unconsolidated, variably sorted silt, sand and gravel, with *Qa2* dissected to form terraces higher than *Qa1* (GeoVic, 2014). The coastal lagoon deposits can be found on the coast of Western Port Bay, to the southwest of the proposed quarry site (GeoVic, 2014). *Qg* consists of variably consolidated, dark grey to black silt and clays.

In this region, these Quaternary sediments directly overlie the Sandringham Sandstone. A stratigraphy column is presented in Figure 9.

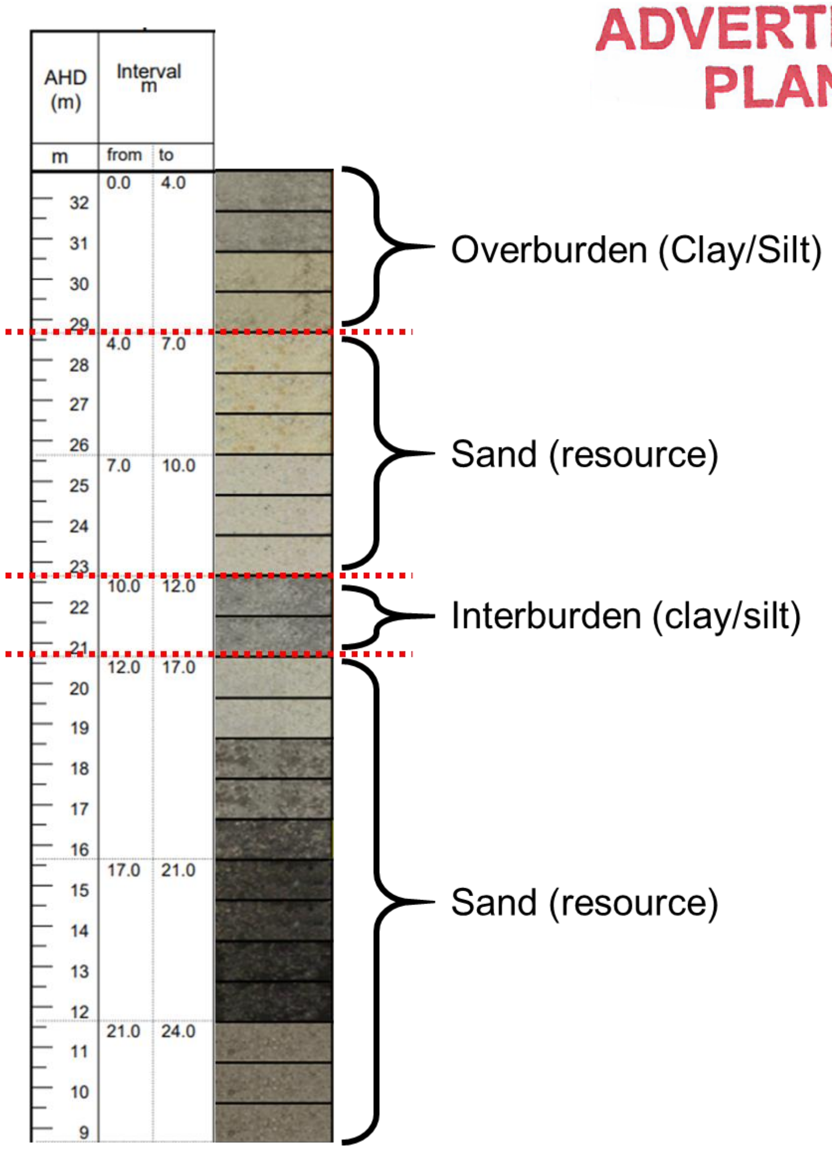

Figure 9 *Typical sub-surface profile at the site*

3.2.4 Major Structures

A search of the Neotectonic Features Database (Geoscience Australia, 2020) reveals a number of faults within a 10 km radius of the proposed quarry site (Figure 10) The Wellington Fault is the closest, at a distance of approximately 1.8 km to the northwest. This is followed by the Heath Hill Fault, which can be found 2.1 km to the southeast. Other major faults within 10 km of the quarry site are the Lang Lang Fault, the Bass Fault and the Almurta Fault (Geoscience Australia, 2020). The major structure traces are presented in Figure 10.

Wellington Fault

The Wellington Fault is the closest mapped structure to the proposed quarry site, with the closest point approximately 1.8 km away. However, the lack of research on the Wellington Fault results in many questions regarding the nature and characteristics of the Wellington Fault. The 1:250 000 Warragul geological map (VandenBerg, 1997) maps the Wellington Fault as a 15 km long, a E to NE trending structure splaying off the Heath Hill Fault near Lang Lang East, extending offshore into Western Port Bay. The Wellington Fault is not listed as a neotectonic feature (Geoscience Australia, 2020), nor has any recorded earthquake greater than magnitude 3 been attributed to it.

Given the present-day stress field of southeast Australia (Rajabi *et al*., 2017), the predominately east trending strike of the Wellington Fault appears unfavourable for ongoing crustal stress relief compared to the more conducive, NE-SW trending Heath Hill Fault. Therefore, the Wellington Fault is unlikely to produce a large earthquake under the current stress regime.

Heath Hill Fault

The Heath Hill Fault is a known fault in the Lang Lang area. The Heath Hill Fault is a NE-SW trending reverse fault represented as a topographical scarp, with the Cretaceous Wonthaggi Formation upthrown relative to the Western Port Sunklands. Geoscience Australia (2020) measures the Heath Hill Fault at 50.3 km, with a location precision of 250 m resulting from small-scale mapping from the 90 m resolution SRTM DEM. It is probable that the Heath Hills Fault has experienced “recent” activity, with the Neogene-aged Haunted Hills Formation displaced across the fault trace, evidence of Pliocene or younger movement.

Lang Lang Fault

The complex Lang Lang Fault is a fault which acts as the northern/western boundary of the Lang Lang Lowlands. The Lang Lang Fault is an approximately 20 km long fault splaying off the Heath Hill Fault just northeast of Heath Hill. The easternmost extent of the Lang Lang Fault has an almost E-W strike, which transitions to NE-SW from around Caldermeade (GeoVic, 2014).

Like the Wellington Fault, the Lang Lang Fault is not listed as a neotectonic feature (Geoscience Australia, 2020). However, topographical analysis of the region show that the Lang Lang Lowlands have been elevated relative to the Western Port Sunklands. Remnants of the Sandringham Sandstone have been preserved on the Lang Lang Lowlands block, in contrast to the purely Quaternary nature of the deposits within the northern sunklands. Therefore, it is likely that the Lang Lang Fault has experienced post-Neogene activity to some degree. However, a combination of the lack of surface expression, the absence of recorded earthquake activity along the fault and the less than optimal orientation of the fault trace suggest that future activity along this fault is unlikely, but not impossible.

Bass Fault/Almurta Fault

The Bass Fault is a NE-SW trending reverse fault located to the east of the Heath Hill Fault. Geoscience Australia (2020) lists the fault as 57.6 km in length, dipping to the southeast. The fault trace is mapped based on its topographic expression, with an estimated vertical displacement across the fault of 45 m. This fault is suggested to be neotectonically active based on displaced Neogene fluvial deposits across the fault scarp. One single earthquake has been recorded in proximity to the Bass Fault, with a magnitude 3.1 recorded in 1987 (discussed further in Section 3.2.5).

The Almurta Fault (located further east) is often considered as continuous with the Bass Fault, however Geoscience Australia (2020) does not consider this to be the case. The 1:250 000 geological map for Warragul (VandenBerg, 1997) also maps these two structures as separate faults.

Other than the fault trace, not much else is known about the Almurta Fault, which is not classified as a neotectonic feature on the Neotectonic Features database (Geoscience Australia, 2020).

3.2.5 Neotectonics

In a search of Geoscience Australia’s Earthquakes@GA database (2021), only two earthquakes with a magnitude greater than 3.0 have been recorded in the 10 km surrounding the proposed quarry site (Figure 10). The most recent of those was a magnitude 3.3 which occurred on 20 December 1987, approximately 600 m from the proposed quarry. Another earthquake was recorded on 18 September 1980, this time 8.5 km to the southeast of the proposed site (magnitude 3.1).

Due to the age of these events, the records for these earthquakes are incomprehensive, recording only the time and location, and not attributed to a specific fault. Based on location alone, it is likely that the 1980 event occurred on the Bass Fault, while the 1987 event occurred in between the Wellington Fault and the Heath Hill Fault.

Based on the earthquake record, large earthquakes are uncommon in the area, with a magnitude 5.0 at the mouth of Western Port Bay being the largest recorded in 1971. However, the area remains seismically active in the Australian context, with smaller earthquakes recorded every few years, the majority recorded within the South Gippsland Highlands. Given the present-day stress field of Australia (Rajabi *et al*., 2017) and the strike of the mapped faults in the immediate area, the Heath Hill Fault and the Bass Fault are the most likely faults near the proposed quarry location to experience a future fault rupture.

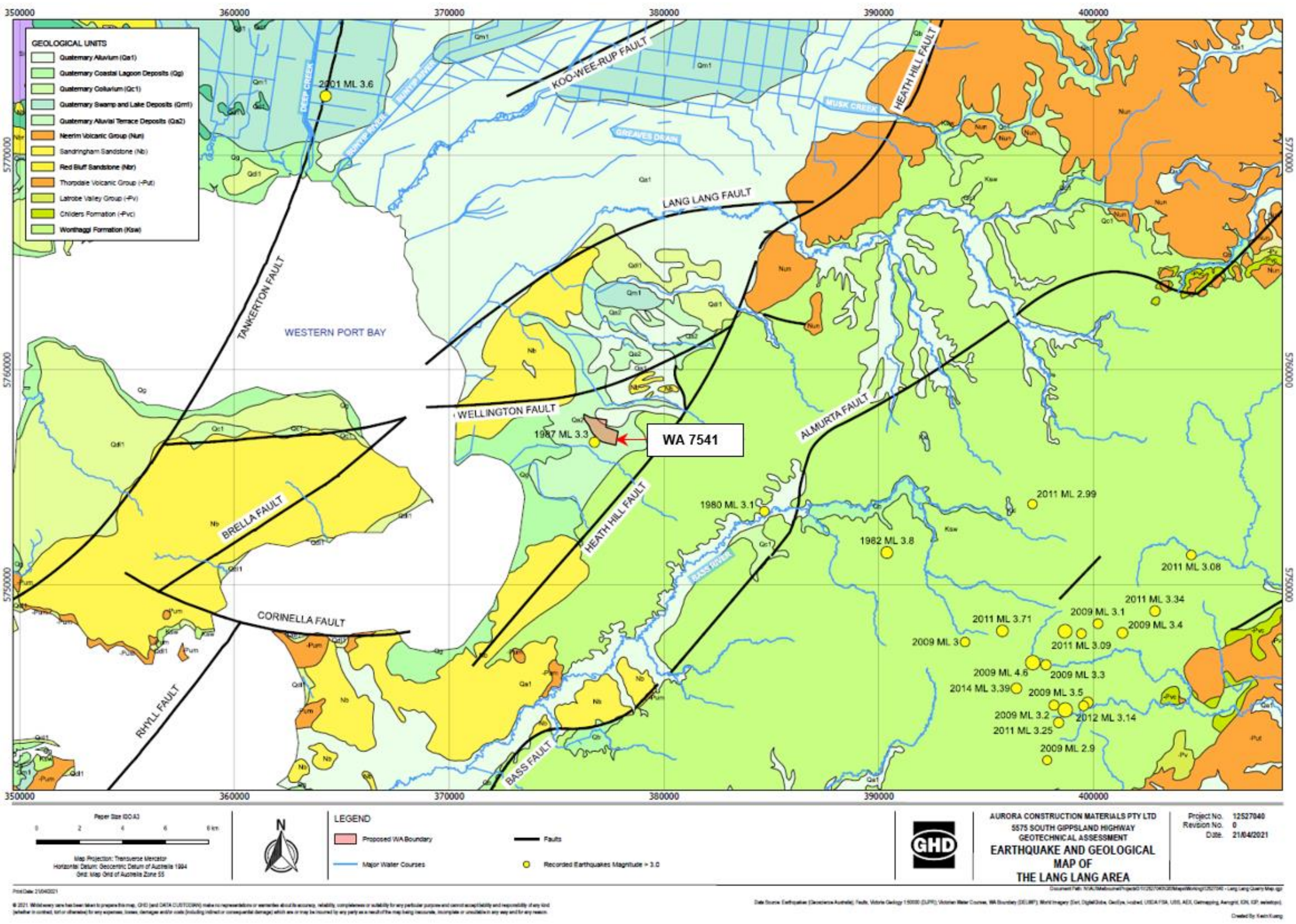

Figure 10 ***Earthquake and Geological Map of the Lang Lang Area. Earthquake ≥ Magnitude 3.0 Shown***

3.3 Hydrogeology

The groundwater table at the WA7541 proposed quarry site was interpreted using Visualising Victoria's Groundwater (VVG), a web based software that federates groundwater data from disparate sources. The depth to water table is depicted in Figure 11. It is noted that this depth to groundwater is generally consistent with the information recorded on the provided lithology logs.

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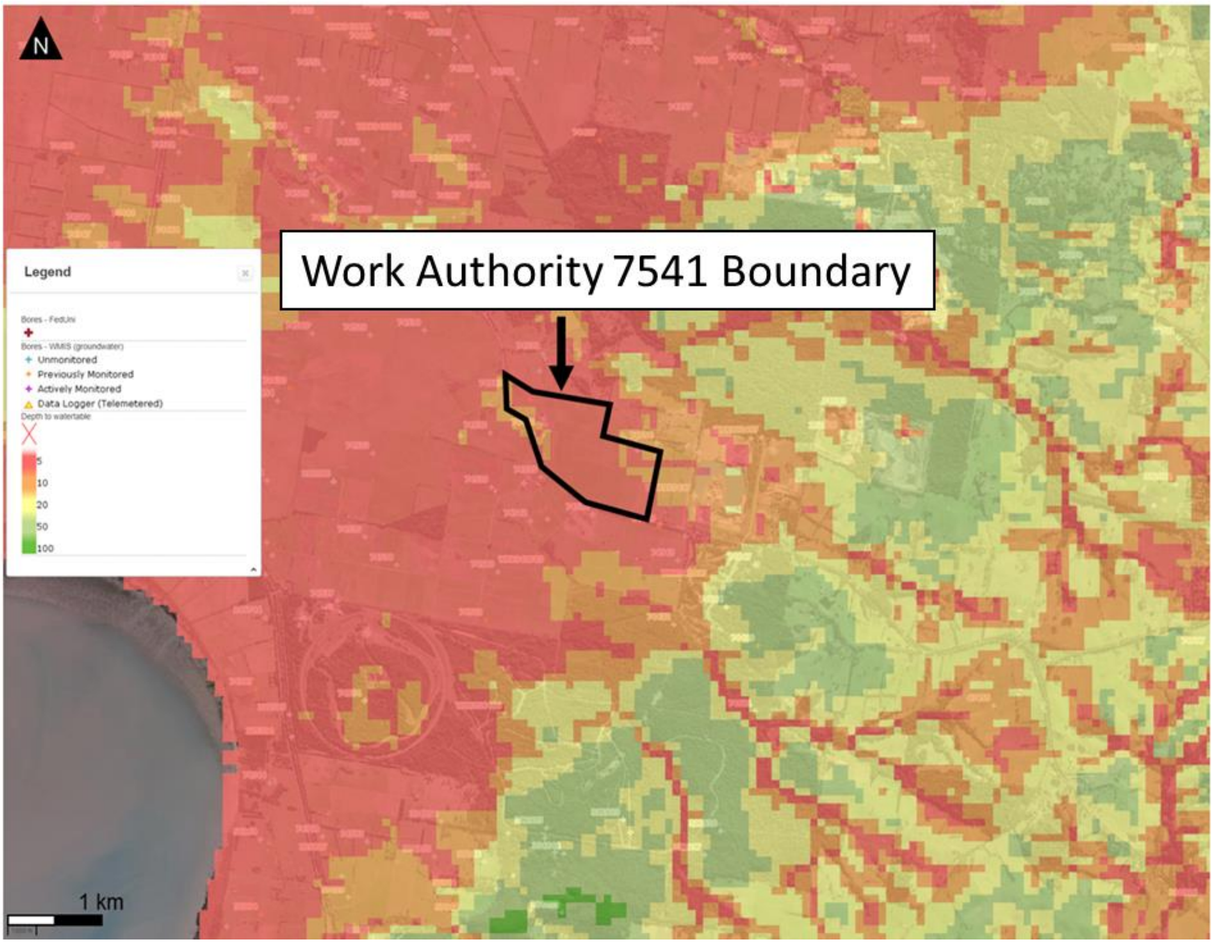

Figure 11 Depth to Groundwater at the WA7541 Site (VVG, 2021)

3.4 Material Strength Parameters

GHD (2022) has performed a number of geotechnical assessments, including site inspection and mapping campaigns, throughout a number of quarries in the Lang Lang and Nyora areas. This has included visual classification of site soils, performance measurements i.e., stable batter and slope angles, observations and measurements of stockpiled materials (i.e., typically the angle of repose of material) and geological mapping of structures (where relevant).

With the benefit of these verified empirical observations of stability conditions and site borehole logs, GHD has enhanced its understanding of the geological and geotechnical conditions in the Lang Lang and Nyora extractives areas and improved the level of geotechnical confidence for those sites. GHD has also been involved in undertaking geotechnical reviews of operating conditions at the nearby sites (i.e., subsequent to commencement of quarrying), with the intent of assessing slope stability conditions and utilising visual observations and measurements to verify design assumptions. These can assist with updating design parameters, which are typically documented in a site Ground Control Management Plan.

As has been undertaken for the nearby quarries, GHD has relied upon published geological information and its growing understanding of this area of Victoria, to determine suitable material strength parameters for use in slope stability modelling for this site. When considering a greenfield site which is to be formed in a locality of known geological conditions, whereby the variability or the lack thereof is well understood, a suitable approach entails making prudently conservative interpretations of material strengths to facilitate stability analyses and appropriate sensitivity calculations.

As outlined above, three main stratigraphic units are present within the proposed quarry footprint, which are categorised according to soil type. The material strength parameters, as assessed by GHD (2022), are based on our experience with similar materials in this area of Victoria and our understanding of batter stability conditions at nearby quarry sites. It is noted that the resource and interburden units comprise variable cohesive material content and as such, a range in typical effective strengths has been outlined in Table 1, which is based on the batter stability observations including measurements of stable batter profile, slope analyses and follow-up geotechnical reviews performed for proximate sand quarries.

For the proposed 5575 South Gippsland Highway quarry, GHD is of the opinion that suitable and appropriate geotechnical information is available to reasonably undertake slope stability modelling. Accordingly, GHD considers that the material parameters (including Mohr-Coulomb strength parameters) in Table 1 are suitable for use in slope stability calculations.

3.4.1 Material Strength Variability

As noted above and for conservatism, GHD has adopted the lower bound strengths for the analyses. Accordingly, the results presented in this report are considered to be conservative. Table 1 outlines and Figure 12 and Figure 13 depict the material strengths assessed for the site. Figure 13 also presents typical friction angles for sand, sandy gravels and silty sand (after Terzaghi and Peck, 1967).

As noted above and for conservatism, GHD has adopted the lower bound strengths for the analyses. Accordingly, the results presented in the GHD (2022) geotechnical assessment report, which are also summarised in Section 3.10, are considered to be conservative.

Table 1 Summary of Mohr Coulomb Parameters

Unit	Description	Unit Weight (kN/m^3)	Cohesion, c' (kPa)	Friction Angle, ϕ' (°)
1	Overburden	19.0	20 – 25	26 – 28
2	Sand (resource)	18.0	3 – 5	32 – 34
3	Interburden	18.0	5 – 10	25 – 30

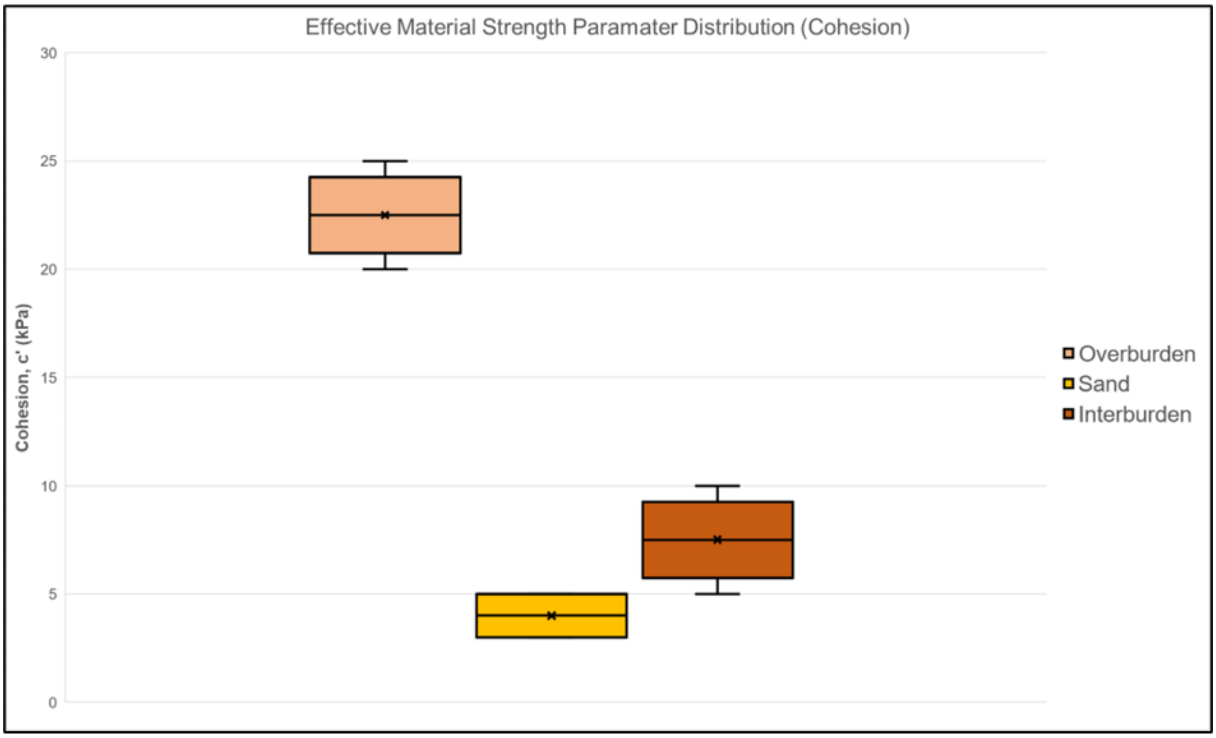

Figure 12 Summary of Effective Strength Distribution (Cohesion)

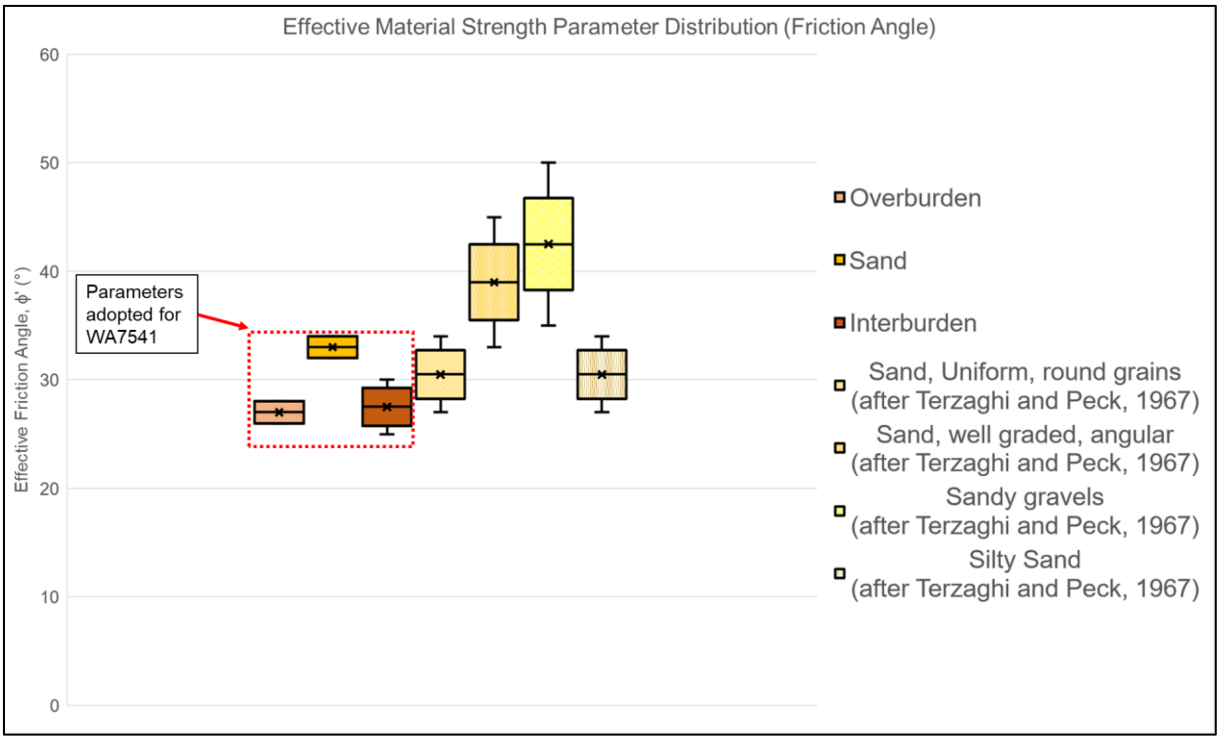

Figure 13 Summary of Effective Strength Distribution (Friction Angle)

As depicted in Figure 15, GHD notes that the material strength parameters adopted for WA7541 are conservative (lower bound) in comparison to the spectrum of typical friction angles (after Terzaghi and Peck, 1967).

3.5 Summary of Anticipated Failure Mechanisms

Table 2 Anticipated Instability Mechanisms Present

Anticipated Instability Mechanisms Present
Primary (Critical) Mechanism – Circular Failure
Instability controlled primarily by shear strength characteristics of the soil materials, the slope angle of the cut face and phreatic conditions within the soil materials.
Secondary Mechanism – Erosion and Piping
Slumping and / or sloughing of any operating, terminal or remediated quarry batter faces and any (temporary) stockpiles, where applicable. This mechanism can lead to the instability of overlying batters if not suitably managed.

3.5.1 Circular Instability (Primary Mechanism)

Circular failures occur in highly disturbed and / or weathered soil / rock materials that typically do not have significant remnant structure. The likelihood for circular instability to manifest is dependent upon the shear strength characteristic of the material and the slope angle of the cut face.

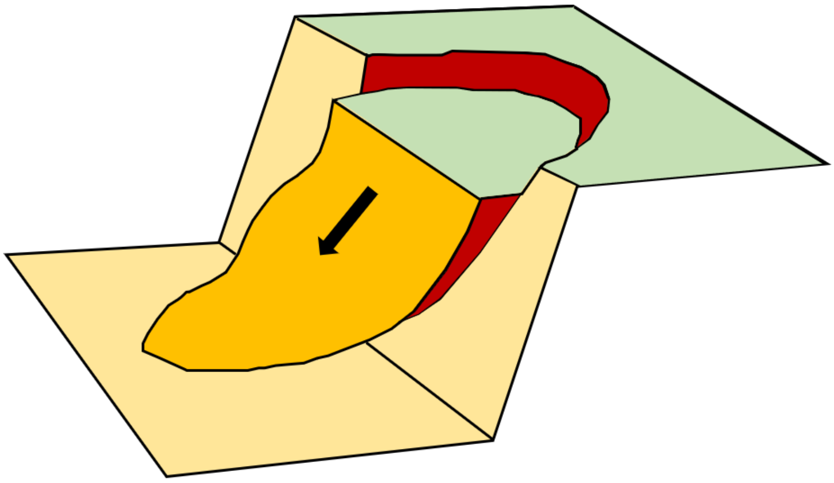

Figure 14 Schematic of a circular failure

Circular failure is dependent upon the shear strength characteristics of the soil materials (e.g., sand resources), the slope angle of the cut face and the phreatic conditions within the soil materials.

Circular failure occurring as a potential failure mechanism has been identified primarily for the overburden and resource units at the site. This failure mechanism is not considered to pose any significant risk, providing adequate surface water management measures are coupled with a suitable pit geometry.

The typical subsurface profile of the proposed development is shown below in Figure 16, which includes cohesive soils (i.e., clays and silts) overly mostly sand resources, with discontinuous and relatively thin layers of interburden (i.e., clays and silts).

3.5.2 Erosion and Piping (Secondary Mechanism)

Erosion of exposed batters has been identified as a secondary instability mechanism which can result as slumping and / or sloughing of operating, terminal or rehabilitated quarry batter faces and any (temporary) stockpiled materials. These potential instabilities can occur due to:

- The presence of highly disturbed material
- Weak planes encountered during excavation of sand resources
- Improper surface water and groundwater management
- Inappropriate construction geometry

Figure 15 *Example of Erosion of Exposed Sand Batters at Nearby Quarry*

Piping can occur as water infiltration or perched water may drain via weak zones in the in-situ materials causing the soil to wash out and undercut overlying batters. This can potentially lead to batter instability if not suitably managed. Based on the encountered materials, it is likely that the primary mechanism of failure is circular failure. Circular failure can also result, particularly where the standing groundwater level interfaces with the exposed sand batters above pond level. Undercutting of the base/foundation could potentially increase the likelihood of circular failure of the overlying batter slope. This instability mechanism can be managed with suitable batter design (including offset from base of slope) and surface water management. The secondary mechanism of potential instability can occur from erosion of exposed batters, as the initiation of instabilities within exposed soil units are usually governed by build of pore water pressures as a result of uncontrolled / excessive surface water ingress. This can lead to a decrease in material strength and eventuate as slumping and / or sloughing of batters.

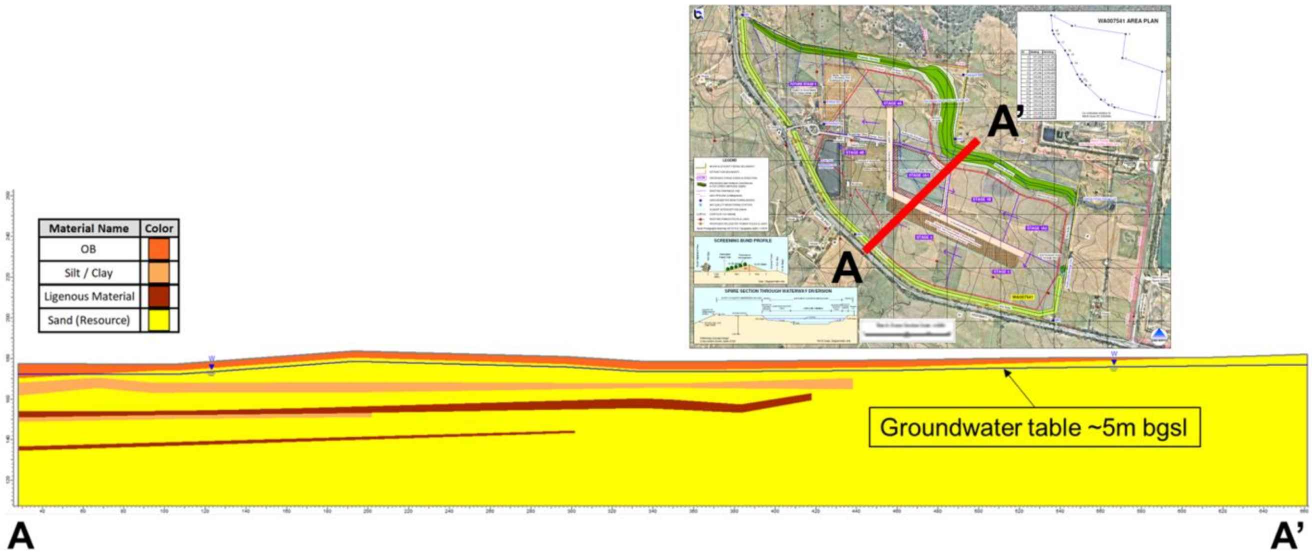

Figure 16 *Subsurface Section Alignment A-A'.*

3.6 Geotechnical Considerations

3.6.1 Seismic Loading

The Melbourne area inclusive of the WA 7541 site is within a relatively intermediate to high risk seismic zone. GHD has undertaken additional stability assessments on the critical slope profiles to determine the sensitivity of the proposed pit to seismic events.

According to the 'Atlas of Seismic Hazard Maps of Australia' 2013, Melbourne and surrounding areas have among the highest Peak Ground Acceleration (PGA) compared to the rest of the nation. The Spectral Acceleration (SA) hazard value at 500 and 2500 year return periods (ARI) are PGA 0.0627 g (refer to Figure 17) and PGA 0.1704 g respectively. Stability assessments have been done in accordance with the CSIRO (2009) guidelines for a 1 in 500 ARI.

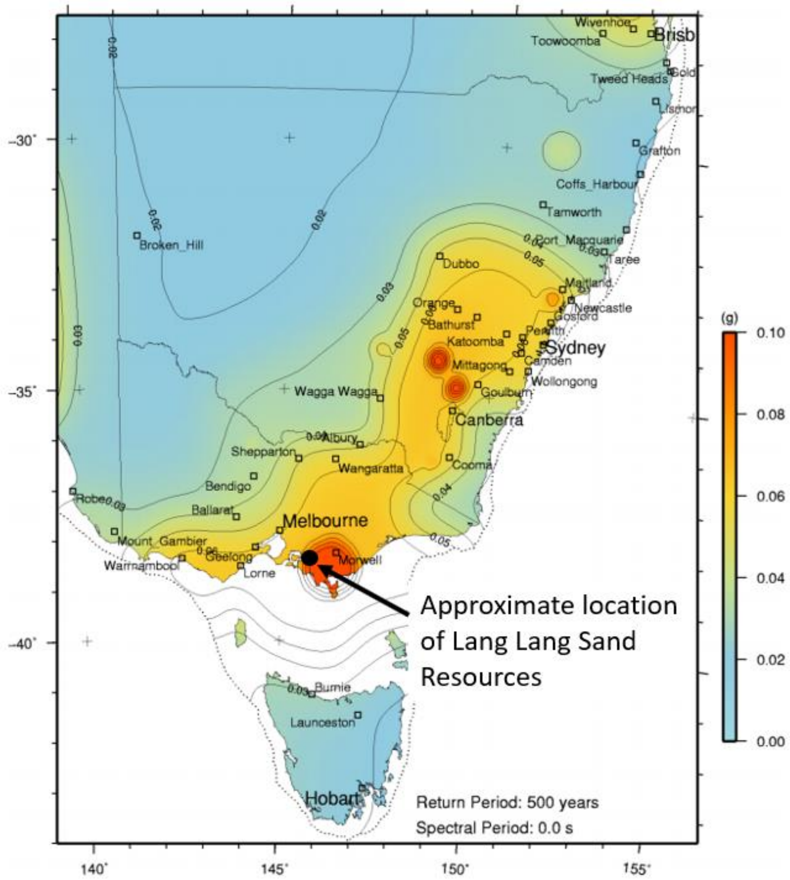

Figure 17 Seismic Hazard Map of Victoria for 1/500 year Return Period

3.7 Data Uncertainty

In the context of quarry operations, data uncertainty arises from the challenges encountered when attempting to quantify the variability in properties and characteristics of the insitu materials (rock / soil) that forms the quarry batters. The uncertainty associated with the materials that form the WA 7541 site can be broadly categorised under three categories, which are: geological uncertainty, material strength parameter uncertainty and model (geometry) uncertainty. By taking a conservative approach for each of the categories listed above e.g. adoption of lower bound strengths, the implications associated with data uncertainty i.e. misrepresentation of stability performance, may be mitigated.

To improve the level of geotechnical understanding of the site once quarrying has commenced, geotechnical inspections of excavated batters may be undertaken to assess stability performance and subsequently verify/refine the material characteristics.

3.8 Design Acceptance Criteria

The nomination of suitable acceptance criteria is a key part of the design and development of stability management protocols. It provides a basis to evaluate the calculated stability performance (e.g. deterministic Factor of Safety (FoS) of batters against the nominated criteria, with due consideration of the likely scale of the potential instability and the associated consequences posed by it. Design acceptance criteria for the proposed site have been nominated in line with accepted industry practice as outlined by DJPR (2020) *Geotechnical guideline for terminal and rehabilitated slopes* for the extractives industry projects, and published precedents as outlined in CSIRO's '*Guidelines for Open Pit Slope Design'*, (Stacey and Read, 2009).

Based on above outlined aspects, and in light of the anticipated risk of instability within the confines of the site, the following design acceptance criteria has been nominated:

– A Factor of Safety of 2.0 is proposed for all Rehabilitated batters
– A Factor of Safety of 1.6 is proposed for Terminal batters
– A Factor of Safety of 1.3 is proposed for Operating batters
– A Factor of Safety of 1.1 for seismic conditions

Table 3 ***FoS Guidelines after ERR (2020)***

Consequence of failure	Examples	Mean FoS
Not Serious	Individual benches; small slopes (< 50 m), temporary slopes, not adjacent to haulage roads	1.3
Moderately Serious	Any slope of a permanent or semi-permanent nature	1.6
Very Serious	Medium sized (50 -100 m) and high slopes (< 150 m) carrying major haulage roads or underlying permanent quarry installations	2.0

3.9 Slope Design Geometry

Presented below in Figure 18 is a depiction of the proposed slope design geometry, which is outlined below.

– Total depth of extraction is expected to be approximately 30 m below current surface level
– Working and rehabilitated profiles of 1V:3H (approx. 18°) above groundwater and 1V:2H (approx. 26°) below
– A 10 m wide beaching bench will be established at the water level

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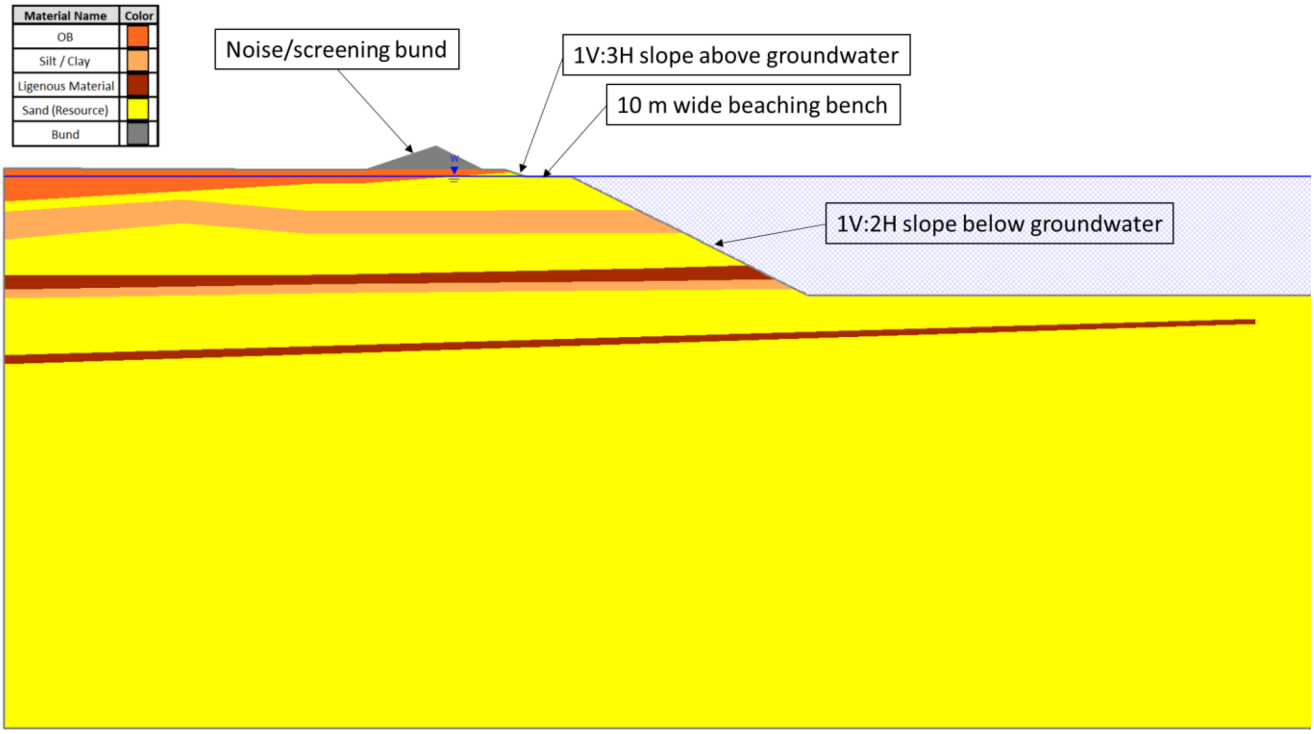

Figure 18 Section A-A' – Critical Pit Geometry

3.10 Stability Performance

The proposed design geometry was assessed as part of the geotechnical assessment undertaken by GHD (2022). In summary the results of the stability analyses results indicate that:

- Based on the proposed method of extraction (crane dredge or dragline dredge) of sand resources below groundwater, a minimum beaching bench width of 10 m is required
- A minimum standoff distance of 6 to 8 metres is required from the crest of the submerged batters to the nearest plant crawler to achieve an operational FoS of 1.2 to 1.3.
- Increasing the offset distance also increases the FoS, however as this crane loading is only for a short term (duration of a month) a FoS of 1.2 can be adopted.
- Critical section A-A' requires an offset distance of 25.5 m to achieve the nominated DAC for terminal batters (FoS > 1.6).
- To achieve the DAC for rehabilitated batters (FoS > 2.0), a minimum offset of 35.5 m will be required.
- The proposed realignment of the waterway to the north / northeast of the proposed WA boundary has a minimum buffer of 40 m to the extraction boundary as stipulated by the water authority, which is greater than the minimum 35.5 m offset distance calculated in the stability analyses. Accordingly, the proposed waterway re-alignment is not likely to adversely impact batter stability.
- Alternative methods of extraction such as floating cutter suction dredging would eliminate the potential for localised instabilities to occur. This excavation method will be investigated further.

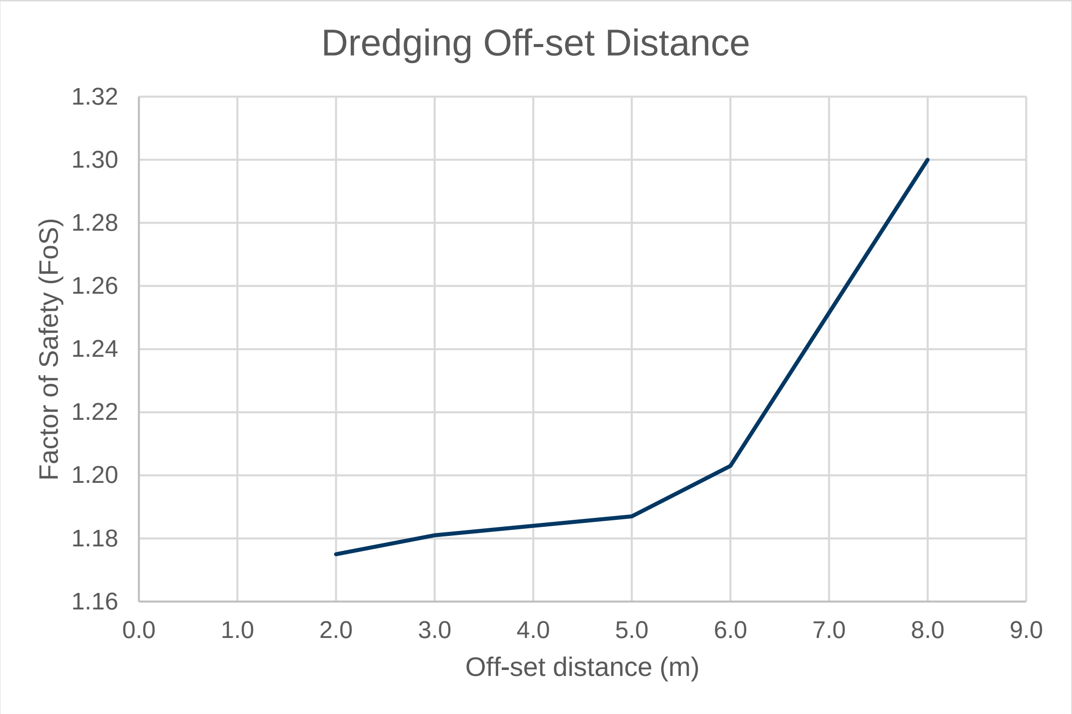

Figure 19 ***Impact of plant off-set distance from crest on batter FoS***

4. Geotechnical Management Process

4.1 General

Outlined within this section are the respective geotechnical and ground stability management protocols that will be implemented at the WA7541 site to ensure that worker safety and risk to external receptors are not compromised.

The overall geotechnical risk management framework within sand quarries such as the ACM Lang Lang site consists of the following considerations:

- Employment of suitable slope formation techniques
- Robust geotechnical monitoring protocols
- Appropriate response approaches to potential geotechnical hazards

Outlined below are the requirements for these considerations within the WA7541 Site.

4.2 Effective Slope Formation at WA7541

Owing to the nature of the soil units within the proposed development, mechanical dredging is undertaken using truck and shovel method for resources above groundwater level. Extraction below groundwater will be undertaken using dredge or dragline.

Whilst the dredge or dragline provides a driving force, excavations below the waterline are supported by quarry lake forces which provide ‘counterweight’ to the submerged batters. Any instabilities which occur below the waterline may manifest as a surficial shear / slump at the beaching point. This will be managed to ensure that the beaching point or submerged batters do not inadvertently undercut the ‘dry’ slopes above. Outlined in this section are the nominated considerations / approaches to mitigate this occurrence.

Where ‘soft’ ground conditions are encountered at the waterline interface a suitably qualified person will inspect the area to ensure geotechnical stability related risks are minimised. Any plant (fixed or mobile) will be located at a safe standoff distance from the crest of the interface. A field bearing capacity assessment, using dynamic cone penetrometers will be undertaken within these locations, prior to undertaking any underwater excavation.

Measures will be undertaken to operate and maintain suitably robust ground conditions at the water line interface, so as to ensure that the material beneath dry slopes are not undermined. A bearing capacity assessment will be undertaken based on the loading of the excavator proposed for extraction. Accordingly, any proposed extraction stockpiles, pads or fixed / mobile equipment will be designed to meet these requirements. Exceeding these requirements may lead to circular failure of the underlying Sand and subsequent affect the stability of the dry batters above.

Dredging will be undertaken at a safe distance from the toe of the waterline interface on which any plant or infrastructure maybe located on to ensure that this zone is not compromised from excavation of the resource.

Additionally, any stockpiling of the excavated / washed material will be undertaken at a safe standoff distance from the crest of the underwater excavation to ensure it is not adversely affected by the stockpile or from leached water. Ongoing management and assessments will be undertaken to determine the safe offset required for stockpiling operations.

This GCMP identifies the potential hazards associated with the dredging process and outlines suitable protocols to be employed to ensure potential geotechnical issues are adequately managed.

4.3 Slope Monitoring requirements

4.3.1 Overview

Monitoring is focused on identifying changes or potential hazards that can be material in governing stability. Ground control monitoring is risk based with the highest priority domains receiving the most attention. The relative monitoring effort has been determined through:

- Risk assessments contained within this document
- Stability assessments – including the development of trigger levels
- Actual field conditions and stability performance history (noting the rehabilitated areas will allow more stable conditions to be achieved, reduced ground movement and optimisation of monitoring requirements in the form of monitoring network intensities and frequencies)

The proposed monitoring system for the WA7541 site will involve the systematic recording of regular visual inspections supplemented with periodic collection of data obtained from a network of survey monitoring points distributed at a relatively wide spacing around the planned pit crest. Refer to Table 4 for timeframes and roles and responsibilities.

If movement is indicated, a more extensive and possibly more sophisticated program can be implemented building upon the initially proposed system.

4.3.2 Visual Inspections

A fundamental element of the WA7541 site slope monitoring program is the visual inspections undertaken by the site production supervisor combined with observations by all personnel working in the quarry. These visual inspections would also encompass the sites material stockpiles (including any temporary stockpiles).

Despite being a qualitative approach, visual monitoring is an extremely important aspect of the program and should be maintained throughout the life of the quarry. Any relevant observations should be recorded in the daily production logs.

4.3.3 Crack Monitoring

If evidence of movement is detected from visual inspection, the first step in augmenting the monitoring program might be simple crack monitoring systems. Results of visual inspection and crack monitoring are a useful guide when selecting additional secondary monitoring points for detailed survey assessments. Crack monitoring at the WA7541 site is expected to consist of:

- Regular detailed mapping of location, depth, width of cracks, rate of extension and opening
- Installation of targets on opposite sides of cracks to monitor rate of opening
- Installation of surface (wireline) extensometers (if deemed necessary)
- Installation of picket lines or lines of targets that can be monitored using theodolites or precise levels to detect changes in alignment, location or elevation along a given crack or the crest of the slope

4.3.4 Survey Monitoring

The most reliable and complete measurements of the 3D movements associated with initial movement could be obtained from conventional survey (prism / pin monitoring) techniques using theodolites. This form of monitoring is considered important for areas that are terminal and rehabilitated.

Accordingly, as batters approach their terminal extents, it is recommended that monitoring pins are installed in proximity to these areas to ensure that stability is maintained and that these areas can be effectively transitioned into the proposed rehabilitated landform.

The survey monitoring system can be installed by site survey personnel, generally with equipment in regular use at the quarry. Geodetic surveys should start by installing a survey network of stable instrument stations and primary monitoring points around the quarry perimeter. This network should be tied to at least three stable reference stations well behind the pit crest.

The nominated monitoring points should be surveyed at regular intervals varying from weekly to quarterly depending on the observed conditions and movement trends. The following survey system consideration should be borne in mind:

Control points for the system should consist of the instrument stations near the crest of a pit slope and reference stations located at least 100 m away from quarrying activities. Control points are usually established by conducting a first-order survey, using conventional survey techniques such as triangulation.

The stability of instrument stations can be checked by resurveying the control network or reference stations each time the instrument station is used. Care must be taken to ensure sufficient observations are made to all reference stations on a regular basis.

Data from the survey monitoring should be plotted and assessed after each set of reading. If movement is detected, monitoring frequency of secondary points will depend on the size of the potential block dimension and movement rates. These protocols are further reflected in the stability management TARP (Trigger Action Response Plan) outlined in Section 4.5.

If instability is detected, additional secondary monitoring points may be established in the area to determine the size, failure geometry and movement rates, and to assist in the planning of remedial measures.

4.4 General Drainage Considerations

Surface drainage and water course diversions should be properly engineered to avoid uncontrolled surface water flows into the quarry. The management protocols in the site specific Surface Water and Groundwater Management Plan should be implemented to ensure that effective management of any potential surface flows across the quarry site.

4.5 Temporary Stockpiles

No permanent stockpiles are planned for this site, however any temporary stockpiles (including any temporary stacked consolidated slimes) will be managed in line with the ACT EPA guidelines for stockpile management (ACT EPA, 2019).

4.6 Trigger Action Response Plan

4.6.1 General

Table 4 provides a hierarchical outline of the slope monitoring procedures that are to be implemented at the WA7541 site. The Trigger Action Response Plan (TARP) associated with the monitoring plan is depicted in Table 5.

Table 4 Summary of Pit Wall Stability Monitoring Procedures

Procedure	Areas	Frequency	Activities	Personnel	Reporting and actions
Daily inspections	All current active mining areas, high-risk areas	Daily	Visual checks for cracking, dilation and scaling requirements	Production Supervisor	Wall inspection book / daily production reports, discussed at daily meeting, and quarry manager (if necessary). Batter and berm inspection forms to be filled and signed off at daily production meeting as required.
Periodic visual inspections of pit perimeter and berms	Pit perimeter and all accessible berms	Weekly to fortnightly and after heavy rainfall	Visual checks for tension cracking, other signs of slope movement and rockfalls	Production Supervisor	Berm inspection form, slopes and berms overlay to pit plan, cracks to be painted and surveyed, advise quarry manager, issue hazard alert as appropriate at production meetings. Refer to Appendix A for inspection form example.
Tension crack monitoring	Cracked areas on pit perimeter and berms	Weekly and as soon as practicable after heavy rainfall. Frequency to be adjusted depending on rates of opening	Measurements of crack widths and visual checks of other signs of slope movement and rockfalls	Quarry Manager	Spreadsheets. Geotechnical consultant to be notified if accelerations noted. Hazard alert to be issued to quarry personnel as appropriate.
Survey (pin / prism) monitoring	Cracked areas around perimeter and on berms, and other designed pit areas	Frequency to be adjusted depending on rates of movement	Survey of changes in prism northings, eastings and elevations	Quarry Surveyor	Geotechnical consultant to be notified if accelerations in movement are noted. Hazard alert to be issued to quarry personnel as appropriate.
Slope Performance Audit	All portions of walls	Upon initial excavation to 5 m depth and 5-yearly thereafter, unless the Quarry Manager is required to engage a geotechnical consultant for any geotechnical concerns	Stability conditions audit	Geotechnical Consultant	Geotechnical consultants audit report.
Slope failure records (hazard alert and incident reports)	Any portion of walls where a rockfall has occurred in ta working area	As required	Complete hazard alert and incident report for the rockfall or failure event	Quarry Manager	Management and senior quarry operations personnel and regulatory agencies.

Table 5 TARP for Slope Condition

Alert	Green	Yellow	Orange	Red
Condition of quarry slopes	Potential for actual fretting, erosion, minor cracks, seepage or ground displacement. (< 25 m^3 in volume).	Potential or actual fretting/erosion of batter face involving ≥ 25 m^3 volume (and < 100 m^3); ground movement / displacement with cracks dilated >5 mm and over 10 m length. Cracks dilated ≤ 20 mm and up to 20 m length. Pooled water ≤ 25 m^2 area.	Potential or actual fretting/erosion of batter face involving ≥ 25 m^3 volume (and < 100 m^3). Ground movement / displacement with cracks dilated >20 mm and over 10 m length. Cracks dilated ≤ 40 mm and up to 20 m length. Pooled water > 25 m^2 area.	Potential or actual fretting/erosion of batter face involving ≥ 100 m^3 volume. Ground movement / displacement with Cracks dilated > 50 mm and over 10 m length. Uncontrolled water flow.
Person Responsible	**Responses**			
Quarry Manager	N/A	N/A	Contact geotechnical consultant and notify personnel of orange alarm level.	Contact Emergency Response Committee, geotechnical consultant and notify personnel of red alarm level.
		Monitor situation as required.	Prepare to evacuate pit. Monitor situation as required.	Evacuate pit, agree on recovery plan, notify corporate, quarry inspectors, emergency services and monitor situation as required.
	Monitor production activities.	Monitor production activities. Communicate with quarry geotechnical engineer.	Liaise with shift supervisor, assess situation and inspect as required. Communicate with geotechnical consultant. Notify stakeholders as required.	Inspect area from outside the failure zone and report to quarry manager. Implement recovery plan once formulated (risk assessment required).

Alert	Green	Yellow	Orange	Red
Shift / Production Supervisor	Report with daily production plan Routine mapping and monitoring.	Monitor slope conditions throughout shift. Report any noticeable change in conditions to the quarry geotechnical engineer. Report any change of conditions or change in TARP level to the next shift.	Communicate with workforce that an orange level has been reached. Closely monitor slope conditions throughout shift. Report any noticeable change in conditions to the quarry manager. Report any change of conditions or change in TARP level to the next shift. Engage with a geotechnical consultant, as required.	Communicate with workforce that a red level has been reached and withdraw personnel and equipment to a safe location. Secure to prevent entry. Inspect area from outside the failure zone and report to superintendent and quarry manager immediately. Implement recovery plan once formulated (risk assessment required).
		Assess area. Determine frequency of inspections, monitoring and remedial work. Notify management of any change. Communicate with quarry workers the location, nature and expected conditions associated with the failure.	Evaluate the monitoring data and provide recommendation for TARP level advance. Assess area. Determine frequency of inspections, increased monitoring and remedial work. Notify management of any change.	Inspect, investigate and formulate recovery plan (formal risk assessment required). Report findings to quarry management.
Quarry worker	Report with daily production plan	Become familiar with location and potential change in pit slope condition during shift. Report any significant change in conditions to shift supervisor. Report with daily production plan.	Elevate level of awareness and monitor pit slope conditions during shift and provide feedback on pit slope conditions.	Comply with emergency evacuation procedures and withdraw to a safe location.

5. Geotechnical Risk Assessment

5.1 General

The geotechnical risk assessment is a quantitative assessment based on the ‘likelihood’ and ‘consequence’ of a major geotechnical hazard occurring.

The qualitative risk assessment process has been utilised, as outlined in the risk assessment matrix presented in Table 7 which aligns with the Australian Standard for Risk Management AS/NZ Standard 4360 (Standards Australia 2004). Table 35 outlines the risk rating acceptability.

5.2 Geotechnical Hazards Identification

Table 6 detailed the findings of this geotechnical assessment and identified geotechnical hazards relating to the proposed quarry design at the WA7541 site:

Table 6 Geotechnical Hazards at the WA7541 Site

Mechanism	Description
Hazard 1 Slumping/erosion of sand batters, slumping of internal stockpiles (including any stacked consolidated slimes stockpiles)	Potential for small scale circular instability, as a result of slumping and / or sloughing of the any operating, terminal or remediated sand batter faces and any (temporary) stockpiles, where applicable. Potential causes for slumping include, but are not limited to: – Highly disturbed materials and/or weak planes encountered during excavation of sand resources. – Improper surface and groundwater management during underwater extraction around the batter faces or periphery of stockpiles – Inappropriate construction geometry. Could occur due to groundwater drawdown in the region surrounding the quarry. Suitable construction of the lower slopes would be required if groundwater levels drop below current levels (i.e., 5 m bgsl).
Hazard 2 Deep seated circular instability	Larger scale slope volume movements that are governed by the soil shear strength characteristics. – Slope instability occurs when the driving forces are greater than the resisting forces. – Movement of this hazard occurs in a circular/rotational manner and is dependent upon the slope geometry, material strength and groundwater conditions. – Consequences of this type of hazard can include partial or full loss of pit crests and impacting working benches / crane pads. – Could occur due to groundwater drawdown in the region surrounding the quarry. Suitable construction of the lower slopes would be required if groundwater levels drop below current levels (i.e., 5 m bgsl). In extreme cases the failure zone may migrate some distance from the pit crest which may exceed the work authority boundary.

Mechanism	Description
Hazard 3 Erosion or piping between nearby quarries.	Represented by small to large volumes of inflow into the excavation. – The failure mechanism (i.e., erosion or piping) could manifest from water flow in the sand between nearby quarries. The consequence of this may range from a minor to full loss of the overlying pit crest but is dependent on volume of flow between the two pits.
Hazard 4a Slumping of sand batters above beaching zone.	Potential for small scale circular instability to occur above the water line (or beaching point). – This mechanism may be exacerbated due to undercutting of the submerged slopes, highly disturbed (very loose) materials, weak planes encountered during excavation of sand resources. This mechanism may also result due to improper surface and groundwater management during underwater extraction or inappropriate construction geometry.
Hazard 4b Slumping of sand batters below beaching zone.	Potential for medium to large scale circular instability to occur due to slumping of batter below the water line, leading to propagation of a failure above the water line. – This mechanism may be exacerbated due to undercutting of the submerged slopes, highly disturbed (very loose) materials, weak planes encountered during excavation of sand resources. This mechanism may also result due to improper surface and groundwater management during underwater extraction or inappropriate construction geometry.

5.3 Risk Management Framework

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. These three stages of the risk assessment process are outlined in further detail in the context of the geotechnical risks associated within the WA7541 site.

Risk analysis involves consideration of the source of risks, their consequences and the likelihood of those consequences occurring. Risks are usually analysed by combining their likelihoods and consequences. The risk evaluation process involves comparing the level of risk derived from the risk analysis with the risk criteria established when the context for the risk management process was considered. The purpose of the risk evaluation is to use the outcomes of risk analysis to decide which risks require treatment, and the treatment priorities.

6. Geotechnical Hazard Management

6.1 Hazard Assessment Process

An ongoing hazard assessment process is applied at the WA7541 Quarry, resulting in risk-based decision-making at all stages of quarry planning, design, development / construction / operations, and progressive rehabilitation / closure. The previous section summarised the anticipated instability mechanisms that pose potential threats to stable ground conditions in the proposed sand quarry. These hazards have been further evaluated as part of the geotechnical risk assessment process, using the risk rating matrix outlined in Appendix A3 of the '*Preparation of Work Plans and Work Plan Variations – Guideline for Extractive Industry Projects',* dated December 2020, prepared by DJPR.

6.2 Geotechnical Hazard Awareness

Regular communication and training are required to be provided to all quarry personnel with regards to geotechnical hazards and the controls which are instated to manage the identified hazards. Site maps can be utilised to identify and highlight geotechnical hazards within the quarry and the respective control measures.

6.3 Geotechnical Hazard Detection

A hazard may be defined as that which has the potential to cause harm or damage. The detection or realisation of geotechnical hazards before they result as ground instabilities is important. This process involves identifying potential geotechnical hazards before it becomes an event. Monitoring and data collection from installed slope monitoring instruments, can assist in identifying potential hazards.

6.4 Risk Matrix

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. These three stages of the risk assessment process are outlined in further detail in the context of the geotechnical risks associated within the proposed WA7541 Quarry as outlined below. Risk analysis involves consideration of the source of risks, their consequences and the likelihood of those consequences occurring. Risks are usually analysed by combining their likelihoods and consequences. The risk evaluation process involves comparing the level of risk derived from the risk analysis, with the risk criteria established, when the context for the risk management process is considered. The purpose of the risk evaluation is to use the outcomes of risk analysis to decide which risks require treatment, and the treatment priorities.

A semi quantitative risk assessment process has been utilised as outlined in the risk assessment matrix below as suggested by Earth Resources Regulation (ERR).

Likelihood	Description	Probability of event occurring
Almost certain	The risk event is expected to occur in most circumstances	**> 90%**
Likely	The risk event is expected to occur in some common circumstances	**70-90%**
Possible	The risk event might occur in some circumstances	**30-70%**
Unlikely	The risk event could occur in some uncommon circumstances, as this is known to occur at comparable sites	**5-30%**
Rare	Highly unlikely, but the risk event may occur in exceptional circumstances, as may have occurred at comparable sites	**< 5%**

Figure 20 ERR Likelihood Descriptions (DJPR, 2020)

Likelihood						
	Almost Certain	Medium	High	Very High	Very High	Very High
	Likely	Medium	Medium	High	Very High	Very High
	Possible	Low	Medium	Medium	High	Very High
	Unlikely	Low	Low	Medium	High	High
	Rare	Low	Low	Medium	Medium	High
		Insignificant	Minor	Moderate	Major	Critical
		Consequence				

Figure 21 ERR Risk Matrix (DJPR, 2020)

Risk level	Description
Very High	Totally unacceptable level of risk. Control measures must be put in place to reduce the risk to lower levels.
High	Generally unacceptable level of risk. Control measures must be put in place to reduce the risk to lower levels or seek specific guidance from ERR.
Medium	May be acceptable provided the risk has been minimised as far as reasonably practicable.
Low	Acceptable level of risk provided the risk cannot be eliminated.
Eliminated	The risk is eliminated.

Figure 22 Risk Rating Acceptability (DJPR, 2020)

Figure 21 must be applied to each identified hazard, by selecting a consequence and likelihood according to the guidelines. The risk matrix is designed to work in conjunction with the site geotechnical log. The log is designed to identify the risk, classify the risk and describe the actions required to minimise the risk.

6.5 Hazard Prevention

Hazard prevention is the most desired outcome of hazard management. Through the implementation of a systematic approach and operational controls as outlined in Section 4 including geotechnical assessment and verification (i.e. Site Monitoring Plan and Data Collection with analysis of data), potential hazards can be identified and measures instated for prevention. These preventative measures are dependent upon the likelihood and consequence of the hazard (e.g. slope failure).

6.6 Geotechnical Hazard Mitigation

Hazard mitigation is the process involving reducing the consequences of a potential ground failure. If the hazard cannot be eliminated, operational and engineering controls must be instated to mitigate or minimise the potential consequences of the hazard.

The following hierarchy of control (Figure 23) can be applied to the mitigation of hazards:

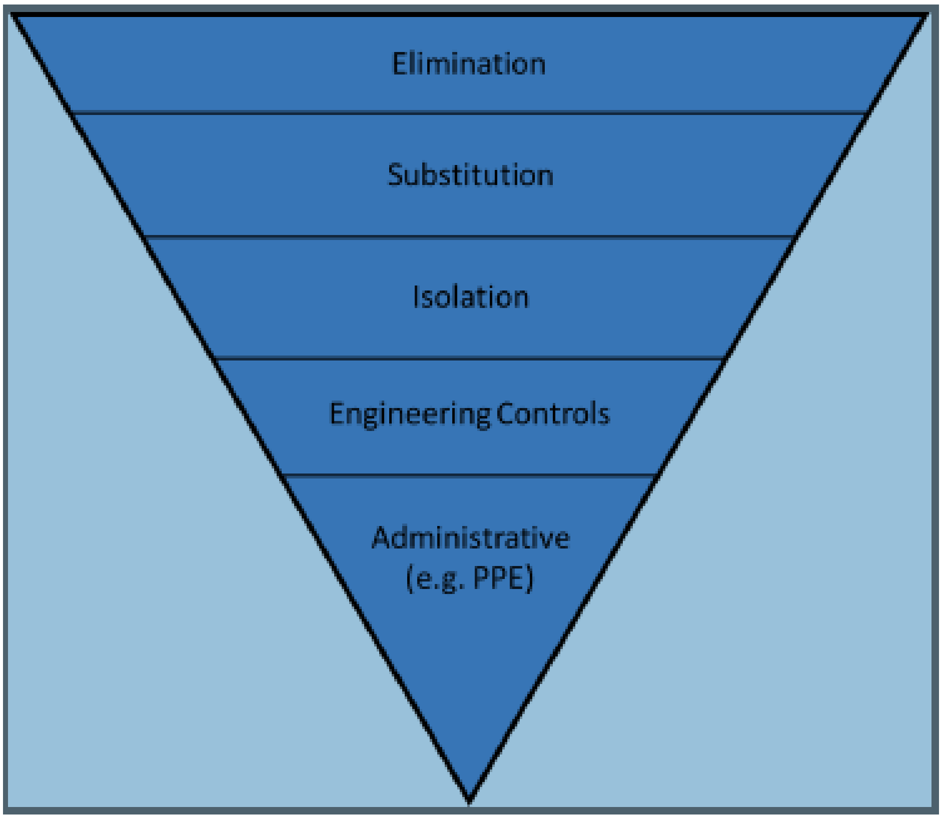

Figure 23 Hierarchy of Controls

- Elimination - The hazard can be quarried out or removed from the site.
- Substitution – Modifications to the quarry design and operational procedures.
- Isolation – Delineating the area of concern to restrict access (e.g. bunding, windrows, fencing etc.).
- Engineering Controls – Revised slope design to improve stability (e.g. buttressing and safety berms etc.) or improving knowledge of slope responses using additional monitoring equipment.
- Administrative – Communication of geotechnical hazards, geotechnical reporting and safety documentation (e.g. safe work method statements (SWMS).

6.7 Risk Register – Site Geotechnical Log

A Geotechnical Risk Register must be kept on site at all times. The register is incorporated into the *Site Geotechnical Log* for simplicity and efficiency. The *Site Geotechnical Log* will be built up over time and have the process for which to close out any required actions, and outline the implemented actions taken to reduce the risk classification (i.e. residual risk). An example of site checklist for assessing geotechnical risks in quarries is provided in Appendix A after the CMPA 'Working Safely with Geotechnical Risks in Quarries', dated February 2016.

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Table 7 WA7541 Quarry Pit Risk Rating

Element at risk	Quarry Boundary	Hazard type	Likelihood	Consequence Category[1]	Risk Rating	Corrective / Management Action(s)	Likelihood	Consequence Category[1]	Residual Risk Rating	Comments
Internal Batters - Personnel safety and Quarry Mobile Plant	All batters	*Hazard Type 1 – Small scale slumping/erosion of sand batters*	Possible	Moderate	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Unlikely	Moderate	Medium	– Establish exclusion zone(s) for pedestrian i.e., on-site personnel – Regular visual observations/monitoring undertaken – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Suitable stand-off distances for haul trucks and vehicles will be maintained from the crest of the underside batter and from the toe of excavated batters. – Bunding will be constructed to reduce the risk of vehicle roll-overs.
		Hazard Type 2 – Deep seated circular instability	Rare	Major	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Rare	Moderate	Medium	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
		Hazard Type 3 – Erosion or piping between nearby quarries.	Rare	Moderate	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater and pond levels; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan	Rare	Minor	Low	– Regular visual observations/monitoring undertaken – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters.
		Hazard Type 4a– Slumping of sand batters above beaching zone. *Hazard Type 4b– Slumping of sand batters water level leading to instability of above water level batters.*	Possible	Minor	Medium	Daily inspections; Suitable as-constructed geometry; Erosion control measures; Dedicated site surface water management plans will be implemented; GPS monitoring and / or prisms and pins should be installed.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel – Regular visual observations/monitoring undertaken – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained. – Where 'soft' ground conditions are encountered at the waterline interface, a geotechnical engineer should inspect the area to ensure stability related risks are minimised. – Any plant (fixed or mobile) should be located at a safe standoff distance from the crest of the interface. A field bearing capacity assessment, using Dynamic Cone Penetrometers, should be undertaken within these locations, prior to undertaking any underwater extraction (min. blow count 6 per 100 mm of penetration).

[1] Determined on the basis of the critical credible or reasonable outcome, which takes into consideration the temporal exposure of at-risk elements.

Element at risk	Quarry Boundary	Hazard type	Likelihood	Consequence Category[1]	Risk Rating	Corrective / Management Action(s)	Likelihood	Consequence Category[1]	Residual Risk Rating	Comments
Quarry infrastructure	Internal	*Hazard Type 1 – Small scale slumping/erosion of sand batters*	Possible	Moderate	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Suitable stand-off distances for haul trucks and vehicles will be maintained from the crest of the underside batter and from the toe of excavated batters. – Bunding will be constructed to reduce the risk of vehicle roll-overs.
		Hazard Type 2 – Deep seated circular instability	Possible	Minor	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
		Hazard Type 4a – Slumping of sand batters above beaching zone. *Hazard Type 4b– Slumping of sand batters water level leading to instability of above water level batters.*	Possible	Moderate	Moderate	Daily inspections; Suitable as-constructed geometry; Erosion control measures; Dedicated site surface water management plans will be implemented; GPS monitoring and / or prisms and pins should be installed.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel – Regular visual observations/monitoring undertaken – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained. – Where 'soft' ground conditions are encountered at the waterline interface, a geotechnical engineer should inspect the area to ensure stability related risks are minimised. – Any plant (fixed or mobile) should be located at a safe standoff distance from the crest of the interface. A field bearing capacity assessment, using Dynamic Cone Penetrometers, should be undertaken within these locations, prior to undertaking any underwater extraction (min blow count 6 per 100 mm of penetration).
Stockpiles	Internal	*Hazard Type 4a*: Slumping of stockpiles	Unlikely	Minor	Low	Stockpiles designed in accordance with DPI (2010); Surface water managed in accordance with site instituted surface water management plan; Avoid saturation of the stockpiled material.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian i.e., on-site personnel – Regular visual observations/monitoring undertaken – Avoid quarry activities that would knowingly decrease the stability of stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained. – Ensure that foundation area of stockpiles is suitable prior to placement. – Suitable stand-off distances for haul trucks and vehicles will be maintained from the toe of any stockpiled material.
South Gippsland Highway	West and South	*Hazard Type 2 – Deep seated circular instability*	Rare	Moderate	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control;	Rare	Moderate	Medium	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material.

Element at risk	Quarry Boundary	Hazard type	Likelihood	Consequence Category[1]	Risk Rating	Corrective / Management Action(s)	Likelihood	Consequence Category[1]	Residual Risk Rating	Comments
						Surface water managed in accordance with site instituted management plan.				– Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
Noise/ screening bund	West and South	Hazard Type 2 – Deep seated circular instability	Unlikely	Moderate	Medium	Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
Beach Energy (Bass Gas) Plant	East / North Eastern	*Hazard Type 2 – Deep seated circular instability*	Rare	Major	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Rare	Moderate	Medium	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
Residential Property	West, East and South	*Hazard Type 2 – Deep seated circular instability*	Rare	Moderate	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Unlikely	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).
Realigned waterway (MW asset RD2504)	North and North East	*Hazard Type 2 – Deep seated circular instability*	Rare	Major	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Rare	Moderate	Medium	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Avoid quarry activities that would knowingly decrease the stability of batters and stockpiles, i.e., undercutting. These stockpiles (including any temporary stacked consolidated slimes stockpiles) will be maintained in accordance with the ACT EPA (2019) guidelines. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).

Element at risk	Quarry Boundary	Hazard type	Likelihood	Consequence Category[1]	Risk Rating	Corrective / Management Action(s)	Likelihood	Consequence Category[1]	Residual Risk Rating	Comments
Access Road	East	*Hazard Type 2 – Deep seated circular instability*	Rare	Major	Medium	GPS monitoring (movement); Regular inspections for signs of instability; Monitoring of groundwater; Geotechnical excavation control; Surface water managed in accordance with site instituted management plan.	Rare	Minor	Low	– Establish exclusion zone(s) for pedestrian, i.e., on-site personnel. – Regular visual observations/monitoring undertaken. – Ensure surface water drainage systems are adequately maintained to reduce water ingress into slope material. – Pond water levels should be maintained to minimise the potential for instability of submerged batters, as lowering of the pond may result in instabilities occurring in previously submerged batters. – Groundwater monitoring data will be collected regularly to identify any adverse trends (if any).

6.8 Risk Assessment Results

The geotechnical risk assessment for WA7541 site is summarised in Table 7.

Based on the risk assessment presented below, the residual risk to external receptors has been assessed to be “Low”.

7. Quarry Closure and Rehabilitation

7.1 Rehabilitation Strategy

The following progressive rehabilitation strategies are recommended for the WA7541 Quarry site:

– Store all topsoil for use on site that can later be used to cover and revegetate disturbed land, and thereby reducing surface erosion and improving slope stability. Where possible topsoil will be used in the creation of 'self-sustaining' landforms that are vegetated with indigenous flora sourced from the local area, be of local provenance, and be appropriate to the site's Ecological Vegetation class.
– Store overburden in stockpiles for future use e.g. select back fill material. These stockpiles will be constructed and maintained in line with the EPA publication 'Construction Techniques for Sediment Pollution Control', to ensure the likelihood of erosion related instabilities (slumping / sloughing etc.) are mitigated.

As far as practicable, progressive rehabilitation should be incorporated into daily operations to achieve the best outcome.

– The following long-term rehabilitation strategies are recommended for the WA7541 Quarry site:
– Undertake final landform slope stability and erosion assessments to understand the nature of the final rehabilitation concept.
– Undertake ground movement and groundwater monitoring at regular intervals until revegetation has established and rehabilitated batters are 'self-sustaining', safe and stable as defined in Section 1.2.
– Should there be any material changes to the stability conditions at the site, the stability assessment and the long-term rehabilitation plan should be reviewed accordingly.

7.2 Erosion Management

An erodibility potential analysis was undertaken by GHD (ref) for the proposed rehabilitation plan. The outcomes are summarised below.

– After 12 months, the estimated soil loss for topsoiled, pre-vegetated batters is 'Very Low' based on the Erosion Hazard guidelines put forward by Morse and Rosewell (1996) and also satisfies the criteria set out by Commonwealth of Australia (2016) (i.e., less than 4.5 t/ha/yr.).
  - However, in accordance with section 89E of the Miner Resources (Sustainable Development) Act 1990, quarry owners are required (requirement no. 42) to rehabilitate the site to a state which is suitable for the planned final use, where vegetation is consistent with the final land use.
  - The erosion assessment indicates that through the establishment of vegetation, the long-term erosion rate for rehabilitated batters satisfies the Commonwealth of Australia (2016) guidelines (i.e., <4.5 t/ha/yr.) after 12 months.

Erosion monitoring and management is an ongoing procedure and is to be undertaken in line with Table 8. Maintenance will be undertaken to ensure that erosion rates are within the Commonwealth of Australia (2016) guidelines.

Table 8 Proposed Erosion Monitoring Criteria

Item	Rehabilitation / Closure Criteria	Elements to be Monitored	Frequency
Erosion (All areas of the site)	**Operationally** No erosion channels greater than 200 mm deep and/or wide: remedial action initiated immediately No more than 5 erosion channels greater than 150 mm deep and/or wide within a 20 m wide area remedial action initiated immediately **At Closure**	**Operationally** Erosion channels greater than 150 mm deep or wide recorded & photographed for follow up. **At Closure** Any visible erosion channels recorded and photographed for follow up.	**Operationally** 6 Monthly Additional inspections after significant rainfall events. **Post Closure** Y1 - 2 Monthly Y2 - 3 Monthly Y3 - 6 Monthly

Item	Rehabilitation / Closure Criteria	Elements to be Monitored	Frequency
	No erosion channels greater than 50 mm deep and/or wide: remedial action initiated immediately No more than 5 erosion channels greater than 20 mm deep and/or wide within a 20 m wide area remedial action initiated immediately		Y4 - 12 Monthly Additional inspections after significant rainfall events.

8. Review and Audit

This GCMP is considered to be 'live' document, i.e. requires continual review and is to be updated as required. In general, updates to this GCMP should include, at a minimum, the following:

Site geotechnical conditions and hazard management

- Review of ground control management.
- Review of data collection and monitoring.
- Stability and suitability (i.e. safe and stable) of quarry pit design
  - The outcomes of the geotechnical inspections undertaken of the excavated batters can assist with assessing stability performance and subsequently verify/refine the material characteristics adopted for the site. This observational approach is considered suitable for the site and the outcomes of which can be utilised to update this GCMP, as required.
- Implementation of the GCMP.
- Compliance with this GCMP.
- Effectiveness and validity of this GCMP.
- Responsibilities and accountabilities are being met.

8.1 Triggers For Geotechnical Review

In addition to regular reviews, the below triggers also require for a geotechnical review to be performed:

- Undertake a stability assessment review subsequent to the exposure of approximately 5 m depth of sand resource within the initial excavations (i.e., initial stability assessment). The intent of this is to validate the parameters (material strengths) and slope geometry analysed in this pre-development assessment.
  - As part of this review, stability analyses of an additional stability section will be undertaken (i.e., an additional section to those undertaken in the GHD (2022) report titled '*5575 South Gippsland Highway, Lang Lang – Geotechnical Assessment'* (GHD ref: 12527040-94528-26, dated 13 September 2022). If required, the outcomes of this geotechnical assessment will be updated based on further geotechnical understanding of the site conditions.
  - In addition to the above, the outcomes of the 'initial' stability assessment will be utilised to validate the pre-development geometry (presented in this assessment), material properties and stability of the slope design. Specifically, if required, the material strengths (of the site soils), site observations (i.e., batter stability performance) recorded during development of the initial 5 m depth, any geotechnical testing information, groundwater and surface water considerations and slope geometry will be updated to reflect observed site conditions and the requirements of geotechnical guidelines.
- Five-yearly reviews are to be performed by a suitably qualified and experienced person. Items which must be addressed in each review may include the items listed above, in addition to any site specific considerations.
- Reviews will be undertaken by a geotechnical consultant in response to triggering events, as set out in the TARP (Table 5), where the Quarry Manager is required to engage a geotechnical consultant.

9. References

ACT Environment Protection Authority (2019), Guideline for Stockpile Management, ACT Government, November 2019.

Australian Standards 1726 (2017) – 'Geotechnical Site Investigations'.

Carillo-Rivera, J. J. (1975). Hydrogeology of Western Port, *Geological Survey of Victoria Survey Report*, *1*.

Casagrande, A., 1948. *Classification and identification of soils*. Transactions, ASCE, vol. 113, pp901-930.

CMPA, 2016, '*Working Safely with Geotechnical Risks in Quarries'*, Guideline prepared by the Construction Material Processors Association (CMPA), February, 2016, Issue 1.

DJPR, 2020, '*Preparation of Works and Work Plan Variations – Guideline for Extractive Industry Projects',* Department of Jobs, Precincts and Regions, December 2020.

DJPR, 2020, *'Geotechnical Guidelines for Terminal and Rehabilitated Slopes: Extractives Industry Projects,* Department of Jobs, Precincts and Regions, September 2020.

DPI, 2010, '*Code of Practice for Small Quarries'*, Department of Primary Industries (DPI), Earth Resources Regulation (ERR)

DELWP, 2019, Water Management Information System (WMIS), Department of Environment, Land, Water & Planning, Online Access - http://data.water.vic.gov.au/. Last accessed: 15 October 2019.

Geoscience Australia (2021). *Earthquakes@GA Database*, Geoscience Australia, Canberra, accessed 15 February 2021.

Geoscience Australia (2020). *Australian Neotectonics Database*, Geoscience Australia, accessed 30 November 2020.

GeoVic (2014). Victorian Surface Geology (Seamless Geology 2007-2014) database. Retrieved from: http://er-info.dpi.vic.gov.au/sd_weave/anonymous.html on 19 August 2020.

GHD (2022). 5575 South Gippsland Highway Geotechnical Assessment, GHD Ref: 12527040-45542-13, dated 30 March 2022. (GHD, 2022)

Mark. L., Burbidge, D. R., Edwards, M., 2013. Atlas of Seismic Hazard Maps of Australia: Seismic Hazard Maps and Hazard Spectra. *Record 2013/41:* Geoscience Australia: Canberra.

McAndrew, J. & Marsden, M. A. H. (1973). *Regional guide to Victorian geology*. [Melbourne] School of Geology, University of Melbourne.

Read, J., Stacey, P., 2009. *Guidelines for Open Pit Slope Design*, first edition, CRC Press, published 18 November 2009.

Standards Australia and Standards New Zealand (2004) – AS/NZS 4360:2004 – 'Risk Management', Sydney, NSW.

VandenBerg, A.H.M., 1997. Warragul SJ 55-10 Edition 2, 1:250 000 scale Geological Map Series, Geological Survey of Victoria.

VandenBerg, A. H. M. (2016). Depositional Facies and Extent of the Late Neogene Sandringham Sandstone in Southern Victoria, Australia, *Proceedings of the Royal Society of Victoria*, *128*, 7-24.

Wallace, M. W., Dickinson, J. A., Moore, D. H. & Sandiford, M. (2005). Late Neogene strandlines of southern Victoria: a unique record of eustasy and tectonics in southeast Australia, *Australian Journal of Earth Sciences*, *52*, 279-297.

Welch, S. I., Higgins, D. V. & Gallaway, G. A. (2011) eds. Surface Geology of Victoria 1:250 000, Geological Survey of Victoria, Department of Primary Industries.

9.1 Relevant Acts

– Environment Protection Act 2017 (Vic)

- Environmental Protection and Biodiversity Conservation Act (1999) Cth
- Flora and Fauna Guarantee Act (1988) (Vic)
- Mineral Resources (Sustainable Development) Act 1990 (Vic)
- Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2019.
- Occupational Health and Safety Act 2004 (Vic)
- Occupational Health and Safety Regulations (2017) (Vic)
- Planning and Environment Act 1987 (Vic)
- State Planning Policy Framework (SPPF, Vic)
- Water Act 1989 (Vic)

9.2 Legislation and Guidance Documents

Commonwealth of Australia (2016), 'Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry, Commonwealth of Australia 2016

DJPR (2020), '*Geotechnical Guidelines for Terminal and Rehabilitated Slopes*', Department of Jobs Precincts and Regions, September 2020

Read, J., Stacey, P. (2009) 'Guidelines for Open Pit Slope Design', first edition, CRC Press, published 18 November 2009

9.3 Relevant Site Documentation/Studies

GHD (2022). 5575 South Gippsland Highway Geotechnical Assessment, GHD Ref: 12527040-45542-13, dated 30 March 2022. (GHD, 2022)

Appendices

Appendix A

Quarry Inspection Sheet

ADVERTISED PLAN

General Slope Stability Checklist

<table>
<tr><th colspan="5">General Slope Stability Checklist</th></tr>
<tr><td>Date of Inspection</td><td></td><td>Inspected by</td><td colspan="2"></td></tr>
<tr><td colspan="3">Area of Observation</td><td colspan="2">Action Required</td></tr>
<tr><td colspan="3">Benches, Berms and Haul roads</td><td>Yes</td><td>No</td></tr>
<tr><td colspan="3">Benches and haul roads stable and without signs of failure (e.g., significant cracking, slumping)</td><td></td><td></td></tr>
<tr><td colspan="3">Wide enough for vehicles and suitable rockfall protection and sufficient toe/ bench catch capacity, debris build-up on benches, loss of bench width (e.g., from erosion or underlying batter instability)</td><td></td><td></td></tr>
<tr><td colspan="3">Adequate passing areas</td><td></td><td></td></tr>
<tr><td colspan="3">Drainage in place and is adequate/effective</td><td></td><td></td></tr>
<tr><td colspan="3">Access and haul roads in good condition, free draining and without signs of movement (e.g., cracking, slumping)</td><td></td><td></td></tr>
<tr><td colspan="3">Edge Protection Berms (or windrows) in place and in order, suitable drainage installed</td><td></td><td></td></tr>
<tr><td colspan="3">Unstable ground (e.g., cracking, loose, fractured, saturated)</td><td></td><td></td></tr>
<tr><td colspan="3">Geological conditions (e.g., loose pockets of material, unfavourable weathering, orientation and intersection of geological structures such as faults, joints, bedding)</td><td></td><td></td></tr>
<tr><td colspan="3">Adverse drainage conditions from access roads</td><td></td><td></td></tr>
<tr><td colspan="3">Stockpiles, Surge Piles and Overburden Dumps</td><td></td><td></td></tr>
<tr><td colspan="3">Installation of edge protection (windrows) to an adequate height where dumping is performed at the top of the stockpile/tip or overburden dump</td><td></td><td></td></tr>
<tr><td colspan="3">Cracking on the surface and crest of the stockpile, heave at the toe of the stockpile or surface water pooling/ponding</td><td></td><td></td></tr>
<tr><td colspan="3">Evidence of undercutting or undermining (i.e., oversteepening) of the stockpile</td><td></td><td></td></tr>
<tr><td colspan="3">Washouts (e.g., run-off related erosion) from rainfall</td><td></td><td></td></tr>
<tr><td colspan="3">Condition/integrity of physical barriers around previous unstable areas or barriers/fences preventing access (i.e. exclusion zones around undercut stockpiles)</td><td></td><td></td></tr>
</table>

Where practical, draw point on surge piles identifiable		
Suitable lighting provided for active areas		
Installation of windrows (edge protection) to an adequate height where dumping is performed.		
Dams and Ponds		
Cracking of earthen slope		
Changes in quantity of seepage, if seepage exists or is anticipated		
Significant erosion in proximity to spillway/overflow		
Significant shrinkage surrounding any pipe work through slope or significant loss of material surrounding any pipes		
Pit Surrounds		
Drainage away from pit, including storm water and surface water		
Any water ponding or normal face water disappearing		
Condition/integrity of physical barriers around previous unstable areas or barriers/fences preventing access		
Surface settlement or subsidence, significant cracking near pit crest		
Signage		
Exclusion Zones signposted for Unstable Faces or other unstable slopes		
Entrance to Pit Requirements signposted, i.e. 10/20/30 Rule/Radio Contact prior to entry		
Warning signs posted at Sediment Ponds, Water Dams		
Crests		
Lowering of ground surface at or behind the crest of the overall slope/bench		
Water running over the crest of the overall slope/bench		
Water entering cracks behind the crest of the overall slope/bench		
New accumulations of water behind the crest of the overall slope/bench		
Surcharging of ground behind the crest of the overall slope/bench		
Tension cracks increasing in size and/or offsets, sliding of one face of the crack		
Edge Protection Berm (windrows) in place and in order		

Faces		
Bulging of the slope face		
Erosion or mass movement of slope materials down the slope		
Settlement of slope face		
Displacement across joints/bedding planes		
Open structural features inclined > 10 degrees out of the face		
Open structural features inclined steeply > 70 degrees out of the face		
Loose material or overhanging material on the face		
Irregular slope gradient		
Irregularities in plan of the slope face		
Excessive water seepage, surface water disappearance		
Drainage blankets blocked		
Overhanging rock above working faces/roadways, not protected by rock traps		
Signs of active/recent failure of the face including bulging of the face and/or sagging of the face		
Slope deterioration or deformation (batter, bench, floor bulging or toe heave)		
Toe		
Ground movements at or in front of the toe of the overall slope/bench		
Water seeping from or in front of the toe of the overall slope/bench		
New accumulation of water at the toe of the overall slope/bench		
Excavations at or near toe of structure not as per design of quarry/tip		
Falling Rock Protection Berm in place and in order		
Bulging or undercut toe		
Waterlogging at or near slope toe		
Other observations		

Crest, Face and Toe Stability Checklist

<table>
<tr><th colspan="6">Crest, Face and Toe Stability Checklist</th></tr>
<tr><td>Date of Inspection</td><td></td><td>Inspected by</td><td colspan="3"></td></tr>
<tr><th colspan="4">Area of Observation</th><th colspan="2">Action Required</th></tr>
<tr><th colspan="4">Crests</th><th>Yes</th><th>No</th></tr>
<tr><td colspan="4">Lowering of ground surface at or behind the crest of the overall slope/bench</td><td></td><td></td></tr>
<tr><td colspan="4">Water running over the crest of the overall slope/bench</td><td></td><td></td></tr>
<tr><td colspan="4">Water entering cracks behind the crest of the overall slope/bench</td><td></td><td></td></tr>
<tr><td colspan="4">New accumulations of water behind the crest of the overall slope/bench</td><td></td><td></td></tr>
<tr><td colspan="4">Surcharging of ground behind the crest of the overall slope/bench</td><td></td><td></td></tr>
<tr><td colspan="4">Tension cracks increasing in size and/or offsets, sliding of one face of the crack</td><td></td><td></td></tr>
<tr><td colspan="4">Edge Protection Berm (windrows) in place and in order</td><td></td><td></td></tr>
<tr><th colspan="4">Faces</th><th></th><th></th></tr>
<tr><td colspan="4">Bulging of the slope face</td><td></td><td></td></tr>
<tr><td colspan="4">Settlement of slope face</td><td></td><td></td></tr>
<tr><td colspan="4">Displacement across joints/bedding planes</td><td></td><td></td></tr>
<tr><td colspan="4">Open structural features inclined > 10 degrees out of the face</td><td></td><td></td></tr>
<tr><td colspan="4">Open structural features inclined steeply > 70 degrees out of the face</td><td></td><td></td></tr>
<tr><td colspan="4">Loose material or overhanging material on the face</td><td></td><td></td></tr>
<tr><td colspan="4">Irregular slope gradient</td><td></td><td></td></tr>
<tr><td colspan="4">Irregularities in plan of the slope face</td><td></td><td></td></tr>
<tr><td colspan="4">Excessive water seepage, surface water disappearance</td><td></td><td></td></tr>
<tr><td colspan="4">Drainage blankets blocked</td><td></td><td></td></tr>
<tr><td colspan="4">Overhanging rock above working faces/roadways, not protected by rock traps</td><td></td><td></td></tr>
<tr><td colspan="4">Signs of active/recent failure of the face including bulging of the face and/or sagging of the face</td><td></td><td></td></tr>
</table>

Slope deterioration or deformation (batter, bench, floor bulging or toe heave)		
Toe		
Ground movements at or in front of the toe of the overall slope/bench		
Water seeping from or in front of the toe of the overall slope/bench		
New accumulation of water at the toe of the overall slope/bench		
Excavations at or near toe of structure not as per design of quarry/tip		
Falling Rock Protection Berm in place and in order		
Bulging or undercut toe		
Other observations		

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