



CLIENTS | PEOPLE | PERFORMANCE

Tasmania Magnesite NL

Report on Arthur River
Magnesite Mine

Geotechnical Review

January 2012

This Report on Arthur River Magnesite Mine, Geotechnical Review , January 2012 ("Report"):

- 1. has been prepared by GHD Pty Ltd ("GHD") for Tasmania Magnesite NL;*
- 2. may only be used and relied on by Tasmania Magnesite NL;*
- 3. must not be copied to, used by, or relied on by any person other than Tasmania Magnesite NL without the prior written consent of GHD and subject always to the next paragraph;*
- 4. may only be used for the purpose of preliminary information on likely geotechnical conditions specific to the proposed site and their effect on development (and must not be used for any other purpose).*

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

If Tasmania Magnesite NL wishes to provide this Report to a third party recipient to use and rely upon, then GHD's prior written consent will be required. Before this Report is released to the third party recipient, the third party recipient will be required to execute a GHD prepared deed poll under which the recipient agrees:

- to acknowledge that the basis on which this Report may be relied upon is consistent with the principles in this section of the Report; and*
- to the maximum extent permitted by law, GHD shall not have, and the recipient forever releases GHD from, any liability to the recipient for loss or damage howsoever in connection with, arising from or in respect of this Report whether such liability arises in contract, tort (including negligence),*

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- were limited to those specifically detailed in Section 1 of this Report and did not include an assessment of hazardous substances, contamination or any other chemical analysis of soil or rock. The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report which are described in this report*

GHD has prepared this Report on the basis of information provided by Tasmania Magnesite NL and Tasmanian Government and Regulatory Bodies (State of Tasmania), which GHD has not independently verified or checked ("Unverified Information") beyond the agreed scope of work.

The opinions, conclusions and recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has not and accepts no responsibility or obligation to update the report to account for events or changes occurring subsequent to the date that the Report was prepared.

Contents

1.	Introduction	5
2.	Background Information	6
2.1	Regional Geological Setting	6
2.2	Topography	6
2.3	Historical Investigations	6
2.4	Seismicity	7
3.	Review of Geotechnical Information	8
3.1	General	8
3.2	Rock Mass Ratings	8
3.3	Laboratory Testing	9
4.	Pit Wall Stability	11
4.1	General	11
4.2	Empirical Slope Design	11
4.3	Pit Analysis	14
5.	Discussion and Recommendations	15
5.1	Overburden	15
5.2	Groundwater	15
5.3	In Pit Rockmass	15
5.4	Hazards & Defects	16
5.5	Batter Slopes	16
5.6	Ground Support	17
5.7	Further Investigations	17
6.	References	19

Table Index

Table 1	Summary of Borehole Details	8
Table 2	Geotechnical Units within Rockmass	9
Table 3	Summary of Laboratory Test Results	10

Table 4	Borehole AR030 Domains	11
Table 5	Pit Dimensions	16

Figure Index

Figure 1	Hoek-Bray Slope Curve (1981)	12
Figure 2	Haines-Trebrugge Slope Height vs Slope Angle for M-RMR (1991)	13

Appendices

- A Geological Map
- B Laboratory Certificates
- C Rock Mass Ratings
- D Appendix D
- E Phase2 Pit Model

1. Introduction

Tasmania Magnesite NL (TMNL) is currently undertaking pre-feasibility level studies for the development of a magnesite mine located near the Arthur River in North-west Tasmania. TMNL have recently undertaken site investigations, which entailed the drilling of 10 boreholes (total length 1070 m), geotechnical logging, and hydrogeological monitoring/testing. TMNL have appointed GHD to review the borehole information and undertake a preliminary assessment of the stability of any open excavations the site. This report outlines the findings of the assessment and provides guidelines on open pit excavations and requirements for further investigations should the project proceed.

2. Background Information

2.1 Regional Geological Setting

The geology of the site has been extensively investigated by TMNL and according to historical geological mapping by Mineral Resources Tasmania (formerly Department of Mines), indicates the presences of several surface lithology's including;

- ▶ Alluvium, swamp, and marsh deposits (Qha, Qh);
- ▶ Siltstones, mudstones, sandstones, and minor conglomerates (Pli, Ptw);
- ▶ Quartz-mica-schist, quartzite, phyllite and rare dolomite (Keith Schist & correlates) (Lat);
- ▶ Chloritic schist with minor phyllite, dolomite, and magnesite (Arthur Metamorphic Complex) (Lac);

Tholeiitic Basalt has also been observed to the northeast of the site, indicative of historic regional volcanic activity and observed contact metamorphism.

Of key note is the probable presence of karst systems associated with Dolomite and Magnesite. This has been investigated and discussed by Household¹, et al. (1999) and further supported by Williams² (1999). Both authors indicated the presence of magnesian karst systems within the Keith-Arthur River region.

A Geological map showing the site is given in Appendix A.

2.2 Topography

The proposed mine is located near the confluence of the Keith River with the larger Arthur River. The Keith and Arthur Rivers delineate the western and northern boundary of the site respectively. The site is relatively flat to undulating near the rivers before becoming increasingly steeper towards the south and west. Johnnys Creek runs in a northerly direction through the site prior to flowing into the Arthur River.

Access to the site is via historic forestry roads from the north (Farquhars Road) over the Arthur River at Farquhars Bridge. The site is largely covered by wet sclerophyll and temperate rainforest. Minor access roads have been cut around the site.

2.3 Historical Investigations

Several historical geological and geotechnical investigations have previously been undertaken at the site. These include the studies by Holm and Berry³ (2002) and Household¹, et al (1999), as previously discussed in section 2.1. TMNL has additionally undertaken extensive drilling programs at this site.

¹ Household, I. et al. "Magnesite Karst in Northwest Tasmania. Geology, Geomorphology, and Hydrology". Report to Department of Development, State of Tasmania. (1999).

² Williams, P. "Report on the Geoconservation Values of the Magnesite Karst in Northwest Tasmania". University of Auckland, New Zealand. (1999).

³ Holm, O. Berry, R. "Structural history of the Arthur Lineament, northwest Tasmania; An analysis of critical outcrops". Centre for Ore Deposit Research, University of Tasmania, Hobart. Australian Journal of Earth Sciences, Edition 49. (2002)

2.4 Seismicity

Consideration for earthquake actions is required for the design of the pit. Whilst mine excavations are outside the scope of AS1170.4 – Earthquake Actions in Australia, it does provide guidance on the possible seismic conditions. Figure 3.2(A) of AS1170.4 indicates that a site Hazard Factor Z greater than 0.08 (corresponding to a 1:500 AEP Earthquake) is appropriate for this site.

3. Review of Geotechnical Information

3.1 General

A total of ten boreholes were drilled by TMNL during the latest round of investigations. Table 1 summarises the details of the boreholes. A site plan showing the location of the boreholes in relation to the proposed pit is provided in Appendix A.

Table 1 Summary of Borehole Details

Borehole Identification	Inclination to Horizontal (Degrees)	Orientation (Magnetic)	Depth Drilled (m)	Vertical Depth (m)
MB07	90	000	43.3	43.3
MB08	90	000	50.3	50.3
AR027	55	060	150.0	122.9
AR028	55	330	71.1	58.2
AR029	60	330	89.1	77.2
AR030	60	330	143.2	124.0
AR031	60	330	150.0	129.9
AR032	60	330	150.0	129.9
AR033	60	330	73.0	63.2
AR034	60	330	150	129.9

3.2 Rock Mass Ratings

To assist with the pit wall stability assessment, the details from the relevant borehole have been segregated into distinct geotechnical units and these have been assessed using the following qualitative systems. The Rock Mass Rating (RMR), as described by Bieniawski (1973)⁴, and Geological Strength Index (GSI), as described by Hoek (1994)⁴, has been determined for each distinct domain. Table 2 below summarises the geotechnical unit in each borehole drilled. Summaries of the differing ratings are given in Appendix C.

⁴ Hoek, E. "Practical Rock Engineering". Vancouver, Canada. (2006).

Table 2 Geotechnical Units within Rockmass

Borehole	No. Units	RMR Ranges	GSI Ranges
MB07	4	15 – 74	18 – 77
MB08	3	69 – 74	38 – 77
AR027	13	15 – 69	18 – 72
AR028	5	15 – 54	18 – 67
AR029	3	15 – 29	18 – 32
AR030	7	15 – 52	18 – 55
AR031	11	15 – 69	18 – 72
AR032	9	10 – 72	0 – 75
AR033	4	15 – 38	18 – 41
AR034	6	17 – 45	20 – 48

The information available indicates that ground conditions across the site are highly variable but generally improve with depth. Several generalised assumptions have been made to account for shortfalls in available information in the above determinations, including;

- ▶ Defect orientations being favourable for pit wall development;
- ▶ All defects may be considered wet.

The borehole logs indicate the presence of some significant structures within the rockmass that are likely to dictate pit slope, however insufficient information on these structures is available. In general, defect orientations within the rockmass appear randomly orientated and of variable persistence.

An additional domain exists at all the borehole locations to account for the overburden materials (alluvium, colluvium and residual soils) above the rockmass. This domain has treated separately to the rockmass domains and is discussed in Section 5.1.

3.3 Laboratory Testing

Two samples of debris obtained from 'voids' in the rock mass were provided to GHD by TMNL which were sent for simple laboratory classification testing. Atterberg Limit and Particle Size Distribution testing were undertaken on the disturbed samples and the results are summarised in Table 3 below. Original Laboratory Certificates of the testing are given in Appendix B.

Table 3 Summary of Laboratory Test Results

Test Type	Borehole AR027 34.0-38.5 m	Borehole AR031 110.0 m
Max Particle Size (mm)	2.36 mm	4.75 mm
D ₅₀ (µm)	600	600
% < 75 µm	12%	14%
Moisture Content	43.1%	22.6%
Liquid Limit (LL)	N.O.	N.O.
Plastic Limit (PL)	N.O.	N.O.
Plasticity Index (PI)	N.P.	N.P.
Unified Soil Classification	Silty SAND (SM)	Silty SAND (SM)

N.O. – Not Obtainable; N.P. – Non-Plastic

4. Pit Wall Stability

4.1 General

A preliminary stability assessment of the pit wall slopes has been undertaken using empirical methods. The proposed pit shell outlines provided TMNL suggest that, borehole AR030 should be the most representative of the subsurface conditions at the proposed open pit. This borehole has been assessed as having 8 distinct geotechnical units, seven of which are located within the rockmass and one within the overlying residual soils. Table 4 below summarises the units within Borehole AR030, together with an estimate of the corresponding RMR, GSI, and Modified Rock Mass Rating (M-RMR) classifications.

Table 4 Borehole AR030 Domains

Down Hole Depth (m)	Actual Depth (m)	Material	RMR	GSI	M-RMR	Ground Characterisation
0.0 – 18.8	0.0 – 16.3	Overburden	-	-	-	Very Poor
18.8 – 19.0	16.3 – 16.5	Magnesite	19	22	0	Very Poor – Poor
19.0 – 24.7	16.5 – 21.4	Magnesite	15	18	0	Very Poor
24.7 – 67.4	21.4 – 58.4	Magnesite	30	33	10	Poor – Fair
67.4 – 95.4	58.4 – 82.6	Magnesite	49	52	35	Fair – Good
95.4 – 98.2	82.6 – 85.0	Siltstone	17	20	0	Very Poor
98.2 – 109.3	85.0 – 94.7	Magnesite	29	32	10	Poor – Fair
109.3 – 143.2	94.7 – 124.0	Magnesite	52	55	38	Fair - Good

4.2 Empirical Slope Design

It is understood that the proposed open pit may be up to 120 m in depth. A review of empirical slope angle, height and rockmass quality relationships has been undertaken to first pass of assessment of proposed pit slopes. A review of various pit slopes by Hoek and Bray (1981)⁵ provides an upper bound slope height versus slope angle curve. For an open pit depth of 120 m (approximately 400 feet), Hoek and Bray recommended that slope angles should not exceed 70°.

⁵ Douglas, K. "The Shear Strength of Rock masses". University of New South Wales, School of Civil and Environmental Engineering. (2002)

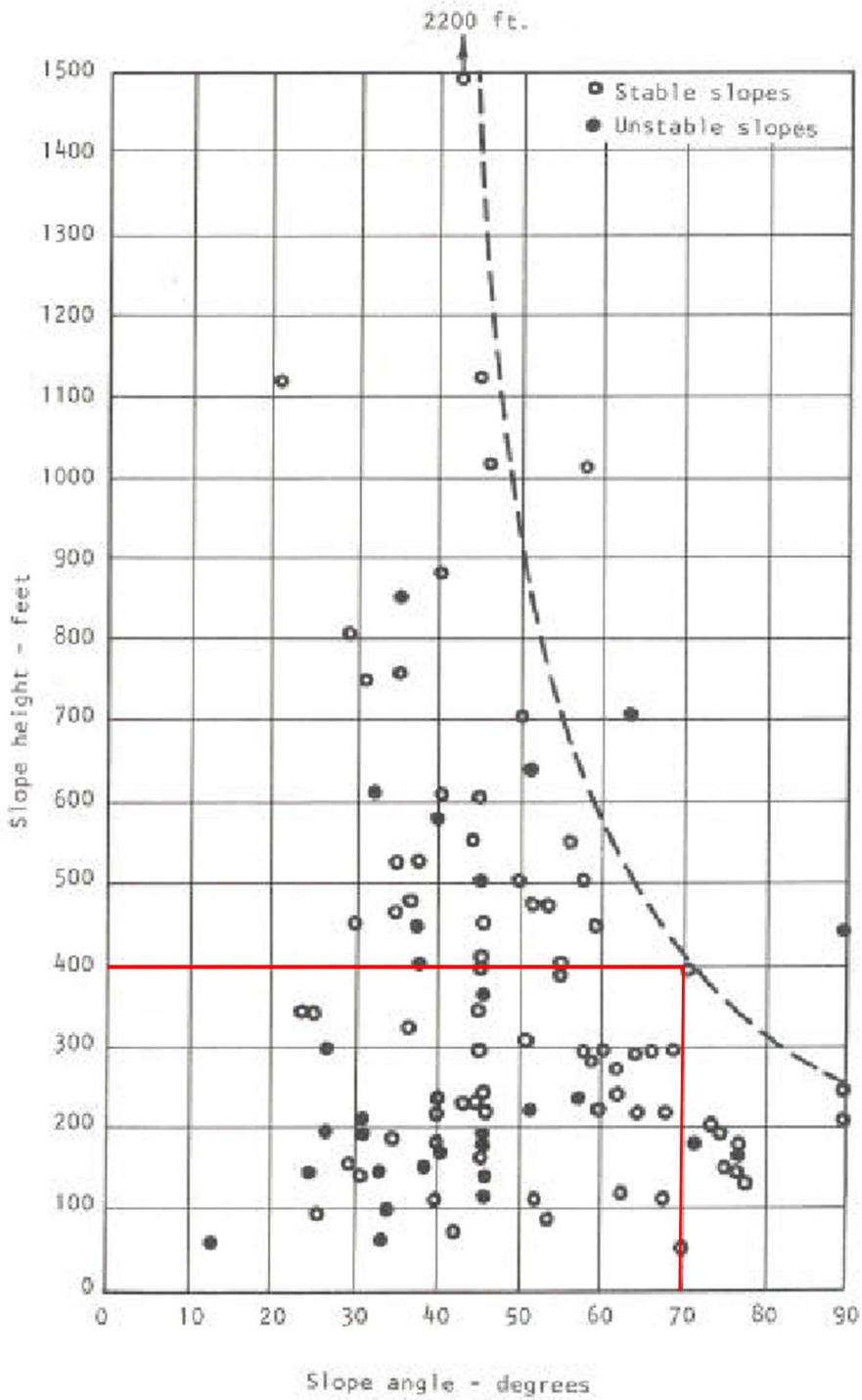


Figure 1 Hoek-Bray Slope Curve (1981)

Haines and Terbrugge (1991)⁶ investigated the relationship between slope heights, slope angles and rockmass quality (in the form of M-RMR). A rudimentary assessment of applicable Factors of Safety has additionally been incorporated. Assuming a 120 m deep pit and a target Factor of Safety of 1.2, Haines and Terbrugge slope curves indicate that slope angles of 45° and 55° may be stable for M-RMR values of 10 and 35 respectively. Slopes steeper than these are considered marginal and would require additional analysis. The Haines-Terbrugge curve is shown below in Figure 2.

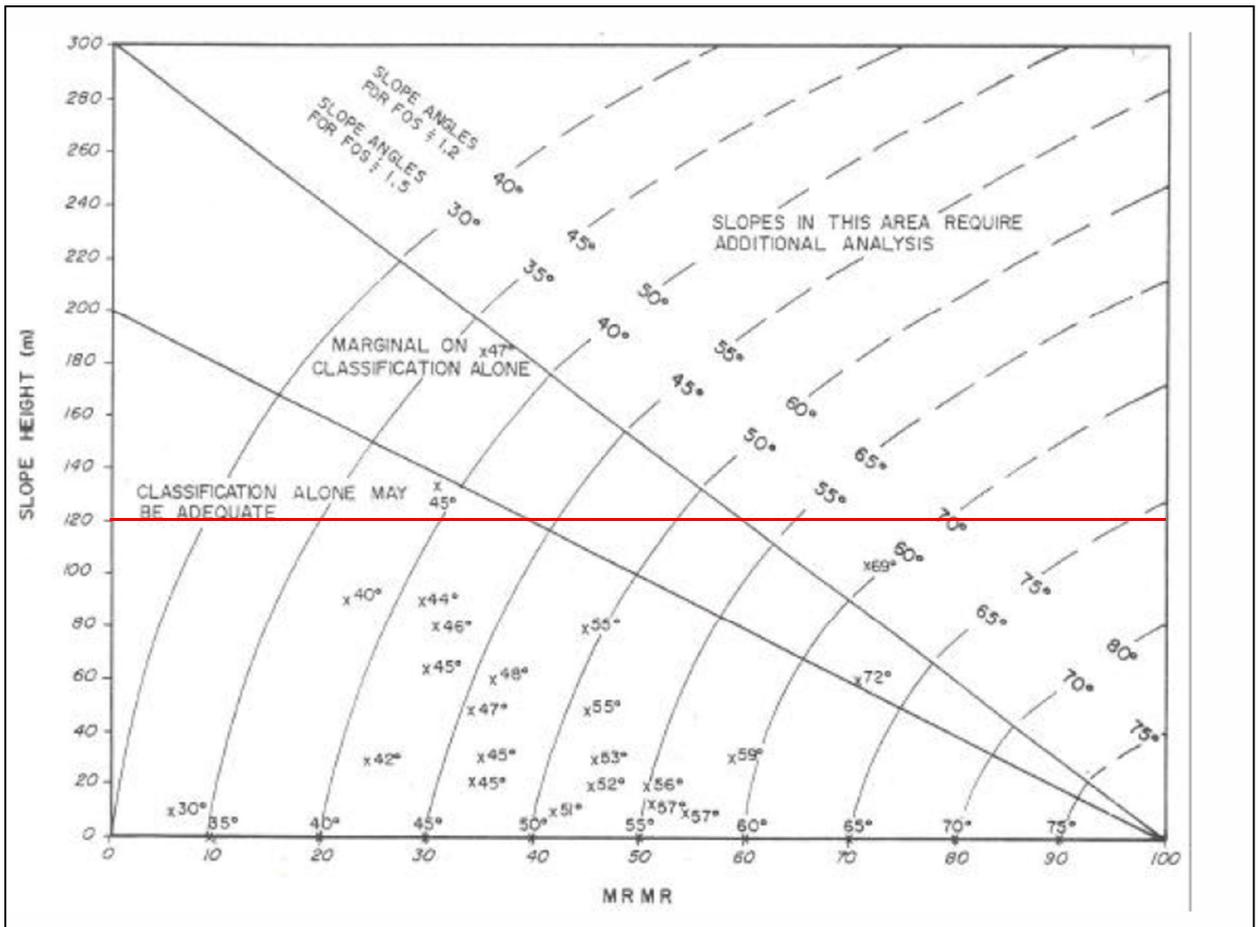


Figure 2 Haines-Terbrugge Slope Height vs Slope Angle for M-RMR (1991)

⁶ Douglas, K. "The Shear Strength of Rock masses". University of New South Wales, School of Civil and Environmental Engineering. (2002)

4.3 Pit Analysis

A simple model of a pit wall has been analysed using the 2-dimensional finite element software package Phase2. The model adopted estimated material parameters using the log from the TMNL borehole AR030. Several key assumptions have been adopted for the model. These include;

- ▶ Geological units and domains are horizontally orientated;
- ▶ The rockmass (including cut face) is saturated;
- ▶ No major structural defects are located within the rockmass;
- ▶ Residual rockmass properties are equivalent to peak rockmass properties.
- ▶ No surcharges (i.e. mining equipment) or seismic loads have been assessed.
- ▶ The 2D model approximates true 3D conditions

A 120 m deep pit has been modelled with nominally 10 m high batter with 5 m wide bench. 45° batter slopes have been adopted for the poorer quality rockmasses located in the upper 60 m of the proposed pit, and 65° slopes have been adopted for higher quality rockmasses located in the lower 60 m of the pit.

The analyses indicate that the Factor of Safety against large-scale failures within the pit is 1.19(1.2). This 1.2 FOS value is considered within the acceptable range for a pit wall under static loading conditions. It must be noted that this modelling is based on limited qualitative data and major structural defects and reduction in material strengths towards residual parameters with long-term loading may lower the Factor of Safety significantly. This assessment generally indicates that the proposed batters will likely require relaxation to flatter angles.

Details of the geometry and material properties adopted in the model are given in Appendix D.

5. Discussion and Recommendations

5.1 Overburden

The geotechnical logs indicate that the depth of overburden across the site varies from relatively shallow (approximately 5 m vertical depth) to deep (in excess of 35 m vertical depth). This may require extensive pre-stripping. The materials encountered include residuals, alluvials, colluvium, and fluvioglacials over the full particle size range, from clays to boulders, however in general it appears to be largely granular materials in the form of sands and gravels, occasionally enveloped in clayey matrix.

Flat batter slopes, in the order of 2.5:1 (H:V) to 3:1 (H:V) may be considered appropriate for overburden materials. Nominally 5 m wide benches should be adopted at 5 m height intervals for cuttings within the overburden. An appropriate buffer zone from the edge of the open pit to the toe of the overburden cutting should also be adopted to minimise the risk of materials from the cuttings falling into the pit. A minimum buffer zone of 20 m is recommended.

It is anticipated that these materials will subject to significant reduction in strength when saturated. Appropriate drainage will be required in order to protect these cuttings.

5.2 Groundwater

Hydrogeological investigations undertaken by GHD, as discussed in the GHD Report "Tasmania Magnesite, Report for Arthur River ML Scoping Study, Hydrogeological Investigation" (GHD Reference: 32/15824/54647), indicates the presence of phreatic surfaces within the proposed pit shells. It is anticipated that the presence of groundwater surfaces may have a marked affect upon the stability of the pit walls, as pore water pressures will act to induce failure and defect moisture conditions will be unfavourable.

5.3 In Pit Rockmass

A review of the current round of geotechnical drilling indicates that the rockmass within and surrounding the pit is highly variable. In general, the rockmass is considered poor near the surface but increasing in quality with depth. The rockmass is inter-sliced with bands of fractured rock, weathered zones, and faults. Defects within the rockmass appear to be variable in condition and randomly orientated.

Borehole AR030, drilled near the proposed south-eastern corner of the northern pit, has been divided into at least eight distinct geotechnical domains, to depth a depth of 120 m. The number of domains throughout the pit is anticipated to be variable, with a minimum of four and a maximum of fourteen separable geotechnical domains identified during the current round of geotechnical investigations.

It is anticipated that the poorer quality domains at depth will dictate the pit slopes in the overlying domains. Flattening of overlying materials will assist in reducing overburden pressures acting to promote failure within the pit walls. It is likely that rockfalls will be a considerable risk for this project.

5.4 Hazards & Defects

A review of the geotechnical logs indicates two major structural defects that are likely to dictate the stability of the pit slopes. These are;

1. The presence of large faults and slickenside structures within the rockmass; and
2. The presence of karstic voids / weathered zones located within the rockmass.

These structural defects are anticipated to largely dictate the development of the pit. In particular, their orientation in relation to the pit wall will dictate whether the wall may be steepened or flattened accordingly. Insufficient information is available from the drill logs to accurately determine the orientations of the structural defects in relation to the pit walls.

A review of photographs of borehole AR030 generally indicates that defect orientations are random, but may be steeply dipping. This is generally considered unfavourable for pit wall development and may require relaxation of pit slopes.

Samples of materials taken from the weathered zones/karstic voids were found to consist of moist to wet granular materials. These materials are generally considered to be very low strength and are likely to erode (including the risk of piping) once a cut face is exposed. The extent and orientations of these zones will dictate the pit structure and may have the potential to result in large scale batter failures.

Observations of 'stress relief' in drill core undertaken previously by TMNL indicate regions of significant in-situ horizontal stresses (Field Stresses) are evident at or near to the proposed mine pit. These horizontal stresses may increase the instability of pit walls if unfavourably orientated. The analysis undertaken has not assessed the effects of any horizontal in-situ stresses nor the elastic rebound of the pit floor during excavation. Measurements of in-situ stresses and the effects of floor rebound should be undertaken during any further investigations.

5.5 Batter Slopes

For the purpose of preliminary resource estimation, the following batter guidelines may be adopted. These guidelines are for estimating purposes only and further investigations and studies as outlined within this report are required to design any mine pit.

Table 5 Pit Dimensions

Depth	Bench Interval (m)	Bench Width (m)	Batter Slope Between Benches (degrees)	Effective Slope Angle (degrees)
0 – 60	10	5	40-45	30-39
60 – 120	10	5	55-65	38-55

Note that there are numerous other suitable configurations however the Effective Slope Angle in column 5 above is the limiting criteria.

5.6 Ground Support

The use of ground support may assist in slope stability of any pit design, however this should be assessed in detail after completion of more comprehensive investigations. Elements within the pit walls such as rockbolts, mesh, fibrecrete, and grouting may be required to locally aid stability and reduce the risk of rockfalls. Ground support elements, short of extensive grouting, is not anticipated to significantly improve the global slope stability. Small scale batter failures may generally be considered acceptable provided appropriate risk management strategies are in place.

Localised rockbolts may be utilised to pin back large blocks within the rockmass that may pose significant rockfall hazards, and fibrecrete in combination with rockbolts may be utilised to reduce rockfall risks and localised batter failures in poor rock quality areas. The presence of deep weathered zones or karstic voids will, however, be difficult to stabilise. Possible stabilisation methods may include pressure grouting prior to the excavation of benches at the void level, then using high capacity cable bolts to aid in pinning the grouted zone into the surrounding rockmass. The size and extent of the potential voids and or weathered zones will dictate the suitability of ground support within the rockmass. Insufficient information is available to provide estimates on the ground support requirements at this time.

Consideration may also be given to the use of rock-catch fences and nets. These items will reduce the risks associated with rockfalls by aiding in the containment and control of small failures. This will be of particular benefit when mining operations are occurring in the lower levels of the pit. The use of catch fences will however not improve the stability of the slope in a global sense and large scale failures will not be contained.

5.7 Further Investigations

Further investigations should include both borehole and geophysical investigations to quantify the rock mass and rock parameters. Detailed geotechnical drilling, incorporating in situ testing and sampling of both rock and also any shear zone or weathered materials is recommended. The orientation of all subsurface defects should be measured, which can be achieved by angled drilling or proprietary core orientation attachments. Drilling should exceed the depth of the proposed open pit by at least 25% of the proposed depth to the floor. As noted above, measurement of horizontal (& vertical) in-situ field stresses is recommended, prior to detailed design of any open pit at this site.

Seismic refraction or other appropriate geophysical surveys are also recommended to identify the size, location, and orientation of any large defects such as voids or shear/weathered zones within the rockmass. Ideally this geophysical investigation should precede any comprehensive geotechnical investigation program

Extensive laboratory testing of retrieved soil and rock core samples should be undertaken to allow for more accurate determination of material parameters.

Consideration should also be given to undertaking either probabilistic or deterministic seismic hazard assessments to investigate the likely seismic conditions relevant to the site. This will allow for design uncertainties to be reduced and pit shells to be optimised. Information gathered in these investigations may also be suitable for design of other mine ancillary structures such as (but not limited to) processing

facilities or waste rock dumps.

6. References

Houshold, I. et al. "Magnesite Karst in Northwest Tasmania. Geology, Geomorphology, and Hydrology". Report to Department of Development, State of Tasmania. (1999).

Williams, P. "Report on the Geoconservation Values of the Magnesite Karst in Northwest Tasmania". University of Auckland, New Zealand. (1999).

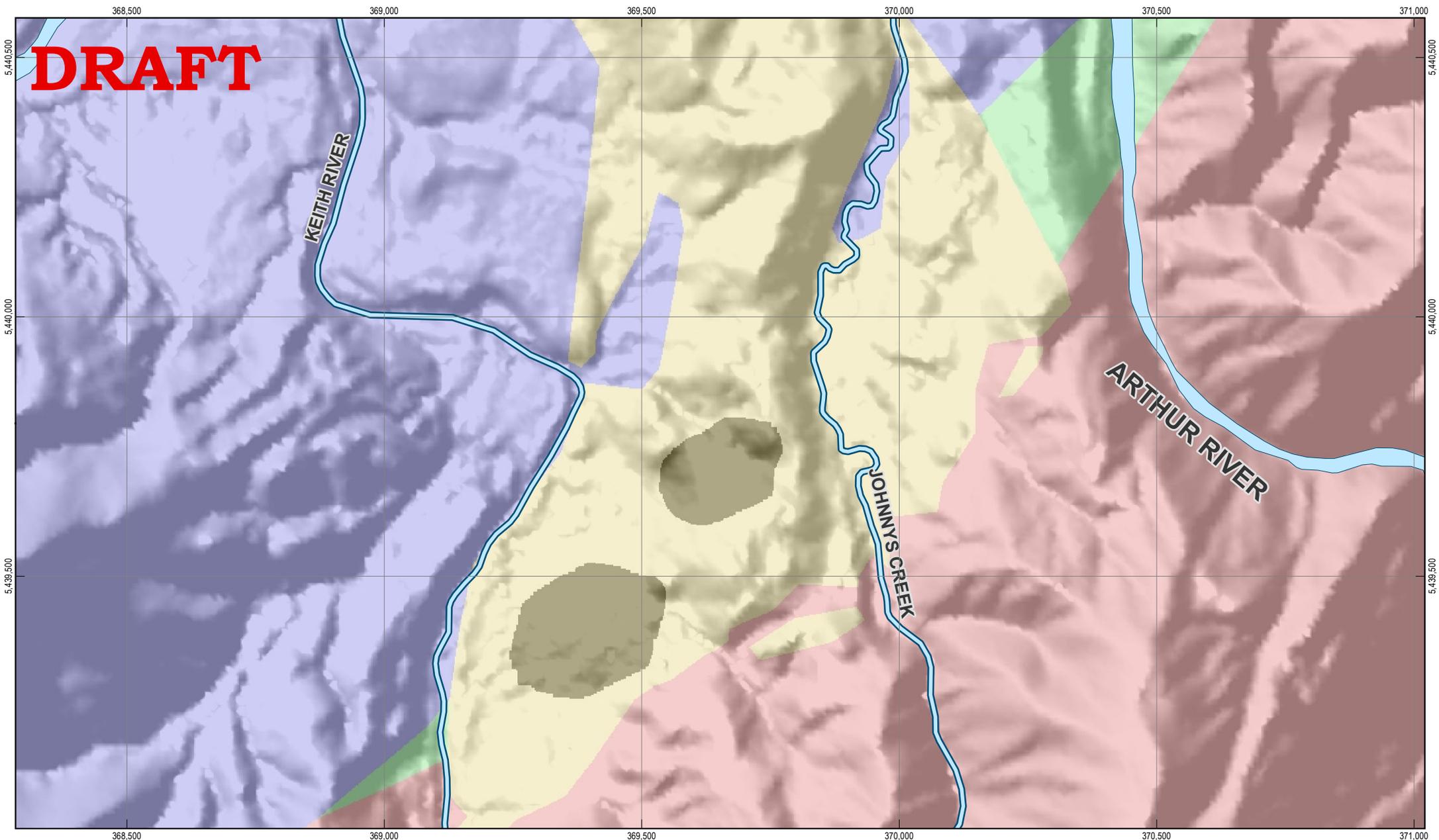
Holm, O. Berry, R. "Structural history of the Arthur Lineament, northwest Tasmania; An analysis of critical outcrops". Centre for Ore Deposit Research, University of Tasmania, Hobart. Australian Journal of Earth Sciences, Edition 49. (2002)

Hoek, E. "Practical Rock Engineering". Vancouver, Canada. (2006).

Hoek, E. Bray, J. "Rock Slope Engineering (Revised Third Edition)". Institute of Mining and Metallurgy, published by Chapman and Hall, London, UK. (1994).

Douglas, K. "The Shear Strength of Rock Masses". University of New South Wales, School of Civil and Environmental Engineering. New South Wales. (2002).

Appendix A
Geological Map



Paper Size A4
 0 50 100 150 200 250
 Metres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 55



- LEGEND**
- Hangingwall
 - Footwall
 - Magnesite
 - Alluvials
 - Pit Locations
 - Waterways



Tasmania Magnesite
 Hydrogeological Investigation

Job Number | 32-15824
 Revision | B
 Date | 20 Jan 2012

Surface Geology
 (after Derwent Geosciences, 2011) **Figure 1**

G:\3215824\GIS\Maps\Figure1_GeotechV2_RevB.mxd
 © 2011. Whilst every care has been taken to prepare this map, GHD make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Raw Geology data (Derwent Geosciences, 2011) Topography data LIDAR (Tasmania Magnesite, 2011), Waterways (Navigate 2011), Tas location map (Geoscience Australia 2005). Created by: Irevans, updated by jpluford
 2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 62100601 E hbamail@ghd.com W www.ghd.com

Appendix B
Laboratory Certificates

ADG LABORATORIES

materials testing laboratories

Unit 1/18a Hull Street Glenorchy

Ph (03) 6272 7844 Fax (03) 6272 7866

ACN 117 593 254

client	GHD
project	Material Evaluation
location	Arthur River
project no	H246
sample no	H11/209
date received	28/6/11
date tested	30/6/11
identification No	3215824 AR027 34.0 - 38.5m
sampled by	Client
test report No	246/CH

Test description	Test Method	Results	units	remarks
	AS 1289			
Liquid Limit	3.1.2	Not Obtainable	%	Air Dried Dry Sieved
Plastic Limit	3.2.1	Not Obtainable	%	
Plasticity Index	3.3.1	Non Plastic	%	
Linear Shrinkage	3.4.1	-	%	
Moisture Content	2.1.1	43.1	%	
Particle Size Distribution	3.6.1			
finer than	mm			
	19.0		%	
	13.2		%	
	9.5		%	
	6.7		%	
	4.75		%	
	2.36	100	%	
	1.18	95	%	
	0.600	56	%	
	0.425	37	%	
	0.300	23	%	
	0.150	14	%	
	0.075	12	%	



This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025.

LABORATORY ACCREDITATION No 16752

Approved signatory

date of issue

D L Maundrill

ADG LABORATORIES

materials testing laboratories

Unit 1/18a Hull Street Glenorchy

Ph (03) 6272 7844 Fax (03) 6272 7866

ACN 117 593 254

client	GHD
project	Material Evaluation
location	Arthur River
project no	H246
sample no	H11/210
date received	28/6/11
date tested	30/6/11
identification No	3215824 AR031 110.0m
sampled by	Client
test report No	246/CI

Test description	Test Method	Results	units	remarks
	AS 1289			
Liquid Limit	3.1.2	Not Obtainable	%	Air Dried Dry Sieved
Plastic Limit	3.2.1	Not Obtainable	%	
Plasticity Index	3.3.1	Non Plastic	%	
Linear Shrinkage	3.4.1	-	%	
Moisture Content	2.1.1	22.6	%	
Particle Size Distribution	3.6.1			
finer than	mm			
	19.0		%	
	13.2		%	
	9.5		%	
	6.7		%	
	4.75	100	%	
	2.36	99	%	
	1.18	86	%	
	0.600	51	%	
	0.425	36	%	
	0.300	26	%	
	0.150	18	%	
	0.075	14	%	



This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025.

LABORATORY ACCREDITATION No 16752

Approved signatory

date of issue

D L Maundrill

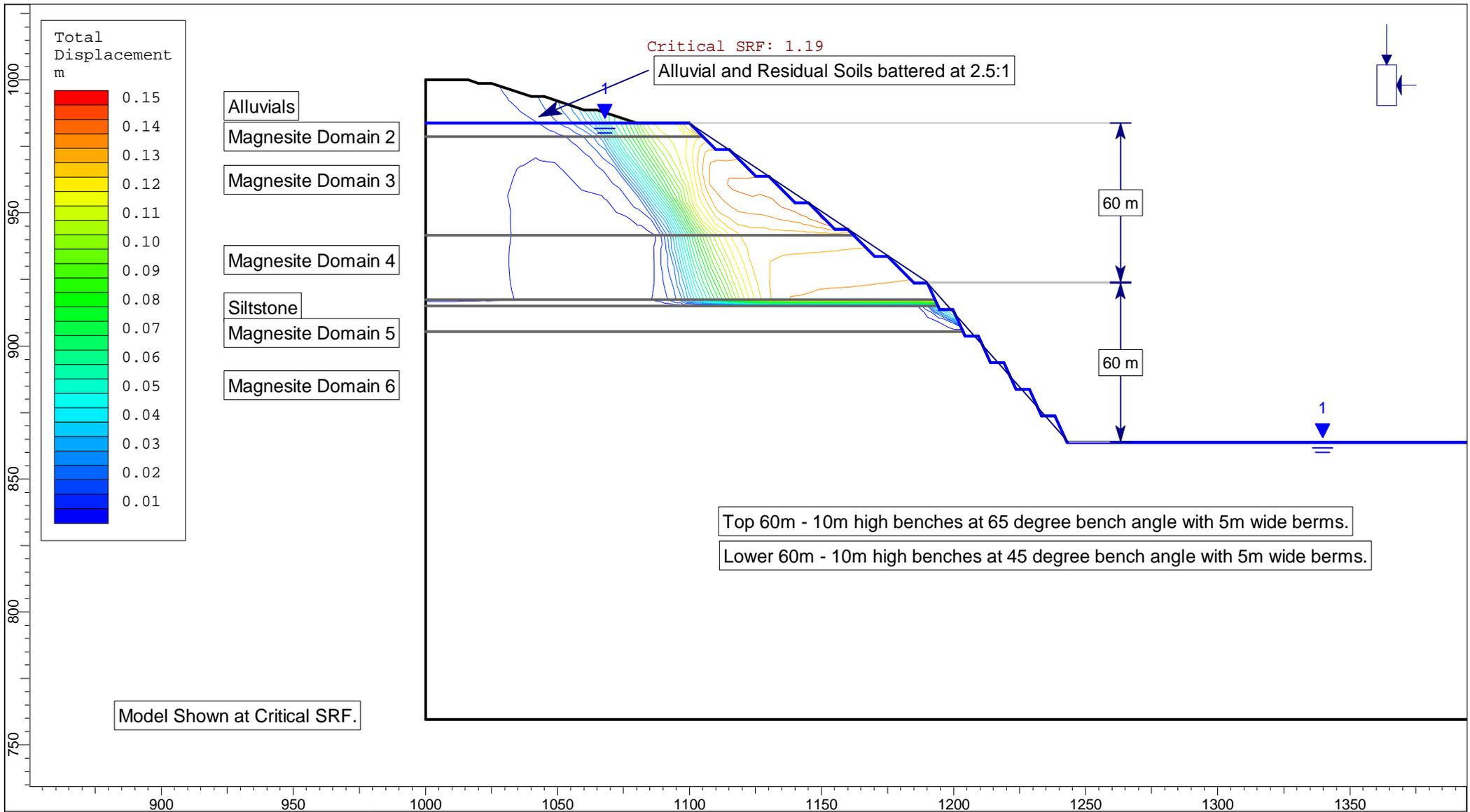
Appendix C
Rock Mass Ratings

Tas Magnesite - Arthur River
 Rock Mass Ratings (RMR)

BOREHOLE ID	Domain (m)	Estimated UCS (Mpa)	UCS Rating	RQD Rating	Spacing of Discontinuities	Condition Of Discontinuities	Groundwater	RMR	GSI	E _{rm} (MPA)	a	s	m _b
AR032	5.5-65.5	0.5	0	3	8	10	7	28	31	242	0.521	0.0000	0.203
	65.5-68.5	0	0	3	0	0	7	10	0	14	0.666	0.0000	0.037
	68.5-76	0.6	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	76-83.5	0	0	3	0	0	7	10	0	14	0.666	0.0000	0.037
	83.5-84	0.6	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	84-90.8	0	0	3	0	0	7	10	0	14	0.666	0.0000	0.037
	90.8-97.2	70	7	13	10	20	7	57	60	3219	0.503	0.0030	0.999
	97.2-100.1	8	2	3	5	10	7	27	30	221	0.522	0.0000	0.192
	100.1-150	105	12	13	15	25	7	72	75	11002	0.501	0.0267	2.279
MB07	7.6-24.8	0.5	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	24.8-33	105	12	8	10	20	7	57	60	3219	0.503	0.0030	0.999
	33-33.7	15	2	3	5	0	7	17	20	89	0.544	0.0000	0.111
	33.7-43.3	110	12	20	10	25	7	74	77	12765	0.501	0.0357	2.543
MB08	6.9-14.2	105	12	20	10	20	7	69	72	8728	0.501	0.0173	1.932
	14.2-33.9	70	7	3	8	10	7	35	38	455	0.513	0.0001	0.298
	33.9-50.3	120	12	20	10	25	7	74	77	12765	0.501	0.0357	2.543
AR033	41-56	0.6		3	5	0	7	15	18	74	0.550	0.0000	0.099
	56-65.8	24		3	5	0	7	15	18	74	0.550	0.0000	0.099
	65.8-66.9	65		13	8	10	7	38	41	597	0.511	0.0002	0.352
	66.9-73	30		3	5	0	7	15	18	74	0.550	0.0000	0.099
AR027	5.56-10.1	0.5	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	10.1-18.6	0.6	0	8	8	10	7	33	36	380	0.515	0.0001	0.267
	18.6-45.3	0.7	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	45.3-52.5	120	12	20	10	20	7	69	72	8728	0.501	0.0173	1.932
	52.5-61.5	65	7	3	5	0	7	22	25	140	0.531	0.0000	0.146
	61.5-67.6	50	7	3	8	10	7	35	38	455	0.513	0.0001	0.298
	67.6-75.4	70	7	8	5	0	7	27	30	221	0.522	0.0000	0.192
	75.4-97.9	40	4	3	5	0	7	19	22	107	0.538	0.0000	0.124
	97.9-117	150	12	17	8	10	7	54	57	2480	0.504	0.0020	0.848
	117-130.2	0	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	130.2-135.2	160	12	20	10	20	7	69	72	8728	0.501	0.0173	1.932
	135.2-141	0	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
141-150	200	12	8	10	20	7	57	60	3219	0.503	0.0030	0.999	
AR031	8.8-48.2	0.6	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	48.2-60.1	4	1	3	5	0	7	16	19	81	0.547	0.0000	0.105
	60.1-75	180	12	20	10	20	7	69	72	8728	0.501	0.0173	1.932
	75-79.1	0	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	79.1-91.8	180	12	8	15	20	7	62	65	4931	0.502	0.0063	1.315
	91.8-96.5	0	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	96.5-106	150	12	8	8	10	7	45	48	1118	0.507	0.0005	0.517
	106-111.1	0	0	3	8	10	7	28	31	242	0.521	0.0000	0.203
	111.1-129	180	12	13	8	10	7	50	53	1744	0.505	0.0011	0.680
	129-132.6	100	7	17	8	10	7	49	52	1596	0.505	0.0010	0.644
132.6-150	100	7	3	10	20	7	47	50	1336	0.506	0.0007	0.577	
AR030	18.8-19	50	4	3	5	0	7	19	22	107	0.538	0.0000	0.124
	19-24.7	0	0	3	5	0	7	15	18	74	0.550	0.0000	0.099
	24.7-67.4	15	2	8	8	5	7	30	33	290	0.518	0.0001	0.227
	67.4-95.4	150	12	17	8	5	7	49	52	1596	0.505	0.0010	0.644
	95.4-98.2	10	2	3	5	0	7	17	20	89	0.544	0.0000	0.111
	98.2-109.3	30	4	13	5	0	7	29	32	265	0.520	0.0001	0.215
	109.3-143.2	200	12	13	10	10	7	52	55	2081	0.504	0.0015	0.759
AR034	34.2-71.5	5	2	3	5	0	7	17	20	89	0.544	0.0000	0.111
	71.5-75.5	40	4	8	8	10	7	37	40	545	0.511	0.0002	0.333
	75.5-99.2	50	7	3	5	0	7	22	25	140	0.531	0.0000	0.146
	99.2-121	70	7	13	8	10	7	45	48	1118	0.507	0.0005	0.517
	121-137.5	15	2	8	5	0	7	22	25	140	0.531	0.0000	0.146
	137.5-150	150	12	8	8	10	7	45	48	1118	0.507	0.0005	0.517
AR029	13-23.6	0.5	0	3	5	0	7	15	18	74	0.550	0.000	0.099
	23.6-59.6	0.6	0	3	5	0	7	15	18	74	0.550	0.000	0.099
	59.6-89.1	2	1	3	8	10	7	29	32	265	0.520	0.000	0.215
AR028	12.4-15.7	0.6	0	3	5	0	7	15	18	74	0.550	0.000	0.099
	15.7-21.4	0.6	0	20	5	0	7	32	35	347	0.516	0.000	0.253
	21.4-39.6	0.6	0	3	5	0	7	15	18	74	0.550	0.000	0.099
	36.9-59.1	200	12	20	10	15	7	64	67	5826	0.502	0.008	1.468
	59.1-71.1	200	12	20	8	10	7	57	60	3219	0.503	0.003	0.999

Appendix D

Phase2 Pit Model



	Project			Tasmania Magnesite		
	Analysis Description			AR030 Pit Wall		
	Drawn By	GHD	Scale	1:2000	Company	GHD
	Date	December 2011			File Name	AR030 Pit Wall.fez

MATERIAL PARAMETERS

Material Name	Color	Initial Element Loading	Unit Weight (kN/m3)	Elastic Type	Young's Modulus (kPa)	Poisson's Ratio	Failure Criterion	Material Type	Tensile Strength (kPa)	Dilation Angle (deg)	Friction Angle (peak) (deg)	Friction Angle (residual) (deg)	Cohesion (peak) (kPa)	Cohesion (residual) (kPa)	Intact Compressive Strength (kPa)	mb (peak)	mb (residual)	s (peak)	s (residual)	a (peak)	a (residual)	Dilation Parameter
Alluvials		Body Force Only	18	Isotropic	20000	0.35	Mohr Coulomb	Plastic	0	1.5	20	18	5	3								
Magnesite Domain 2		Field Stress and Body Force	30	Isotropic	75717.1	0.25	Generalized Hoek-Brown	Plastic							7000	0.099433	0.099433	6.8995e-006	6.8995e-006	0.549987	0.549987	0.03
Magnesite Domain 3		Field Stress and Body Force	30	Isotropic	260152	0.25	Generalized Hoek-Brown	Plastic							15000	0.226708	0.226708	6.06649e-005	6.06649e-005	0.518255	0.518255	0.07
Magnesite Domain 4		Field Stress and Body Force	30	Isotropic	7.77467e+006	0.25	Generalized Hoek-Brown	Plastic							150000	0.643948	0.643948	0.000952	0.000952	0.504991	0.504991	0.21
Magnesite Domain 5		Field Stress and Body Force	30	Isotropic	497925	0.25	Generalized Hoek-Brown	Plastic							30000	0.214587	0.214587	5.24803e-005	5.24803e-005	0.519528	0.519528	0.11
Magnesite Domain 6		Field Stress and Body Force	30	Isotropic	1.25499e+007	0.25	Generalized Hoek-Brown	Plastic							200000	0.759342	0.759342	0.001471	0.001471	0.504048	0.504048	0.51
Siltstone		Field Stress and Body Force	24	Isotropic	112740	0.25	Generalized Hoek-Brown	Plastic							10000	0.08632	0.08632	9.2194e-006	9.2194e-006	0.543721	0.543721	0.03



<i>Project</i>	Tasmania Magnesite
<i>Analysis Description</i>	AR030 Pit Wall
<i>Drawn By</i>	GHD
<i>Date</i>	December 2011
<i>Company</i>	GHD
<i>File Name</i>	AR030 Pit Wall.fez

GHD

2 Salamanca Square Hobart 7000
GPO Box 667 Hobart 7001
T: 03 6210 0600 F: 03 6210 0601 E: hbamail@ghd.com

© GHD 2012

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	P.Lyden	M. Schult	<i>M. Schult on behalf of M. Schult</i>	<i>[Signature]</i>	<i>P. Lyden</i>	<i>27/01/2012</i>