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То:	Cheryl Ward & Shari Rankin	From:	Rod Huntley
Cc:	David Brown & Jemima Krzyzanski	Our Ref :	5016_260_005
Re:	Blue Hills Geotechnical Summary	Date:	March 2023

Geotechnical Work Completed

To assess the rock mass characteristics and pit design criteria for the proposed Blue Hills Quarry the following works have been completed.

- Constraints Assessment
- Field geotechnical mapping
- Pit location assessment and environmental sensitivity analysis
- Materials testing and petrology
- Three phases of drilling with the latest phase of drilling completing downhole optical and acoustic imaging.
- Conceptual groundwater assessment
- Pit design iteration and finalisation
- Volume Estimation and development of initial pit design criteria.

These inputs have been used to develop a geotechnical model for the site, which has been summarised in this precis. Relevant plans for the proposed quarry are included as:

- Drawing 5016_012 Site Location Plan
- Drawing 5016_017A Site Orthophoto and Topography
- Drawing 5016_014 Nearest Sensitive Receptors
- Drawing 5016_008 Regional Geology
- Drawing 5016_021 Proposed Final Pit Extent
- Drawing 5016_021A Proposed Final Pit Cross Sections A-A' to C-C'.
- Drawing 5016_023C Surface Water Layout Plan
- Drawing 5016_025 Groundwater and Drill Results Summary

While much of the background work has been done a final comprehensive report will be prepared pursuant to the relevant guidelines when the approval pathway is finalised.

Pit Location Assessment

As part of assessing viability for a potential site on the available land holdings, multiple locations were considered with most sites negated early due to an unfavourable setting with respect to nearby sensitive receptors. This issue quickly led to the southern portion of the land being considered clearly more favourable, as quarry related impacts could be more successfully managed using the available topography and attenuation of impacts by distance, design rationale. Once this initial assessment was completed a reconnaissance drill campaign was then completed to identify general rock mass characteristics the degree of weathering and general lithologies on site.

Resultant of these assessments a lower lying portion of the site, nestled between two significant ridgelines was identified as being a potentially favourable location with respect to the closest northern sensitive receptors. Importantly the proposed quarry site is shielded by a prominent ridgeline with the height of this ridgeline rising up to approximately 350 mAHD. The bench level of the northern face of the quarry is approximately 290 mAHD with a small portion of the north east corner having a bench level of 305m AHD. Much of the north-western portion of the top quarry bench is at 275m AHD, which allows for significant shielding of noise, dust, and visual amenity impacts. The quarry will not be visible from the nearest sensitive receptors. The closest sensitive receptor to the proposed site, refer Drawing 5016_014 is a house approximately 1360 metres to the north, while all other sensitive receptors occur at distances greater than two kilometres to the quarry.

Once this potential site was identified more detailed work was completed on this area which involved detailed site geological mapping and structural assessment, collection of samples for an initial material quality assessment and two additional phases of drilling.

Field Geotechnical Mapping

To further assess the hornfels resource for viability geotechnical field mapping was completed in the proposed quarry area as significant levels of geological outcrop-subcrop occur on site. As background to the geology of the area the resource is hosted in the Ordovician age Castlemaine Group which are variously described as cordierite to biotite hornfels rocks along with rarer calc silicate units, refer Drawing 5016_009.

In the area of interest the variably weathered *insitu* hornfels is a prominent feature of the drainage lines, where over the millennia surface water has eroded away the topsoil and weathered rock profile, refer Plates 1 and 2. Bedding and remnant sedimentary structures (fluting and lode casts) are still evident in much of the hornfels with the bedding, while variable, commonly recognised as dipping very steeply to the south, with dip directions ranging between 170 and 250 degrees. Dips ranged between 67 and 88[°] and are considered to reflect the impacts of intrusion of the large Devonian granite body which occurs approximately 650 metres to the east of the eastern quarry bench. This mostly westerly dip makes good sense as the eastern granite is interpreted to have intruded up and under the hornfels resulting in steep westerly dips in this area

Minor folding is also recognised while the main drainage features are interpreted to be stress relief planes which radiate in a generally perpendicular orientation from intrusion the main granite body. No granite apophysis or dykes were recorded in outcrop although several zones of buck quartz swarming occur within the resource area. This quartz enrichment demonstrates secondary fluid movement into zones of dilation although volumetrically and spatially they are small, generally less than 5 x 5 meters in surface extent and are not expected to have any material impact on pit design criteria ore geotechnical stability. As displayed in outcrop the key features of the cordierite hornfels are:

- Of pelitic to psammitic origin which displays localised bedding and banding however, is massive in part typical of a bulk deposited turbidite flow.
- Individual beds range between 100mm and 2000mm thick.
- Is variably weathered however weathering appears to be of localised impact and is deeper adjacent to the drainage lines which cut the area.
- In outcrop is commonly of high strength, pursuant to AS1726-2017 requiring 7-8 blows to fracture the rock mass.
- On a local scale appears to be meta greywacke/sandstone rich hornfels with only lessor meta pelitic units noted in the hornfels assemblage.

Pit location assessment and environmental sensitivity analysis

In assessing the extent of the pit, environmental values have been integral to the design and have been designed around, where practicable. This key design philosophy of practical integration is guided by the outcome of relevant studies. In short, the quarry pit area has been reverse engineered in an attempt to minimise salient and important impacts. Designing around these issues manifests in the following tangible outcomes:



Plate 1 : Is typical of the amount of outcrop and exposure which is evident in the drainage lines on site. The bulk of the hornfels dips steeply to the west and south.



Plate 2 : A further example of outcrop which shows remnant sedimentary features being lode casts and flute structures in the hornfels.

- The main waterway has not been disturbed been and a one hundred metre wide buffer has been left to the waterway.
- The bulk of the tributaries and ephemeral gullies in the pit area are not impacted at all with a 30 metre wide buffer left to these features.
- The main scar tree recognised has been left insitu, with the northern boundary pulled south to leave an adequate buffer to the tree.
- Buffers have been left to the western road reserve while many of the large established trees in this stockpile area can be retained and will simply be worked around.
- Direct rainfall, or waters which impact with the working will be harvested in a sump and reused for dust suppression purposes.
- Clean surface water will be diverted away from the quarry workings.

Materials Testing and Petrology

To understand the engineering performance of the rock mass bulk sampling was completed on surface outcrop and drill cuttings with the results summarised below, refer Table 1, and Attachment 1 for a copy of the NATA certified test certificates and petrology reports. Point load testing for geotechnical modelling was also completed along with a sample submitted for Polished Aggregate Friction Value. Typical engineering parameters for rock mass quality of construction materials were also assessed with density, degradation factor, wet strength at 10% fines, SSS and Los Angeles Abrasion values tested for.

In summary the testing has demonstrated that the rock has an exceptionally high skid resistance, with a Polished Aggregate Fraction Value PAFV of 62. Practically, this will make asphalt aggregate from the quarry enhance safety outcomes for road works, as the common PAFV values of most rocks is a PAFV of 45-48. Regarding strength, durability and chemical inertness, the hornfels similarly passes all tests and can be considered a very high quality rock when considered against the relevant specifications for construction materials. The rock is chemically inert.

Drill Data

To assess relevant engineering rock parameters three phases of drilling have been completed on site, with the location of the drill holes shown on Drawing 5016_025. 2016 Drilling

The first drilling completed by Mawsons was in 2016, with broad scale percussion drilling completed across the larger area with drilling assessing the extent of the hornfels, the thickness of the scree and

the approximate location of the eastern granite body. The hole numbers for this drill program were PC16-01 to PC16-28. This drilling focused on material type, degree of weathering, strength and hardness of both the granite and the hornfels. It also confirmed the mapping completed by Geovic is accurate within +/- 50 metres which for is excellent for mapping completed at this scale given the complexity and irregularity of the hornfels granite contact. Weathering depths resultant of this drilling along with depths of groundwater are summarised on Drawing 5016_025. The logs for these holes are included as Attachment 2.

2019 Drilling

A second campaign of more targeted drilling was completed by Mawsons in 2019 which consisted of the drilling of ten RC holes in the proposed pit area with these holes drilled vertically to a depth of approximately 40 metres. These holes further delineated the engineering characteristics of the rock mass in the concept quarry area. Groundwater levels were recorded along with the degree of weathering, hardness, strength, and lithology encountered. The logs for these holes are included as Attachment 2. The hole numbers for this drill program were RC19-01 to RC19-10, and they are also shown on Drawing 5016_025.

2021 Drilling

Based on the results of the 2019 drilling completed by Mawsons, a further detailed campaign of infill drilling (eight deeper holes) was completed with these holes also surveyed using downhole optical and acoustical televiewer scanning to log the holes for structural features and changes in lithology. The televiewer data was then used as the basis for assessing potential geotechnical issues in relation to the pit wall designs. This data was also used to inform pit deign criteria including bench widths and heights along with suitable batter angles for the various benches.

In summary no significant structures were identified in the televiewer data, and it is very apparent that the rock mass in general is a moderately jointed, high strength rock mass which has not identified any large scale geological features or changes in rock type. The contact geometry of the hornfels and eastern granite is not known however, is considered very unlikely to occur in this pit area as the main contact is some 650 meters to the east while the contact geometry of these types of granites is generally steep. The drill logs for these holes are included as Attachment 2. The hole numbers for this drill program were RC21-01 to RC21-08, and they are also shown on Drawing 5016_025. The televiewer data is included as Attachment 3.

Concept Groundwater Assessment

Based on the ground water levels encountered in the proposed quarry pit area it is very clear that the rock mass behaves as a low yielding fractured rock aquifer with the drill data illustrating the high degree of variability and inconsistency of groundwater levels encountered in the rock mass. Practically it also demonstrates the lack of connectivity, transmissivity and interconnectedness of the aquifer as holes often have very little apparent relationship in groundwater depth to nearby holes, even when left to recharge.

While additional and more specific data is being collected by Mawsons, the preliminary impacts regarding groundwater on slope stability may require further consideration however, are likely to be minimal. Currently the groundwater table is being assessed in more detail however, for the purposes of the preliminary assessment it is modelled as occurring approximately 30 metres below surface although when additional data is collected this could well change, and resultantly the stability modelling will change to reflect and update the additional groundwater data.

Recent dipping of holes has confirmed that in several areas the groundwater levels are approximately 27 metres below surface although this data set was highly variable, again being representative of a poorly connected low transmissivity rock mass.

Blue Hills Engineering Data

Relevant engineering data assessed in geotechnical design work for the quarry is provided in Table 1.

Rock Mass Property and Conditions	Values and Comments
Rock Type	Interbedded Hornfels
Density Range	Measured at 2.71 t/m ³
Mohr Coulomb Friction Angle	Estimated at 42 ^o
Mohr Coulomb Cohesion kPa	Estimated 250+
	Measured Ranges between 290kN and 450 kN have been returned at 13.2 to
	9.6mm. Modelled at 300 kPa. Supported by Wylie et.al Refer Attachment 7 Fig
% Wet Strength Range at 10% fines	14-11.
UCS	Correlated from Point Load 100-140MPa Very Strong Rock
Point Load Is50 MPa	Measured Average PLT Is50 = 7 MPa (Conversion factor used K=20 Is $_{50}$ for UCS.)
Youngs Modulus Estimated	Estimated 60GPa
Poisson's Ratio	Estimated 0.12

Table	1: Engineering	Parameters
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	Measured Highly variable cross site. Main hornfels is a low storativity fractured
	rock aquifer with very low transmissivity rates. i.e., hosts very low levels of
Groundwater Level	groundwater.
Number of Joints	Measured 4 + 1 minor random sets as per televiewer data
Major Structures	Estimated Nil in pit.
Rock mass model	Assumed Continuous homogeneous isotropic linear elastic
Buffer Zones	Variable 100 metes to defined watercourse 30 metres to tributaries
Seismicity K level	Design considerate of AS1170.4-2007.
	Estimated Pseudo-static earthquake loading has been considered in the limit
	equilibrium analysis. maximum). The earthquake acceleration as a fraction of the
Seismic Loading applied	acceleration due to gravity used a range of values between 0.08 to 0.04.
Bench heights	15 metres
Terminal Batters	70 to 75 degrees in unweathered rock 35-45 in weathered upper bench.
Residual Soil Thickness	Measured 200-400mm thickening toward west away from main ridgelines
	Measured Main pit area averages 15 metres transitioning into unweathered
Hornfels Weathering Depth	material at approximately 20m depth.
Infill-Veining	Minor quartz stockworking and veining in evident on site
Alteration	Silica alteration via contact metamorphism/hornfelsing is ubiquitous
Deg Factor Range	Measured 45-80%
	Estimated nondispersive when unweathered. Emerson Class 3 in upper bench
Dispersiveness	areas.

Pit Design Criteria

Based on the available information contemporary and standard pit design criteria will be suitable for site although it will be modified and specified as needed for relevant areas of the quarry. Currently the pit design criteria proposed to be used are:

Quarry Wall	Slope Height	Total Slope Angle	Bench Heights	Bench Widths	Batter Angle	Upper Bench	Upper Bench	Batter Angle
	Metres	Degrees	Metres	Metres	Degrees	Metres	Metres	Degrees
			SW-FR	SW-FR	SW-FR	SW-DW	SW-DW	SW-DW
West Wall	90	40	15	15	70-75	15	15	40-45
North Wall	100-120	35-39	15	15	70-75	15	15	40-45
East Wall	120 135	33	15	15	70-75	15	15	40-45
South Wall	100-135	43-44	15	15	70-75	15	15	40-45

Table 2 Preliminary Blue Hills Pit Design Criteria

Volume Estimate

In the proposed concept pit outline illustrated on Drawing 5016_021 slightly over 20 million m³ of material has been delineated although this volume could change slightly if pit design criteria change.

Geotechnical Issue	Comments	Data Source	Risk Mitigation	Risk
Limited geotechnical information (e.g. greenfield site)	The rock mass is homogenous and the structural setting reasonably simple. Site conditions will always be slightly different to those expected.	Drilling, materials testing, televiewer information and outcrop. Site conditions will always be slightly different to those expected.	Conservative slope design in high strength rock	Moderate
Limited testing of rock mass properties (unrepresentative values)	Significant outcrop and drill results have all returned very similar results. The rock is of high strength.	Vic Roads Mawson's Lab	Compliance testing will commence with production to further validate current test results	Low Moderate
Limited knowledge on ground control management	Management operates several quarries and have 25+ years of experience	Previous site development, drilling and televiewer information and outcrop Site conditions will always be slightly different to those expected.	Geotechnical training and support will be provided	Moderate
Unverified failure mechanisms	This is a possibility on any undeveloped site; however, this rock mass is proportionally massive and homogenous.	Previous site development, drilling and televiewer information along with significant outcrop	Bench designs are conservative and could be amended further if needed	Moderate
Limited ability (financially or otherwise) to suitably manage ground movements	The Mawson's Ad-Bri JV is well funded with one being a listed ASX entity	ASX	Adequate width benches scaling and catch bunds will be used	Very Low
Potential for sudden falls of ground causing harm to sensitive receptors	There are no sensitive receptors adjacent to or near the quarry that could be impacted by slope instability or rockfall risk	Site Layout Plan	Adequate buffer zones have been retained	Very Low
Significantly variable ground conditions	Possible although all drilling, development areas and drilling demonstrates homogeneity	Previous site development, drilling and televiewer information and outcrop. Site conditions will always be slightly different to those expected.	Geotechnical Model and GCMP information will be updated frequently	Low Moderate
Important infrastructure in close proximity.	Nil	Site Layout Plan	Not Relevant	Very Low

Table 3 : Risk Assessment Slope Design Data

Risk Assessment Slope Design Data

In completing a risk assessment of the slope design the ERR Guidelines have been assessed in a preliminary fashion with results provided in Table 3.

Current Project Status

While still being assessed in detail the preliminary work completed has not identified any major geotechnical issues and it is considered very likely that conventional pit design criteria will be suitable for site.

Should you require any further information please do not hesitate to contact me.

Regards

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Rod Huntley B.Sc. M.App.Sc, MAIG, MAusIMM.



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