Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Stability Review

Tomingley Gold Extension Project
Newell Highway, Tomingley

Prepared for
Department of Planning & Environment (NSW)

Project 217140.00
September 2022

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	217140.00	Document No.	R.001.Rev0
Document title	Report on Geotechnical Stability Review Tomingley Gold Extension Project		
Site address	Newell Highway, Tomingley		
Report prepared for	Department of Planning & Environment (NSW)		
File name	217140.00.R.001.Rev0.docx		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Draft A	Stephen Fityus	Scott McFarlane	16 September 2022
Revision 0	Stephen Fityus	Scott McFarlane	20 September 2022

Distribution of copies

Status	Electronic	Paper	Issued to
Draft A	1	0	Stephen O'Donoghue, Department of Planning & Environment (NSW)
Revision 0	1	0	Stephen O'Donoghue, Department of Planning & Environment (NSW)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		20 September 2022
Reviewer		20 September 2022

bsi ISO 9001 Quality Management Systems CERTIFIED
FS 604853

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region Mail Centre NSW 2310
Phone (02) 4960 9600

Douglas Partners
Geotechnics / Environment / Groundwater

Executive Summary

A review of the geotechnical stability of the existing Wyoming One and proposed SAR open pits has been completed, and the outcomes are presented here. The review considered documents provided as part of the Tomingley Gold SAR Extension Project, and it was additionally informed by specific knowledge and experience gained through a visit to the existing Tomingley Gold Operations on 22 August 2022. The primary focus of the review was on the three geotechnical stability reports provided: an open cut geotechnical assessment for the proposed SAR pits (WSP, 2021); a long term slope stability analysis of the proposed SAR north pit (AMC, 2021b); and a stability analysis of the existing Wyoming One pit (AMC, 2021a).

The stability assessments considered in this review describe geological conditions consisting of relatively deep, geotechnically-poor alluvium and saprolite overlying highly to slightly weathered and fresh rock. The alluvium and saprolite have relatively low strength and high susceptibility to dispersion and erosion, and have been associated with numerous bench and multi-bench scale pit slope failures in the Wyoming One and Caloma pits since the mine began operations in 2013.

The geotechnical assessment of the proposed SAR pits undertook a limited amount of drilling and laboratory testing, but the geotechnical model adopted ultimately used the same geotechnical strength parameters for the different geological materials that had been adopted in previous geotechnical assessments. It also adopted a geological model informed by exploration drilling undertaken by the mine, which defined layer boundaries on the basis of reasonable factual data, but which did not attempt any sedimentary structural interpretation. Using these values, the stability of a nominated preliminary pit design was evaluated using the 2D limit equilibrium approach and found Factor of Safety (FoS) values for “local” failures of the proposed slopes of between 0.9 and 1.4. On this basis, recommendations for acceptable maximum bench slopes were adjusted, with some being increased and some decreased. These were presumably used in the next iteration of pit design, however, no stability analyses of a refined pit design were provided in that report.

The geotechnical assessment of the proposed SAR pits also included a characterisation of rock mass defects and considered rock mass instability through wedge and planar sliding mechanisms. The structural defect data used in that assessment was all derived from borehole and bore core measurements, and the outcomes were internally inconsistent. A single shear strength value for all types of structural defects was adopted, based on a value taken from an assessment by others. The role of rock mass discontinuities such as faults and igneous intrusions was not given specific quantitative consideration.

A significant shortcoming of the geotechnical assessment of the proposed SAR pits, which significantly undermines confidence in its outcomes, is its complete reliance on previously determined data and data from site investigation and testing, with no attempt made to calibrate models and parameters using observations, measurements and analyses of the extensive examples of slope performance available in the existing Wyoming and Caloma pits. The origin and values of the design shear strength parameters used in the design of the Wyoming 1 and Caloma Pits could not be determined from the documents provided, however, on the basis of the slope performance observed during the site visit, it would seem that they are inadequate for the design of the pit slopes that were ultimately constructed, suggesting that greater effort is required in specifying slopes that have a reduced risk of instability.

The long term slope stability analysis of the proposed SAR North Pit utilises the same geotechnical parameters that were adopted for the preceding WSP geotechnical assessment, but adopts an updated pit design (presumably incorporating the recommendations of the geotechnical assessment).

As for the WSP geotechnical assessment (WSP, 2021), no advantage was taken of the opportunity to study the performance of the existing Wyoming One pit and calibrate strength parameters using the many examples of failures that are already evident in that pit. It proposes two possible criteria to capture the likely long-term stability condition of the final void slopes; a likely long-term stable slope of 20º and a slope given by the slip circle that would correspond to a factor of safety 1.5 in the design slopes.

These criteria have limited justification, but do not seem unreasonable. However, they typically result in conflicting estimates of long-term stable slopes. Estimates based on the factor of safety of 1.5 are between 20º and 28º, and subsequent estimates of slope crest regression are based on these values. If the value of 20º were adopted everywhere, some of the crest retreat distances would increase by as much as 60 m. These outcomes were not compared with long-term slope predictions in the Landloch erosion study (Landloch, 2021), as the predicted 1000 year profiles were considered implausible.

The long-term analysis of the existing Wyoming One pit also utilises the same geotechnical parameters that were adopted for the preceding WSP geotechnical assessment, but takes the opportunity to calibrate strength parameters of the saprolite in the south-east corner by back-analysis a failure that occurred there. The parameters obtained are significantly lower than those adopted for saprolite in other reports. The new lower parameters are then used for the analysis of pit slopes in the south-east corner, but the higher, previously-adopted values are used again for analysis of other parts of the pit, without support from a detailed geological model to justify the use of different saprolite strength values in different areas. The Wyoming One report again proposes the same two criteria to capture the likely long-term stability condition of the final void slopes; a likely long-term stable slope of 20º and a slope given by the slip circle that would correspond to a factor of safety 1.5 in the design slopes. Estimates of the stable slope angle for the south-east corner, using the calibrated parameters and based on the factor of safety of 1.5, are around 18º which appears reasonable. Estimates for other parts of the pit are between 25º and 28º, and these are generally consistent with the Landloch erosion study 1000 year slope angles, which are plausible for the Wyoming One pit. Subsequent estimates of slope crest regression are based on these values, however, if the value of 20º were adopted everywhere, some of the crest retreat distances would increase by as much as 65 m.

The AMC WY1 report concludes that as the southeast corner has "marginal stability" and that "slope remediation could be required for this wall area to remain as part of the current approved final landform." Further back-analysis of failures (in both the alluvium and saprolite) and improved geological mapping of the alluvium and saprolite is likely to find that the same applies to more (if not most) areas of the pit. The report concludes that flattening of the slopes in the alluvium and saprolite is inevitable for a stable final landform, and that it is likely that this process will happen spontaneously, and "in the short-term rather than the long-term". Through its recommendation to manage safety risks of instability through exclusions and management procedures, the AMC report implies that significant spontaneous slope evolution could occur on a timescale as short as the operating life of the mine. Observations during the site visit on 22 August 2022 confirm this is already happening.

It is noted that "without implementation of management measures, such as good surface water drainage and re-vegetation, long-term erosion has the potential to lay the slopes back at nominally 20º through the alluvium and saprolite." Observations during the site visit on 22 August 2022 confirm observations in the report that the site soils may be highly dispersive, with benches, slopes and bunds all showing signs of rapid deterioration through mechanisms of soil dispersion and tunnelling erosion.

Maintenance of effective water diversion structures on this site will be challenging, requiring future commitment well beyond the life of the mine. If, as correctly suggested, the rate and extend of slope regression will rely on keeping water away from the upper pit slopes, it will be difficult to ensure that deterioration does not increase significantly after the mining operations cease and the site is relinquished.

The reports provided to inform the TGEP proposal in regard to the stability of existing and proposed pits generally fall short of providing adequately justified, or definitive answers in a number of areas. Uncertainty in different aspects of the assessments carried out result in uncertainties in the likely future performance of the operating pits and final voids. This review identified many of the more significant uncertainties, and it recommends additional clarification that might be sought to reduce the uncertainties related to future pit performance. These include seeking a revised geotechnical stability assessment, which utilises improved geological and geotechnical models, informed by structural and sedimentological mapping of the existing pits at Tomingley, observation of existing slope failures and their causes, and parameters calibrated from back-analysis.

Douglas Partners
Geotechnics | Environment | Groundwater

Table of Contents

Report on Geotechnical Stability Review
Tomingley Gold Extension Project
Newell Highway, Tomingley

1. Introduction

This report presents a tomingley gold extension project at Newell Highway, Tomingley. The investigation was commissioned by Stephen O'Donoghue of Department of Planning & Environment (NSW) and was undertaken in accordance with Douglas Partners' proposal 217140.00.P.001.Rev0 dated 3 August 2022.

This report presents pit a geotechnical stability review for the pits associated with the proposed Tomingley Gold Extension Project (SSD-9176045), in accordance with the Statement of Requirements received by email from Mandana Mazaheri on 20 July 2022.

The scope of the review addresses the outputs nominated in the Statement of Requirements as:

- Review the adequacy and appropriateness of geotechnical stability analysis conducted, and proposed criteria for the slope stability analysis / analysis of high and low wall geotechnical stability of the voids for the project, including robustness of the inputs used in making conclusions;
- Advise if further information is required; and
- Provide draft and final expert advice including recommendations to the DPE for input into the DPE's assessment report.

Documents provided as the subject of the review comprised the following:

Environmental Impact Statement (EIS) Documents for Expert Review
Volume 1 - Appendix 6 – Pit 1 Slope Stability Analysis (AMC, 2021a)
Volume 1 - Appendix 7 - Open Cut Erodibility Assessment (Landloch, 2021)
Volume 1 - Appendix 8 – Pit 2 Geotechnical Assessment (WSP, 2021)
Volume 1 - Appendix 9 - Pit 2 Long Term Slope Stability Analysis (AMC, 2021b)
Volume 1 - Appendix 10 - Eastern Cutback Geochemical Assessment (RGS, 2021a)
Volume 1 - Appendix 11 - Extension Project Geochemical Assessment

Background Documents
Project SEARs 22/11/21
EIS – Executive Summary
Volume 1 - Appendix 4 - Additional Information Supporting the Project Description (mine design, final landform)
Resources Regulator - EIS advice 06/04/2022
Applicant's Submissions Report 05/22
Resources Regulator - Submissions Report advice 10/06/22
RFI 4 – Applicant's Response to Resources Regulator advice on Submissions Report (this document is currently being reviewed by the Resources Regulator):
The existing development approval 2012 - 2022

The review focused heavily on the Appendix 4 (RW Corkery, 2021), Appendix 6 (AMC, 2021a), Appendix 8 (WSP, 2021) and Appendix 9 (AMC, 2021b) documents, as these are the documents which directly consider geotechnical stability of open pits. The review considered the geochemical assessments of Appendix 10 (RGS, 2021a) and Appendix 11, however, as these have limited relevance for the assessment of geotechnical stability, specific detailed reviews of these are not included. The erodibility assessment of Appendix 7 (Landloch, 2021) is also outside the strict scope of a geotechnical assessment; although only brief comments on Appendix 7 are included, relevant aspects of that report are referenced as appropriate, in the review of the proposal.

This review also draws on observations collected during the site visit of 22 August, 2022, which provided an opportunity to inspect the site, with good access to observe the Wyoming One and Caloma 1 pits, and to seek clarification from senior mine staff and a representative from R. W. Corkery, who are understood to be coordinating the TGEP proposal on behalf of Alkane Resources. A specific report on the site visit has not been included, however, the observations collected have been used throughout this review to illustrate some of its discussions and conclusions.

Please note that although the nominated scope of the review makes reference to "high and low wall geotechnical stability of the voids" the subvertical nature of the strata and the circular shape of the pits for this project cannot be differentiated as high walls or low walls. All excavated pit walls will be included in this assessment, without differentiation as being high walls or low walls. Further, as there is no in-pit disposal in the Wyoming One or Roswell (SAR North) pits, the side slopes of the waste rock emplacements in the final landform are not considered to be low walls, and consideration of their stability falls outside the scope of this review. It is noted that there is a limited area in the final Roswell Pit where spoil backfill in the central pit comprises the upper part of the southern wall in the final void, but the stability of this is not addressed in any of the proposal documents provided, and its stability is not considered in this review.

Assessment of the stability of the Residue Storage Facility also falls outside the nominated scope of this review, and is also excluded from this review.

2. Review of Appendix 8 (WSP, 2021)

2.1 Specific comments on Report by Section

2.1.1 Scope of Work

The scope, as noted in the report, was adequate to generate sufficient data and interpretation to adequately assess stability for the TGEP development.

Geotechnical Investigation and Data Sources

A good amount of potentially useful pre-existing data was available to the assessment. Additional drilling, testing and analysis was undertaken, however, there has generally been an over-emphasis on investigating the conditions along the north-south axis of the SAR pits, at the expense of adequately investigating the eastern and western margin; in the eastern margin where foliated chlorite schists may occur and the western margin, where the Cotton Formation rocks are likely to be encountered.

Little justification is given for the chosen location of SAR boreholes, and although Borehole SARG009 is close to the Roswell fault, it is unclear if it was positioned with the intention of determining the geotechnical characteristics of the fault. There is also no reason given for the decision to drill inclined holes, which seem only to have led to inconsistencies in structural interpretation (discussed below).

The opportunity to utilise observational data from the existing Caloma and Wyoming pits has not been utilised to any significant extent.

Groundwater data available to the project is inadequate.

All of these aspects regarding the acquired and available data and its utilisation are considered further in this assessment.

Geology and Geotechnical Model

Aspects of Figures 4 to 7 are unhelpful: the legend is ordered alphabetically; colours are hard to distinguish and non-systematic; and superimposed bore profiles of little use and inconsistent with surfaces from the Alkane model.

The unit surfaces for the base of alluvium, base of saprolite and based of oxidised zone, obtained from Alkane Resources, appear to simple linear interpretations of point data. It would have been helpful to present these as contour surfaces, potentially allowing some interpretation of the structure of the base of alluvium to better interpret the obvious paleochannel features. This would have been helpful in informing the structure of contact surfaces in the cross sections analysed for stability.

Characterisation of Alluvium and Saprolite

A reasonable amount of new and existing test data is available to guide strength characterisation of these units, but it is relied on exclusively. The attribution of a dense to very dense relative density for the sandy clay soils is strictly incorrect.

The new triaxial tests appear to be multi stage tests on single samples, though this is neither explicitly stated on the test result sheets nor in the report. Despite this, the availability of triaxial data is beneficial.

The Mohr-Coulomb strength parameters shown on Figure 9 of the report for the WSP tests on Tertiary alluvium are inconsistent with the data shown in the graph, however the values shown in subsequent figures are correct and the error in Figure 9 is not carried forward.

Shear strength parameters were assigned based on testing by WSP and previous tests by others. The strength relationship bounds for Tertiary alluvium from combined test results in Figure 10 of the report are mostly reasonable though they may slightly over-estimate the shear strength at low stresses. The bounds for Quaternary alluvium in Figure 11 of the report from testing by others are reasonable, however the lower bound for saprolite in Figure 12 of the report seems to disregard a particularly low set of values corresponding to one of the tested samples. As this data is also adopted from a previous report, there is no means of considering why this should be, and no reason is given. This remains as a discrepancy between the data and the adopted values, and it could have been addressed by additional triaxial testing of some of the samples from the boreholes drilled for this report, or by back-analysis of failures in similar materials in the existing Caloma and Wyoming pits.

The reduction in the strength parameters for the Tertiary alluvium in the San Antonio pits is arbitrary.

Rock Mass Model

The extent and analysis of data with regard to the rock quality and rock mass features is generally adequate, and parameters such as RQD, defect spacing, defect type, weathering and rock strength are reasonably characterised for the different major horizons. Whilst the relative contributions of rock types in the Mingelo Volcanics is generally well established, more precise distributions are lacking. In particular, the Cotton Formation lithologies are poorly represented in the data. It appears that these are likely to be only represented in the western side of the SAR pits, but there is no rock or rock mass data for this formation, and no assessment as to whether its rock and rock mass characteristics are likely to be consistent with those of the Mingelo Volcanics.

Perhaps more significantly, it is acknowledged that “data and information on the location of the Cotton Formation/Mingelo Volcanics contact is limited” and that “the contact at Tomingley is interpreted as a fault.” This is not elsewhere considered or clarified. A more thorough assessment of the likely exposure of the Cotton Formation and its contact in the wet pit faces, and the consequences of a faulted contact would improve confidence in the stability assessment of the western pit slopes. Further comments follow elsewhere in this assessment.

Similarly, it is uncertain whether the chlorite schists, responsible for unravelling failures in the Wyoming One pit, will be encountered in the eastern side of the SAR pits.

It is also noted that the cross-sections in Figures 3 to 7 of the report indicate significant potential exposures of dacite, andesite and monzodiorite down the axis of the pits, though only the monzodiorite is represented in rock strength tests and only in two tests (one of which was invalid). Based on the limited cross sections presented, igneous units could occur extensively in the north and south pit walls.

A significant number of the rock strength data are derived from samples taken from previously drilled and cored exploration bore denoted “RWD045”. There is no location map for this bore (or any RWD bores) in any figure, and no indication of drilling date/age. Correspondingly, there is no assessment on the significance that age/storage might have had on the core quality, and subsequent measurements.
It is noted, that for the number/length (11/717 m) of new cored holes drilled, the point load data (17 measurements) is scant, and not measured on the fresh core as it was recovered from the borehole. The derived values of GSI for the weathered and fresh rock seem reasonable.

Defect shear strength values appear to have been adopted directly from the previous report of the MOC Consultants, with no additional input from the additional data acquired for the WSP assessment. The basis for the MOC values (“joints within the slightly weathered to fresh rock mass are likely to have a defect shear strength of between 33° to 37° with a cohesion of zero. Faults and shears are assessed as having a defect shear strength of 20° and cohesion of zero.”) was not available to this review, and so, the reasonableness of these values cannot be assessed.

Structural Patterns

The explanatory notes for the borelogs note that “dip (is) measured relative to the horizontal plane in vertical boreholes and relative to core axis in inclined boreholes.” The report notes that “based on each pit area, WSP has produced stereographic projections (stereoplots) in DIPS4 using the combined geotechnical and exploration structural data and these are presented in Appendix H. Stereoplots are of the combined data from the boreholes and show all the logged structures.” There is no reference made to whether/how the data were corrected for borehole orientation, but presumably they were. Details would assist in evaluating the rigour of the approach used, and the reliability of the outcomes.

“Stereographic projections (stereonets) of the geological structure interpreted in the downhole geophysics … are provided in Appendix G.” Again, there is no reference made to whether/how the data were corrected for borehole orientation, but again, presumably they were.

There is nothing in the report to suggest that the two sources of the same structural data (ie borehole geophysics and bore core features) were combined, or even cross referenced, and instead the two interpretations are presented separately. Figure 1 (below) compares the stereoplots for the full data from each source, and plots the data separated into major and minor structures. It is clear from this comparison that there is little or no correlation between the data derived from the two sources. Whilst perfect correlation would be unexpected, an absence of meaningful correlation is concerning, and it suggests that one or both methods are inherently flawed. The report notes that “the success of the downhole geophysics was poor due to many holes being blocked” and due to poor image quality in the more weathered materials. However, no evaluation is provided for the likely sources of the inconsistency between data from different sources, which is likely to be reliable/more reliable, and how the identified significant structural features to be used in design were selected from the data.

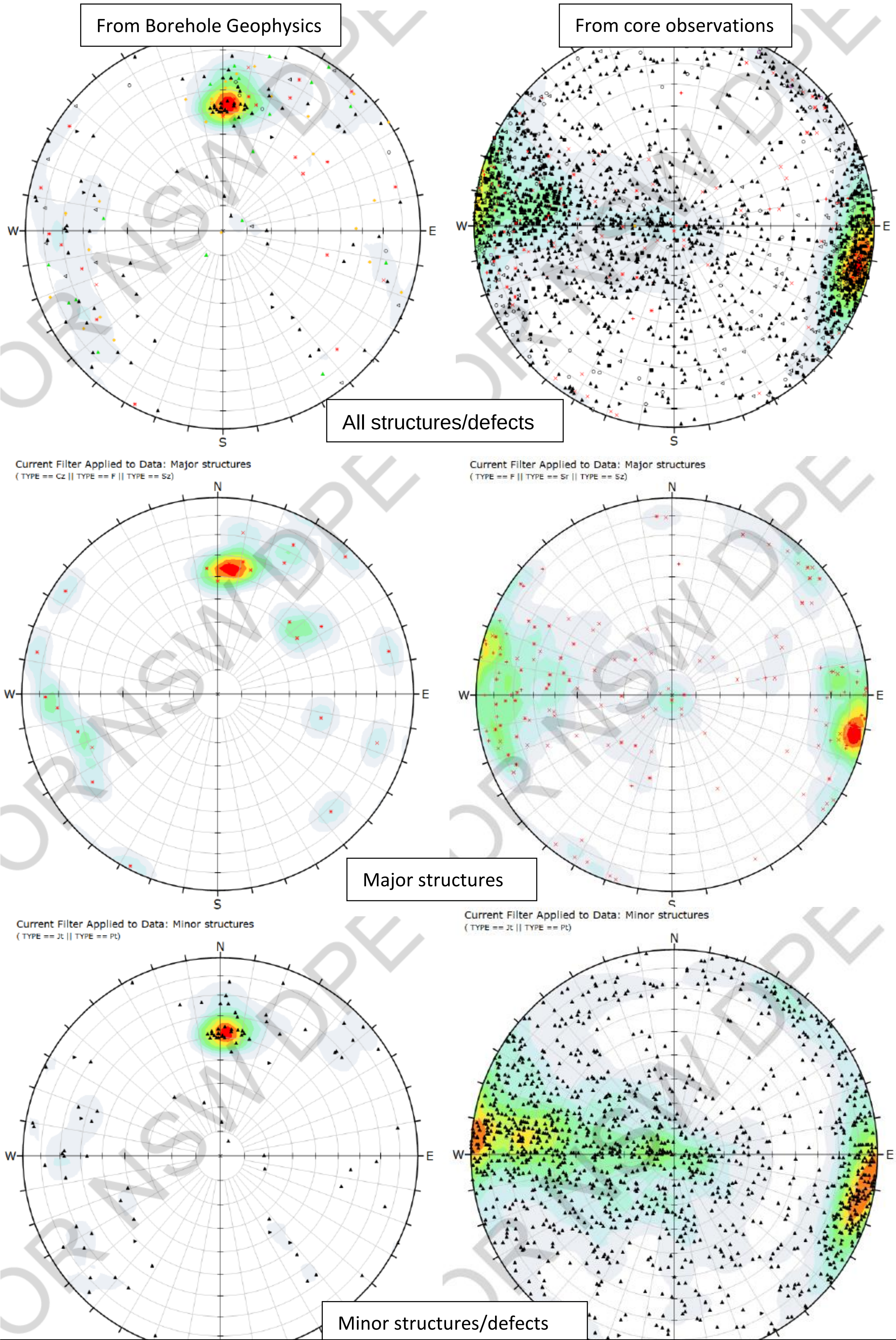


Figure 1: Comparison of structures geophysics (left) and logged in cores (right)

The data from the logged defects and structures in the boreholes would seem to be more consistent with the regional geological structure, as it has been summarised elsewhere. It might also be suspected that the source of the data inconsistency could lie in errors associated with orientating data in inclined boreholes and correcting it to dips and dip directions relative to vertical and horizontal axes. This again highlights the importance of outlining the approach and processes used. It is noted that the bore core data used was a combination of features from the SAR series of boreholes drilled for this report, and features in exploration boreholes drilled by the mine. It would be useful, in evaluating the reliability of the structural data, to present a comparison of these two sets of somewhat independent data, to confirm that the general trends were not systematically different.

Structural feature NFL1 is potentially of concern, in that it was strongly identified in the geophysics of SARGT007, but only in that borehole and only by the geophysical data. It is considered likely that the persistence of this trend in the SARGT007 data denotes a significant structural feature trend, but given the inconsistency of the geophysical data as a whole, some effort is required to reconcile the features responsible for displaying this trend in the geophysics with the corresponding features in the borehole core logs, to understand what the features are and why they do not appear to have been picked up by the manual borehole logging.

It is noted that for many of the principle structural features identified, their orientation is interpreted as being “consistent with the main foliation orientation”. This observation is inconsistent with the geological setting described earlier in the report, which did not identify any of the lithologies as having a significant foliation. There is also no recognition of any contribution of foliation to measured strengths or failure directions in the point load test data. If the lithologies do have a pervasive foliation, some indication of its orientation and strength would be helpful.

It is surprising to not see a summary or inventory of major structural features that express, or have historically caused problems, for the existing Caloma and Wyoming pits. It was apparent from the site visit that these pits afford the best opportunity to display likely geological structures on a regional scale. Figure 2 (below) presents a selection of images taken of the Wyoming One pit walls during the site visit on 22 August 2022, which show a selection of obvious structural features with varying potential significance for the rock slope behaviour. Structural characterisation from photogrammetric models derived from images captured by UAV have all but become standard practice, and could have provided invaluable data for resolving inconsistencies in the structural trends. Whilst structures in the existing pits may or may not express exactly the same in the proposed SAR pits, it would seem to be of value to at least look for previously encountered structural trends in the SAR pits, to identify which of these are present, and specifically look for and eliminate those that are not. Given the broad scatter of the data in Figure 13 of the report, it is quite possible that important specific structures have been missed. Experience with structures in the Caloma and Wyoming that have been identified the SAR pits would be insightful in quantifying their likely potential impact.

The groundwater data and conclusions, as presented are inadequate. Table 9.1 of borehole levels and depths does not include any indication of borehole depths, casing details, screened depths or backfill/sealing depths. Whilst the conclusion (that water levels are below the base of the alluvium and saprolite) may well be correct, poorly specified/installed groundwater bores which do not adequately capture hydraulic conditions in a multi aquifer system, may fail to detect a perched aquifer in the overlying sediments. It is likely if there was water ponded in the sediments overlying rock, seepage would be noted at these interfaces in the existing Caloma and Wyoming pits, and mine staff would be familiar with/aware of it. As this is not reported, then the conclusions are probably correct, but a specific exclusion of shallow water based on observations/experience in the existing pits in the report would improve confidence in this.

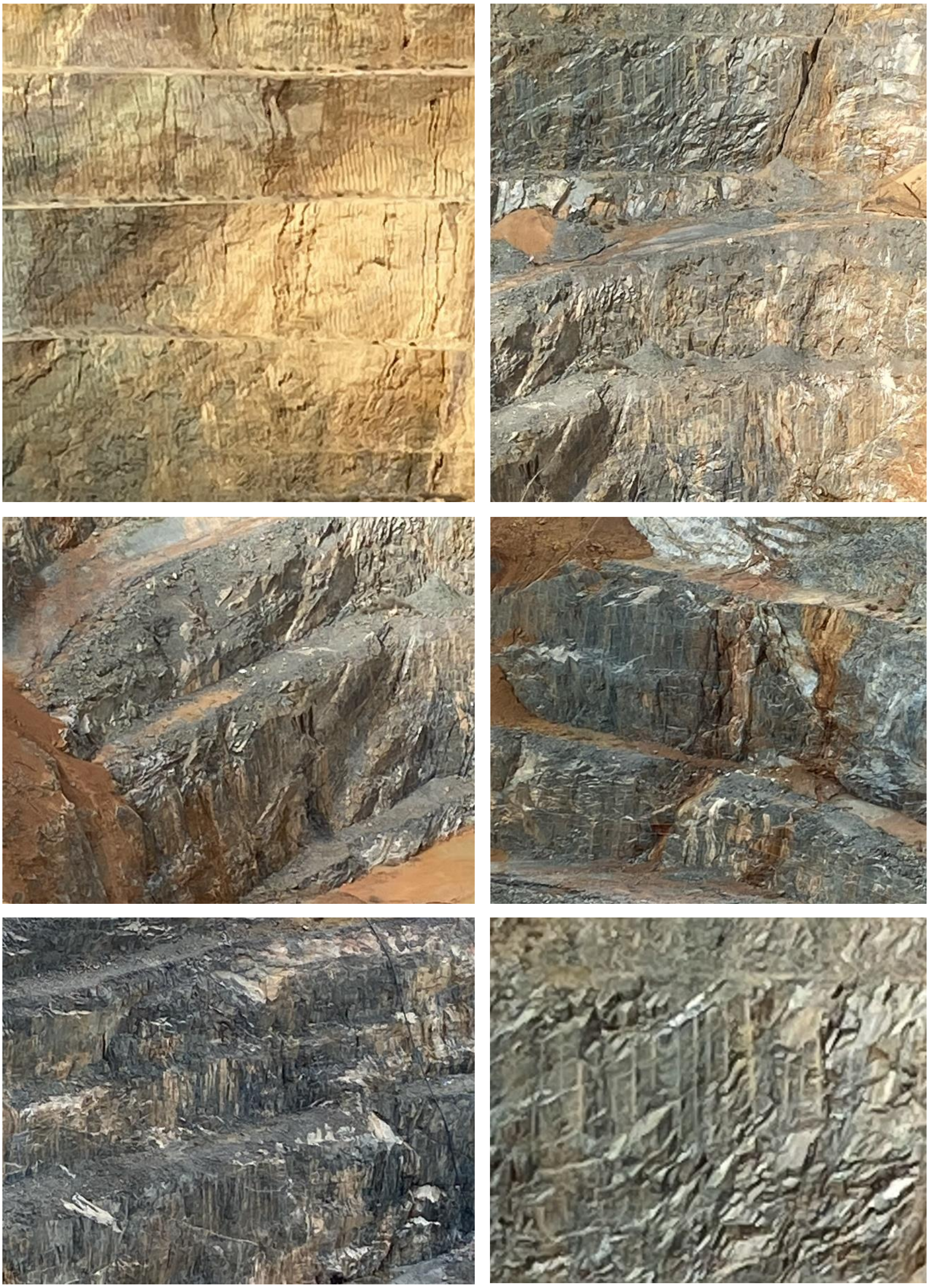


Figure 2: Structural features displayed in the existing Wyoming One pit showing different degrees of importance for rock slope behaviour

Slope Stability

The identified slope stability controls are comprehensive and adequate. There is due recognition of the importance of groundwater, notwithstanding the inadequacy of what was presented previously to inform any specific groundwater considerations. Recognition of the difficulty in characterising the nature and behaviour of the saprolite is pertinent and important.

The selection of 88 2D sections to analyse is also comprehensive and well distributed. It is understood that the results reported in the section on stability analysis related to the pit slopes based on the concept pit design sar_c5c11_201203, which utilised a preliminary geotechnical model with assumed parameters from previous works.

It is unclear why a combination of SVS and SLOPEW analyses were used, but each is reasonable. The results seem reasonable, notwithstanding comments previously made about the geotechnical and groundwater models and geotechnical parameters that have been adopted.

Undercutting Analysis

The undercutting analysis appears to consider the analysis of any instability which would initiate in the weathered to fresh rock mass. It considers instability triggered by wedge and planar sliding modes, but no specific consideration is given to failures resulting from toppling.

Graphs in Appendix J are poorly presented and difficult to interpret, but it is assumed that the vertical axis (labelled “Frequency %”) denotes the probability of undercutting or Pu, and the horizontal axis (labelled “Dip”) denotes the inter-ramp angle or IRA. In the results for each case analysed, up to 4 trend lines are plotted on the figures: it seems that the upper bound IRA values for any of these trends is used to choose a critical slope value for Pu values of 5% and 10%, though this is not stated.

The statistical methodology adopted for the undercutting analysis seems generally reasonable, however, the conclusions in regard to suitable IRA slopes to avoid undercutting failures are potentially influenced by shortcomings in the parameters adopted that have previously been identified. Specifically, these are:

- The outcomes of the Pu analyses are directly the result of the major sets of structural features identified for this design, which were not convincingly justified on the basis of the core and borehole geophysics data, and which are understood to have not specifically considered trends of observed structures, or experiences of stability/instability, in the existing Caloma and Wyoming pits.
- A blanket defect strength model of no cohesion and a friction angle of 20 degrees has been adopted for all defects, based on “laboratory data” (quoted, and not part of the assessment) “and mapping in the Tomingley pits and on WSP experience with similar rock mass types and assumed typical shear strengths of faults and shears”. Whilst this adopted defect shear strength does not appear to be unreasonable, no stated consideration was given to possible shear strength differences between faults, shears, shear zones, crush zones and infilled structures, which are likely to differ, perhaps significantly.
- The kinematic analysis included “major structures” but did not consider joints, fabric or bedding. Some assessment of whether these are or are not likely to participate in kinematic failures leading to undercutting could be made based on the observed behaviours in the existing Caloma and Wyoming pits.

The particular methodology does not specifically include any quantitative consideration of undercutting likelihood, instead defaulting to “WSP experience (that) a Pu of 5% to 10% is appropriate for inter-ramp angles (toe to toe) …. however, a Pu of 10% is considered aggressive, especially in ramp areas.”

Also, whilst the analysis identifies suitable IRA slopes to control the likelihood of rock mass instability, it provides no consideration of the consequences of instability, especially in the context of “combination” mechanisms for the slope as a whole, which comprises soils and saprolite in its upper ~30-50 m. That is, there is no consideration of the lateral extent of a combination soil-rock slide, triggered by an undercutting structural rock mass failure, but extending back through the overlying soil layers. It is stated that “structurally controlled failures are applicable to the bench and inter-ramp slope scales” but there is no justification as to why a structurally-controlled failure at an angle lower than the pit slope in rock (say related to NFL1, NFL4, SFL2 or FL5) which propagates up from the base of the pit, could not affect slopes well up into the saprolite and alluvium.

As a final comment, the significance (or not) of the east-west dykes in not explicitly quantified, though it is recognised as posing a risk. Whilst these dykes do not strictly constitute defects, localised difference in rock mass strength/weathering at dyke contacts can be a source of localised or larger instability in steep exposed walls. Figure 3 below shows an example of penetrative dykes in the northern end of the Caloma 1 pit, indicating the potential for the dykes to affect slope performance. Some explicit consideration of this based on observations from the existing Caloma and Wyoming pits would address this.

Figure 3: East-west dykes in the north wall of the Caloma 1 pit, with differential weathering in the weathered zone showing potential to affect slope stability.

Recommended Pit Slope Design

It is understood that the results reported in the section on stability analysis (which predicted that many of the slopes in this design would have FOS values between 0.9 and 1.2) related to the pit slopes based on the concept pit design sar_c5c11_201203. It is further understood that the recommended pit slope design values in this section are also provided for the same arrangement of pits and pit depths proposed in the concept pit design sar_c5c11_201203. Presumably the downward adjustments in recommended parameters between the preliminary values presented in Tables 11.1 and 11.2, and the revised recommended parameters in Tables 11.3 to 11.8 are intended to improve some of the more marginal factors of safety. It is also presumed that where increases in recommended parameters are allowed, these are to allow pit wall steepening where FOS values are deemed suitably conservative.

Notwithstanding this reasonable approach to refine the recommended design values, there is only a qualitative discussion of the extent to which the predicted stability would be affected: that is, the improvements in stability are not quantified. Using the revised recommended parameters, the report describes the pit design sar_c5c11_201203 as “aggressive”, which is unhelpful and undefined.

It would have been useful to see a comparison table which compares the FOS values for the sar_c5c11_201203 design in Section 10 with FOS values for equivalent sections with slopes adjusted to the recommended values in Section 11. This would afford some consideration of enhancements (or otherwise) to the predicted stability and some better appreciation of how "aggressive" the design would be.

The discussion provided with the recommended pit slopes duly acknowledges the:

- Potential for "failure in the saprolite (due to relict structure and loss of strength on exposure to rainfall) especially in areas of dolerite dykes that have swelling clays"
- "Risk for … overall scale failure of the alluvium and saprolite in the west walls and south wall of the south pit", noting "slopes higher than 60 m (and up to 77 m) have not been developed through these materials at Tomingley and so their performance will be somewhat uncertain".

However, these are not quantified.

Geotechnical Risks

Significant geotechnical risks are justifiably identified. It is correctly stated that "eliminating collapse or failure in the saprolite and weathered rock through design is difficult and as such an observational approach to identify early signs of instability", which acknowledged that progressive collapse, even during the life of the mine is likely.

This section identifies seven specific risks which remain poorly characterised by the report, and all are significant (and pre-empted by data deficiencies already identified by this review).

2.2 Overarching Discussion and Conclusions

The WSP PS117942-GEO-REP-005 RevB report (WSP, 2021) presents data and associated analysis to evaluate the stability of the proposed SAR pits for the Tomingley gold Extension Project. A reasonable amount of data was acquired and presented, to facilitate a basic theoretical analysis of the likelihood of instability in the pit walls, resulting from failure in the upper alluvium and saprolite units and the underlying volcaniclastic rocks of the Mingelo Volcanics, with some consideration of the potential for combined modes of instability. It provides sufficient and reasonable information to conclude that the sar_c5c11_201203 pit design is "aggressive", and that that it will be prone to localised bench failures, and possible wall failures of larger scale, that will need to be proactively managed during the life of the mine.

Limitations of this report include:

- It does not quantify the "aggressive" nature of the pit design by providing likely factors of safety that would result from adoption of the recommended pit slope angles;
- It does not quantify the residual uncertainties in the risks of instability, arising from:
    - Inadequate groundwater data;
    - Inadequately characterised material properties and structural characteristics of dolerite dykes and other intrusions;
    - Inadequately characterised contact between the Mingelo Volcanics and the Cotton Formation, and poor characterisation of the Cotton Formation lithologies.

  - At least one major fault structure that runs through the pit.

It does, however, explicitly acknowledge that these are limitations of the assessment, with recommendations that at least some of them be addressed.

- It does not give any consideration to the possibility and consequences of multiple instability events, whereby an initial failure of a pit slope in alluvium and saprolite would steepen the slope, potentially triggering subsequent instability, and so on, resulting is a progressive collapse of the slope, to an extent greater than any single limit equilibrium analysis might predict. Such a failure is shown in Figure 4 below.
- It provides no comment or discussion of the likely rate that slopes would fail in the final pit shell, after proactive monitoring and remediation activities during mining have ceased.

Figure 4: Example of a regressive, multiple-slice slope failure in the western wall of the Caloma 1 pit.

Recommendations for increasing confidence in the conclusions of the TGEP geotechnical study include:

- Confirming that the groundwater assumptions used in the assessment of stability are valid and accurate, and confirming that water will not accumulate in the alluvium and saprolite layers (and reconsidering the stability analyses if the groundwater conditions deviate from those assumed).
- Checking and reconciliation of the structural data from the bore cores and borehole geophysics.
- Undertake an observational/investigative study of the pit slope performance of the existing Caloma and Wyoming pits, and reference this as appropriate, to support (or otherwise) slope performance predictions in the report. Note that this was listed as part of the scope of the PS117942-GEO-REP-005 RevB report, but did not appear explicitly in the report, with only passing reference being made to performance in the existing pits anywhere in the report. This study might include:
    - Stereoplots of joints and other structures that are exposed in the existing pit walls;
    - Specific characterisation of particular behaviours/failures that might be associated with a particular set or type of structure;
    - Assessment of wall behaviour associated with discordant/non-conforming contacts between igneous intrusions and stratified rocks;
    - An inventory of slope failures that occurred during the life of the existing pits, the fabrics/structures they were associated with, and the mode of failure;
    - Changes in the nature, rate and/or extent of instability that occurs with time, with increasing exposure of the pit walls to climatic and atmospheric influences; and
    - Groundwater observations.
- Validation of the shear strength parameters assumed for all structural defects by some means such as defect shear strength testing, or back-analysis of an observed failure along a structure in the existing Caloma or Wyoming pits.
- Clarification of the lithological characteristics of the Cotton Formation rocks to establish if they have an inherent fabric and if that fabric contributes in some way to any mode of instability.
- Consideration of the possibility that the chlorite schists in the east wall of the Wyoming 1 pit might be encountered in the proposed SAR pits and designing to account for their potential adverse impact on slope performance.
- Characterisation of ground conditions adjacent to the Roswell fault.
- Quantifying the typical FOSs that are likely to result if the recommended pit slope values are adopted.

3. Review of Appendix 9 (AMC, 2021b)

3.1 Specific comments on Report by Section

The purpose of this report was to undertake geotechnical stability analyses on the proposed final slopes of the Roswell pit, and provide geotechnical advice on the long-term stability of the Roswell pit (SAR north pit) slopes to inform mine rehabilitation studies as part of the Tomingley Gold Extension Project (TGEP).

This report post-dates WSP report (WSP, 2021) and had access to it. It did not collect any new data; it adopted stratigraphic data from supplied by Alkane resources derived from the mine's geological model, and informed its parameter selection by reference to WSP reports and the Jacobs draft groundwater report.

The report considered final rehabilitated landform slopes as proposed by the des_sar_combined_210422 pit design, which post-dates the earlier preliminary sar_c5c11_201203 pit design considered by the WSP (WSP, 2021).

It is also noted that this report predates the "Wyoming 1 Open Cut and SAR North Pit Voids Assessment of Long-term Stability to Erosion" (Landloch, 2021).

Overview of the Geotechnical Model

As was done for WSP report (WSP, 2021), the geological profiles for analyses adopted stratigraphic surfaces provided by Alkane. This is likely to be the best data available, in lieu of undertaking further site investigation.

Based on the Jacobs draft groundwater report the groundwater was characterised as a fractured rock aquifer system controlled by the regional water table and hydraulically disconnected from the overlying alluvial groundwater systems. It suggested that alluvium is likely to be predominantly unsaturated but acknowledged that some small perched and discrete alluvial groundwater systems could exist. This is a similar assumption to that made in the WSP analyses, however, if water is able to perch at the base of alluvium, it will have an effect on stability.

Based on the preliminary groundwater modelling report by Jacobs 2021 the final void equilibrium water level was taken to be at 180 m Australian Height Datum (AHD).

Slope Stability

The report lists the same four potential modes of instability as the WSP report (WSP, 2021), which reasonably capture the possible mass failure modes. In addition, it identifies primary long term failure mechanisms including "ongoing deterioration of the alluvium and saprolite and rock mass style failures at a bench and multi-bench scale within this material" but also notes the likelihood of "unravelling of weathered rock over time".

The likelihood of soil loss through erosion and dispersion is noted. It is further suggested that "without implementation of management measures, such as good surface water drainage and re-vegetation, long-term erosion has the potential to lay the slopes back at nominally 20º through the alluvium and saprolite." Although over-generalised, this seems like a plausible assertion. It defers to the Landloch (2021) geomorphological assessment for a more refined assessment. It is noted, however, that the concept of "long-term" is not quantified, so the required commitment to ongoing landform management cannot be determined.

Despite recognising four potential modes of mass instability, the approach taken to consider long-term slope stability was limited to limit equilibrium analysis of five cross sections, assuming a circular style failure through the alluvium, saprolite and weathered rock horizons. This effectively considers two of the four modes identified. Structure controlled rock mass failure was not considered, either qualitatively or quantitively, as a factor in the long-term stability of the pit.

To estimate the likely long-term stable slopes of the proposed Roswell pit, the report defers to “AMCs experience and industry guidelines for open pit stability (Read & Stacey 2009) (that) the failure path for a FOS of 1.5 proves an appropriate indication of the extent of slope that may experience failure in the long-term.” Read and Stacey is an extensive book on open pit stability, covering many aspects. Upon requesting clarification as to which part of Read and Stacey (2009) this criterion was based on, Table 9.9 was nominated. The data in 9.9 do not strictly support the adoption of the criterion, as stated, although Table 9.1 might lend it some support. However, there are few explicitly stated criteria with which to make such an assessment, and in the absence of a better approach, this does not seem unreasonable, provided it is adopted consistently with other geomorphology-based approaches to long-term landform evolution, and reconciled with the anticipated final slope of 20º that was also noted.

The stated scope of the assessment included “reviewing all the available geotechnical data relevant for the assessment of slope stability”. This does not appear to have been done in any rigorous way, (or at least it was not recorded in the report) and instead, strength parameters were taken directly from the WSP report (WSP, 2021), without any additional consideration of their appropriateness.

After carrying out the 2D limit equilibrium analysis of the five selected slopes, the immediate factors of safety ranged from 1.1 to 1.4. The failure circles corresponding to FOS values of 1.5 corresponded to circular surfaces with an average slope (crest to toe) of between 20º and 26º, which is not fully reconciled with the noted likely long-term slope laybacks of 20º. Whilst it is acknowledged that the limit equilibrium analyses estimate stable slopes on the basis of soil strength, and the ultimate value of 20º is based on combined processes including erosion, in the absence of any discussion around the relative timeframes for each, each must be considered a plausible long-term outcome. In summary

- The average slope for a limit equilibrium FOS of 1.5 for the west wall was 20º, so the 47 m crest retreat value is appropriate.
- The average slope for a limit equilibrium FOS of 1.5 for the northeast wall was 22.5º, and inconsistent with a long-term layback of 20º. If a 20º slope is fitted to the same alluvium/saprolite/weathered rock interval, then the predicted 58 m layback increases to 80 m.
- The average slope for a limit equilibrium FOS of 1.5 for the north wall was 22.8º, and inconsistent with a long-term layback of 20º. If a 20º slope is fitted to the same alluvium/saprolite/weathered rock interval, then the predicted 58 m layback increases to 81 m.
- The average slope for a limit equilibrium FOS of 1.5 for the east wall was 26º, and inconsistent with a longterm layback of 20º. If a 20º slope is fitted to the same alluvium/saprolite/weathered rock interval, then the predicted 58 m layback increases to 131 m.
- The average slope for a limit equilibrium FOS of 1.5 for the northwest wall was 29º, and inconsistent with a longterm layback of 20º. As this slope contains a wider ramp section, the predicted failure is limited to the Quaternary alluvium. If a 20º slope is fitted to the interval through the Quaternary alluvium, then the predicted 9 m layback increases to 19 m. If the failure were to be considered through the full alluvium and saprolite, it may increase slightly.

It is noted that only five cross sections were considered, and that these gave a relatively broad range of slope crest retreat predictions. Whilst it is likely that the range is a reasonable envelope of possible distances, it is apparent that each prediction is specifically influenced by the pit design geometry and the particular variations in the shape and size of the alluvium and saprolite layers, which show significant lateral variation according to the layer surface geometries provided by the mine. Hence, if the retreat distance in a particular location/position was of specific interest/concern, a targeted analysis should be undertaken to provide an appropriate prediction.

It is difficult to compare the AMC report predictions through limit equilibrium analysis with those subsequently predicted in the Landloch long-term erosion study, as the 1000 year profiles predicted by Landloch appear improbable, and although this reviewer is not an expert in erosion modelling, the estimated long-term profiles for the SAR pit seem unlikely to be realistic (this conclusion is elaborated in Section 5 of this report).

3.2 Overarching Discussion and Conclusions

The AMC (AMC, 2021b) report predicts crest retreat distances for the proposed Roswell north pit. The two cited criteria for long-term stability appear reasonable, but the outcomes of each are inconsistent, and no discussion is offered to reconcile them. Whilst AMC might have good reasons to accept that final slopes will be stable, long-term at up to 29º, having recognised that long-term laybacks can be as low as 20º, they have not presented them. Hence, the predictions based on 2D limit equilibrium analyses may underestimate the retreat distances.

The parameters upon which the analyses for this report were based were taken directly from the WSP report (WSP, 2021) without augmentation or review. Hence, they are inherently limited by any shortcomings in that data, which included very limited utilisation of observational data from the existing Caloma and Wyoming pits at TGP, which afford many opportunities to determine strength through back-analysis of actual failures. As the analytical outcomes are particularly sensitive to the shear strength values adopted for the saprolite and alluvium layers, any parameters derived for these materials from observed slope behaviour would be invaluable to improve confidence in the analyses. The parameters adopted are not informed by such observational data and back analysis.

The outcomes of the analyses are also very sensitive to the assumed groundwater conditions, which are derived from the Jacobs draft report, and which acknowledge the possibility of perched water in the alluvium layers. No consideration has been given to the sensitivity of predictions to the assumed groundwater conditions.

The findings that the pit crest will retreat significantly through collapse of the upper slopes in the alluvium and saprolite are reasonable and correct, and consistent with the slope performance in the existing pits, to date. However, no consideration is given to the timeframe over which spontaneous slope adjustments will occur, and a final self-stabilised landform is likely to be achieved.

4. Review of Appendix 6 (AMC, 2021a)

4.1 Specific comments on Report by Section

The purpose of AMC report (AMC, 2021a) was to provide geotechnical advice on the long-term stability of the as-built Wyoming One (WY1) pit slopes, which was required for TGO’s mine rehabilitation studies. It was stated that open cut mining in WY1 ceased in 2019 leaving pit slopes about 180 m high, and that the proposed final rehabilitation and post mining land use for WY1 is a void that will be bunded and fenced.

The report deemed that “as there was an appropriate amount of existing data, no further collection of data was done to complete the scope of work. Additionally, inputs such as shear strength parameters, into slope stability analyses were based on existing data and information provided by TGO.” The report states that the primary source of data used were three reports by PSM between 2016 and 2018 on different aspects of the existing Wyoming One pit performance; a 2019 report by WSP which considered future performance of the WY1 slopes; and the draft Jacobs groundwater report. This AMC report post-dates WSP report (WSP, 2021) and AMC report (AMC, 2021b), but makes no reference to utilising information from either of them.

It is also noted that this report predates the “Wyoming 1 Open Cut and SAR North Pit Voids Assessment of Long-term Stability to Erosion” (Landloch, 2021).

Pit slope geometry and stratigraphic surfaces used in the analytical model were provided by the mine

4.2 Performance of the Pit Walls

In overviewing past pit behaviour, it was stated that “historically, the slopes within the saprolite and weathered rock horizon have experienced stability issues in several pit areas, predominantly in the east and south walls, at both the bench and multi-bench scale.” Three areas of concern were recognised

- “Southeast collapse involving multi-bench collapse of the saprolite and weathered rock between RL 240 AHD to 195 AHD that was experiencing ongoing unravelling and rock fall.
- Chlorite schist unravelling where minor rockfalls were occurring from the saprolite and weathered rock horizons on the east wall between RL 240 AHD and 195 AHD.
- Ramp collapse involving ongoing movement of the saprolite beneath the switchback at the multi-bench scale.”

It is emphasised that “both the southeast collapse and the chlorite schist unravelling have the potential to promote large scale instability that could impact the location of the long-term pit crest.”

This section notes that signs of movement (such as cracking) have been observed in the WY1 pit, and to understand these better, the mine has installed and monitored a network of survey prisms. Monitoring data is provided in an appendix for periods of between 6 and 24 months. The AMC report correctly observes that the data do not indicate any sustained acceleration in the movements. A significant one-off step is noted in most of the data in April 2021, which appears to indicate a small but significant sudden movement, but this is dismissed in the report as “likely to be due to atmospherics and not prism movement”. However, this explanation seems implausible, as the offset remains for all subsequent readings (as many as 20 over the next 6 months), suggesting a permanent change in positions occurred. It is less likely, and indeed implausible, that there was a profound and sustained shift in atmospheric conditions at this time, which has prevailed thereafter.

Long-Term Failure Mechanisms

The report considers that “the main mechanism that will contribute to long-term stability is the ongoing deterioration of the alluvium and saprolite and rock mass style (circular mode) failures at a bench and multi-bench scale”. Based on the observations made by AMC in the report, and during the site visit on 22 August 2022, this seems reasonable.

It is further stated that “The unravelling of the existing collapse/failed areas within the alluvium, saprolite and weathered rock is likely to continue for some time, especially after heavy rainfall events. However, it is expected that the slope will reach an equilibrium and unravelling will slow over time if water is directed away from the collapsed areas. The slopes in the collapsed areas are likely to reach their final profile sooner than long-term.” However, “sooner” and “long-term” are not quantified, so no actual timeframe is nominated.

As was noted for the Roswell north pit assessment, it is again stated that “without implementation of management measures, such as good surface water drainage and re-vegetation, long-term erosion has the potential to lay the slopes back at nominally 20º through the alluvium and saprolite.”

Observations during the site visit on 22 August 2022 confirm these assertions that dispersion, erosion and “unravelling” will be (and already have been) detrimental to slope performance, and they lend support to the assertion that the long-term final slopes through the alluvium and saprolite could ultimately be as low as 20º. Observations from the site suggest that trying to reduce this by controlling runoff will also be challenging.

Back Analysis for South-East Corner

For this report, an attempt is made to infer saprolite strength parameters from the failure in the south-east corner of WY1. This is a valuable and important aspect of the work, that was significantly absent from the two reports that considered geotechnical stability of the proposed SAR pits. The assumed groundwater conditions are reasonable, though no consideration of the sensitivity of the outcomes to this assumption is given.

The inferred Mohr-Coulomb parameters are $c' = 13$ kPa and $\phi' = 21^{\circ}$. These are significantly lower than the single pair of values previously adopted by others for the saprolite ($c = 55$ kPa and $\phi = 29^{\circ}$) which were copied again here for the saprolite, in all areas other than the southeast corner, for which the back-analysed results were used.

Slope Stability Analyses

The assessment of long-term stability considered only three slopes: the east wall, the west wall and the southeast corner. The report notes that the east wall and west wall section locations were analysed as failure in these wall areas could impact the re-aligned Newell Highway corridor and a residues storage area, respectively.

The lower inferred Mohr-Coulomb parameters of $c' = 13$ kPa and $\phi' = 21^{\circ}$ were used for the southeast corner (where the failure they were inferred from occurred) but the higher values previously adopted by others for the saprolite ($c = 55$ kPa and $\phi = 29^{\circ}$) were copied again here for the saprolite in all areas other than the southeast corner. No discussion or justification is provided in the report for using such different values for the saprolite layer in different areas around the pit. From the geological and geotechnical models presented, the reasons for ascribing different saprolite strength values to different areas are not apparent. From observations made during the site visit on 22 August 2022, it appears that saprolite derived from the Cotton Formation may perform better than saprolite derived from the Mingelo volcanics, however, the context of the higher strength parameters is unspecified, and their appropriateness for any of the saprolite at the site is uncertain.

Notwithstanding the assertion that “long-term erosion has the potential to lay the slopes back at nominally 20º through the alluvium and saprolite”, to estimate the likely long-term stable slopes of the self-stabilised pit, the report also defers to “AMCs experience and industry guidelines for open pit stability (Read & Stacey 2009) (that) the failure path for a FOS of 1.5 proves an appropriate indication of the extent of slope that may experience failure in the long-term.” These are the same criteria adopted for the long term stability assessment of the Roswell north pit.

After carrying out the 2D limit equilibrium analysis of the three selected slopes, the immediate factors of safety ranged from 1.0 to 1.3. The failure circles corresponding to FOS values of 1.5 corresponded to circular surfaces with an average slope (crest to toe) of 18º, 25º and 28º, for the southeast corner the east wall, and the west wall (respectively) which is not fully consistent with the noted long-term slope laybacks of 20º. Again, notwithstanding that the limit equilibrium analyses estimate stable slopes on the basis of soil strength, whilst the ultimate value of 20º is based on combined processes including erosion, in the absence of any discussion around the relative timeframes for each, each must be considered a plausible long-term outcome. For the Wyoming One pit, the Landloch (2021) 1000 year slope profile predictions were also plausible and could also be compared. In summary:

- The average slope for a limit equilibrium FOS of 1.5 for the southeast corner was 18º, so the predicted 64 m crest retreat value is appropriate: it is noted, however, that this section adopted the reduced value for saprolite strength, derived from back-analysis of a failure at this location, which explains why the predicted equilibrium slope was so much lower (and closer to 20º) than it was for other locations.
- The average slope for a limit equilibrium FOS of 1.5 for the east wall was 25º, and inconsistent with a long-term layback of 20º. If a 20º slope is fitted to the same alluvium/saprolite/weathered rock interval, then the predicted 36 m layback increases to 78 m. For comparison, the 1000 year profile predicted by the Landloch erosion study was 27.7º.
- The average slope for a limit equilibrium FOS of 1.5 for the west wall was 28º, and inconsistent with a long-term layback of 20º. If a 20º slope is fitted to the same alluvium/saprolite/weathered rock interval, then the predicted 23 m layback increases to 88 m. For comparison, the 1000 year profile predicted by the Landloch erosion study was 24.2º.

Only three cross sections were considered, and these gave a relatively broad range of slope crest retreat predictions. It is apparent that each prediction is specifically influenced by the pit design geometry and by the particular variations in the alluvium and saprolite layers, which show significant lateral variation according to the layer surface geometries provided by the mine. Hence, if the retreat distance in a particular location/position was of specific interest/concern, a targeted analysis should be undertaken to provide an appropriate prediction.

Conclusion

The AMC WY1 report concludes that as the southeast corner has “marginal stability, slope remediation could be required for this wall area to remain as part of the current approved final landform.” It suggests that “the most effective option to improve stability and reduce the potential for rock mass style failure in the southeast corner will be to flatten the slope through the alluvium and saprolite”. That is, it concludes that flattening of the slopes in the alluvium and saprolite is inevitable for a stable final landform, and that it is likely that this process will happen spontaneously, and “in the short-term rather than the long-term”, if it is not deliberately achieved sooner than this. Through its recommendation to manage safety risks of instability through exclusions and management procedures, the AMC report implies that significant spontaneous slope evolution could occur on a timescale as short as the operating life of the mine.

4.3 Overarching Discussion and Conclusions

The AMC WY1 report specifically considers future stability of the existing WY1 pit, and it mostly adopts geotechnical data from previous studies related to that pit, with the addition of new data derived from a back-analysis of an observed instability event in WY1. It does not utilise any of the new data assembled for the WSP TGEP proposal, however, as the WSP report used parameters that were heavily influenced by previous investigations related to WY1, little would have been gained in doing so. The attempt to derive saprolite strength parameters from back-analysis greatly improves the confidence in the saprolite strength values adopted in slope stability analyses, although justification is required as to why these parameters were only deemed appropriate for the southeast corner and not the entire pit. Adoption of the lower parameters would likely reduce the pit slopes with a factor of safety of 1.5, closer to the nominal long-term eroded slope of ~ 20º, and resulting in crest retreat distances greater than those predicted.

Risks to long-term stability from geological structures in the underlying weathered and fresh rock are given little or no consideration, with attention focussed instead on the alluvium and saprolite horizons. Whilst the saprolite and alluvium layers certainly pose the greatest risks to the stability of steep pit slopes, a more explicit statement regarding the potential for rock mass structures to influence final stability would be appropriate. There are many strongly developed geological structures in the rock mass of the WY1 pit, with significant potential to cause or contribute to rock mass instability. A structural defect survey of the pit walls (such as using digital analysis of a 3D photogrammetric pit face reconstruction based on images acquired by UAV) would have been appropriate to give this due consideration.

It is noted that the AMC WY1 report identifies the foliated fabric in chlorite schists, as a being a significant factor in controlling long-term stability/slope performance. In the report, it is noted that “the collapse mechanism was likely to be toppling style within the chlorite schist unit that has pervasive sub-vertical foliation dipping into the wall. Further toppling of the weathered schist promoted the collapse of the saprolite above and laterally towards the north.” Chlorite schists are inconsistent with the reported lithologies of the Mingelo Volcanics and not at all integrated into the geological model for the site.

Consideration of the possibility that chlorite schists may be encountered in the SAR pits is largely absent in the WSP TGEP and AMC Roswell reports, although it is understood that the geological conditions in the SAR pits will be similar to those of the Wyoming pits. The lack of any comment regarding the potential for chlorite schists to affect pit wall performance in the proposed SAR pits is a reflection of the uncertainty in the geological conditions on the east and west walls of these pits; ie, in areas offset from the line of the lode.

As for both the WSP TGEP and AMC Roswell reports, groundwater conditions for the analyses were informed by the draft Jacobs groundwater report, with recommendations that the outcomes be confirmed when the Jacobs report was finalised. This is a valid and important recommendation which should be followed.

5. Review of Appendix 7 (Landloch, 2021)

5.1 General Comments

The assessment of erodibility and its significance for long-term geomorphic evolution are strictly outside the scope of a geotechnical stability assessment. Hence, a detailed review of the methods used, and the outcomes achieved is not presented here. However, geomorphic evolution and erosional stability are relevant when considering the possible long-term landform characteristics of the final voids, and so offer a parallel consideration those offered by the AMC long-term geotechnical stability reports.

It should be acknowledged that this reviewer is not an expert in the field of landform evolution through erosion, and that the comments presented here do not reflect a detailed evaluation of the methods used and the parameters adopted. The comments presented here are limited to an opinion of the reasonableness of the predicted long-term landforms, and how they might be expected to align with predictions based on geotechnical stability.

The Landloch report undertook long-term erosional modelling of a limited number of slope profiles for both the Wyoming One and SAR north pits, estimating the evolution in slope profile that might occur at 10, 100 and 100 years after mining. Figure 5 shows three of the predicted long-term profile predictions.

The predictions for the slopes of the WY1 pit seem plausible, showing smoothing and flattening of the slopes within the alluvium and saprolite lithologies. No indication is given as to how these profiles integrate with slope that continues into the underlying bedrock, however, it is noted that the modelled thickness of alluvium and saprolite are between 25 m and 40 m which may be less than the maximum thicknesses of 60 m - 70 m that do occur around the pit. This could affect the predicted slope crest retreat distances.

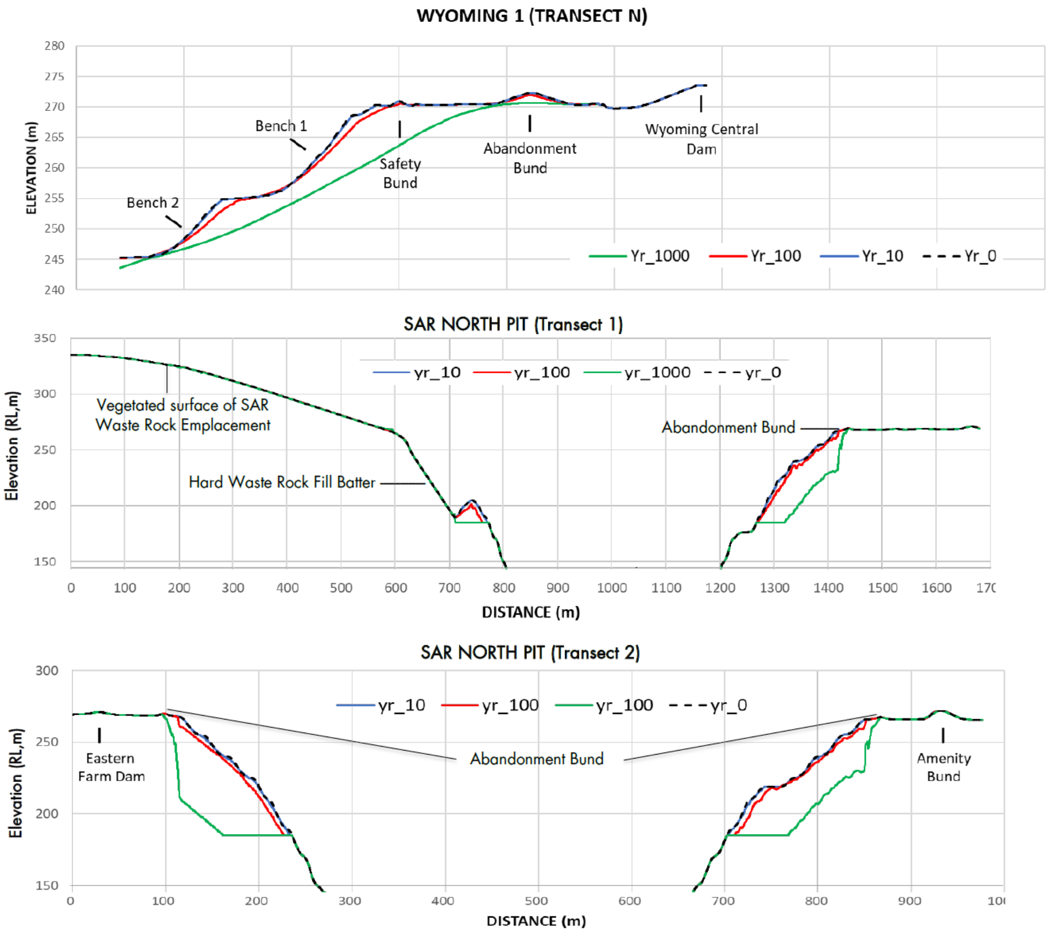


Figure 5: Predictions of pit slope profile evolution from the Landloch report.

By contrast, the predictions for the slopes in the same materials of the SAR north pit are very different and indeed, seem improbable. It is difficult to understand how 1000 years of erosion in the alluvium could result in near vertical slopes. Perhaps there are constraints and assumptions in the models used that can justifiably result in the profiles shown, but they were not apparent from the text of the report.

It is interesting to consider the inherent differences between predictions of stable slopes that are based on long term erosion and predictions of stable slopes that are based on geotechnical stability. Predictions based on erosion effectively consider that material is removed from the slope, grain by grain, according to the amount and energy of water that flows over the slope. This approach can predict the formation of deep erosion gullies with steep sides that are geotechnically unstable, but the models used have no means of accounting for any mass movement (slope instability) that would subsequently occur. As such, they are likely to underestimate process rates, and underpredict the extent of slope evolution at any time.

Predictions based on geotechnical stability assume an intact slope of some specified geometry (usually that planned or created during mining), with no consideration of erosion. Intact slopes created to a neat, uniform profile may have factors of safety greater than one, but subsequent localised erosion (say, from the toe of the slope or differentially somewhere between materials of different erodibility) can cause subtle but significant changes in slope shape that could significantly undermine the stability of the slope and reduce the factor of safety. Hence, geotechnical stability assessments in erodible materials that do not account for erosion are also likely to over-predict stability, and underestimate the likelihood of slope deterioration. Notwithstanding that the assessment of geotechnical stability in the AMC reports does not quantitatively address the likely timeframes for slope deterioration, it is reasonable to assume that each approach to consider the nature of the long-term stable slopes for the TGO and TGEP pits, will underestimate the rate of pit slope evolution that will occur when erosion and geotechnical slope failure work together (as they already do in the Wyoming and Caloma pits).

6. Review of Appendix 4 (RW Corkery, 2021)

“This Appendix (was) prepared to accompany the Project Description presented in Section 3 of the EIS. This Appendix provides additional information relevant to the Project Description that for the sake of conciseness has been excluded from Section 3. The information presented in this Appendix should be read in conjunction with the information presented in Section 3.”

This document appears to post-date all of the preceding documents, and to contain a summary and synthesis of them.

6.1 Specific comments on Report by Section

Section A4.2 SAR Open Cut Layout and Design

In this section, the outcomes of the SAR geotechnical assessment and SAR long term stability assessments are summarised. It is stated that an open cut optimisation was undertaken by Proactive Mining Solutions (PMS) incorporating the geological, geotechnical inputs “as they were then understood to derive the optimal open cut mining solution”. “That optimal solution maximises recovery of the defined ore and provides a basis upon which to complete the detailed open cut design.”

As a “Design Response” it is proposed to “establish a minimum 50m offset distance between the SAR North Pit crest and SAR Open Cut Clean Water Diversion Bund” and “engage a suitably qualified and experienced geotechnical engineer to review the performance of the SAR South and Central Pits, as well as Stage 1 of the North Pit and provide recommendations in relation to the long-term stability of the SAR Open Cut North Pit.”

Section A4.3 Waste Rock Material Characterisation

Consideration of the waste rock emplacements is outside the scope of this review. Notwithstanding this, the section focusses on geochemical assessment and presents no significant information of characteristics that would influence the gross structural stability of the waste rock dump.

Section A4.4 SAR Waste Rock Emplacement Design Assessment

Consideration of the waste rock emplacements is outside the scope of this review. Notwithstanding this, the focus of this section was on achieving an aesthetically and functionally acceptable final landform. No consideration is given to the geotechnical stability of this landform.

Section A4.5 Mine Closure and Rehabilitation

This section considers feedback from consultations sought in regard to the rehabilitation of the TGEP, and presents strategies to incorporate the feedback and achieve an acceptable final rehabilitated state. It specifically notes matters raised by government agencies in regard to the proposed final landform, which specifically includes “Long-term stability of the final voids, including consideration of mass movement and erosion potential.”

The section goes on to present proposed land use domains, one of which is the “final voids” domain. It proposes to manage risks associated with the final voids by limiting public access through fences, gates, bunds and signs. It suggests a bund offset distance of 20 m from considerations of erosional stability, but notes reassessment of this distance should be undertaken at the time of mine closure.

6.2 Overarching Discussion and Conclusions

Although the purpose of this document is to provide supplementary detail in regard to operational layout and design, and site rehabilitation, consideration of the stability of final voids is limited. The design of a stable pit is based on the outcomes and recommendations of the geotechnical assessments, which have already been considered in this review.

7. Outcomes of this Review with Regard to the SEARs, dated 22/11/2021

As part of the documentation provided to undertake this review of application SSD-9176045, a document containing the Planning Secretary’s Environmental Assessment Requirements (SEARs) according to Section 4.12(8) of the Environmental Planning and Assessment Act 1979 and Schedule 2 of the Environmental Planning and Assessment Regulation 2000 was provided. This section of the review provides comments in regard to how the SEARs pertaining to mine stability are addressed by the technical support documents provided. Only aspects of the SEARs which require considerations of slope stability of open pits/final voids are considered, in accordance with the scope of the requested review. Considerations of subsidence and underground stability from any proposed underground mining are excluded.

In the Context of General Requirements: A Full Description of the Development

The documents provided for the review included sufficient information to understand the proposed layout of pits, dumps and ponds to understand where pit slopes would be created during the development and how they related physically to adjacent infrastructure and activities.

- *Regional geology including a supporting map.*

The geotechnical reports provided to this review of geotechnical stability contained limited maps, figures and cross sections to support the models and analyses they employed for the specific pits. None of the reports provided to this review provide sufficient geological overview to allow the geological conditions at TGO to be reconciled with those at the TGEP. Some clarification was only achieved through responses to specific questions during the site visit. Aspects of the geology were inadequately described; these include specific positions of dykes and other intrusions; the contact between the Mingelo Volcanics and the Cotton Formation; and lithological inconsistencies between the geology of the Caloma/Wyoming pits and the proposed SAR pits (such as in regard to the occurrence of foliated rocks and chlorite schists). Consequently, the potential for slope instability related to these features is poorly considered or absent.

- *The mine layout and scheduling and details of construction, operation and decommissioning, including any proposed staging of the project.*

The documents provided contained sufficient figures and descriptions to understand the size and location of geotechnical structures, the sequence of construction and their permanence, although different reports were completed according to different pit designs (as these were being developed). Detailed information of agreed/acceptable final landforms was not provided. (It was subsequently learned during the site visit on 22 August 2022 that a motivation for leaving Wyoming One as an unfilled final void was to facilitate access for future exploration and direct underground access).

- *The likely interactions between the development and any other existing, approved or proposed developments in the vicinity of the site.*

Information was provided to show the existing and re-aligned Newell Highway corridors. Information was also provided regarding the position of exclusion bunds and the likely distances that the pit crest would retreat as the pit shape evolved through spontaneous instability. Specific comment in regard to the impact of the pit crest regression on the highway corridor was not found, other than in the Landloch erosion study report.

Information was also provided to explain how wastes from the SAR operations would, in part, be accommodated in some of the existing Tomingley pits.

In the Context of General Requirements: A Waste (overburden, tailings, etc.) Management Strategy

General information in regard to in-pit waste rock disposal, out-of-pit waste rock disposal and residues disposal was provided. Indicative contours for the out-of-pit waste rock dumps appeared on some figures, but no geotechnical design information was provided in support of these.

In the Context of General Requirements: A Mine Closure and Rehabilitation Strategy, including Details of the Progressive Rehabilitation of the Site

The documents provided included an assessment of the stability of the SAR and Wyoming One pits to erosion, as well as reports which address the immediate and long-term geotechnical stability of the final voids. The documents presented a design for the geomorphic (erosional) stability of the waste rock dump, with some reference to rehabilitation, but no consideration of long-term geotechnical stability.

In the Context of Key Issues: The Likely Impact of the Development on Landforms (topography), including the Long-Term Geotechnical Stability of any New Landforms on Site

The geotechnical reports provided (Appendices 6, 8 and 9) indicate that open pit mining conditions will be difficult, due to the problematic nature of the deep alluvium and saprolite layers which overlie rock on the site. (This was confirmed by observations made during the site visit.) The proposed pit slopes will have marginal stability, even during mining, with the likelihood that slope failures at bench and multi-bench scale will need to be actively managed, particularly during active mining. The ultimate landform (in the context of geological timeframes) will certainly be very different from that which exists at the time of abandonment, with upper slopes becoming laid back, and subsequent pit infilling, due to ongoing or progressive slope instability and erosion. Hence, whilst the final voids could be considered likely to approach long-term stability in a timeframe of tens or hundreds of years, long-term stable cannot be taken to mean that instability will not occur in the foreseeable future after abandonment.

In the Context of Key Issues: Geotechnical Assessment that Supports Mining Methods and Mine Design

The scope of the WSP geotechnical report is sufficient to support a stable open pit design for this project. The approach adopted to inform the design of a stable SAR pit is less than appropriate; as noted in Section 2, aspects of the study that was carried out could be improved. These include:

- Improving the geological model, in aspects such as
    - interpretation of sedimentary structures such as palaeochannels;
    - mapping and differentiation of the sediments and saprolite in different areas of the Wyoming One pit to support the assignment of appropriate shear strength values;
    - characterisation of the lithologies of the Cotton Formation and its contact with the Mingelo Volcanics;
    - characterisation of the chlorite schists in the Wyoming One pit, confirmation of their presence (or not) in the proposed SAR pits, and accounting for the significance of any foliated rock fabric in the Mingelo Volcanics, or else, eliminating it as a factor;
    - reconciling the significant inconsistency between rock mass structural data from bore cores and geophysics;
    - characterisation of contacts between strata and igneous intrusions;
    - characterisation of the Roswell fault.
- Making use of observational data and historical slope performance from the existing Wyoming and Caloma pits, to
    - confirm groundwater assumptions;
    - increase confidence in alluvium, saprolite and rock defect shear strength estimates through back analysis;

  - increase certainty that the geological structure analysis is accurate and valid.
- Confirmation of groundwater conditions, and/or a sensitivity analysis to consider the consequences of ponded water in the alluvium or saprolite.
- Improving the geotechnical characterisation of the shear strength of the major geological structures used in the assessment of rock mass stability.

In the Context of Key Issues: Water (An Assessment of the Hydrological Characteristics of the Site)

All of the geotechnical assessment reports make reference to a draft Jacobs groundwater report, although this was not available for this review. All of the assumed groundwater conditions assumed for the geotechnical assessments are based on the draft report. It is implied that a finalised groundwater report would be forthcoming, and all of the geotechnical assessments appropriately recognise the need to confirm the validity of groundwater conditions that were based on the draft report.

Slope stability is very sensitive to groundwater conditions. All of the stability assessments carried out for this project have assumed (on the basis of the draft Jacobs report) that unsaturated conditions would prevail in the problematic alluvium and saprolite layers. It is important that this assumption is ultimately confirmed, as ponded water in either the alluvium or saprolite is likely to decrease the factor of safety against instability.

In the context of Key Issues: Hazards and Risks – including a Preliminary Hazard Analysis (PHA), Covering an Assessment of the Likely Risks to Public Safety

A risk assessment is presented in Appendix 4 of the proposal but it is focussed on Rehabilitation Risks.

It recognises an "Erosion and failure of landform, drainage and water management/storage structures" risk related to the "Ecosystem and Land Use Development Phase of Rehabilitation", and it rates this risk as high for the final voids. The nominated controls are:

- Assessment of final landform design and stability.
- Geotechnical assessment prior to mine closure.
- Visual inspection and remediation program.

The assessment of the voids in the final landform design has determined that slope failure will occur in the transition to a long-term stable final landform; geotechnical assessment at closure will allow some opportunity to manage the specific risks at the time; no details of a program of visual inspection or final void remediation was found in the documents provided to this review.

The risk assessment also recognises "Final landform unsuitable for final land use (e.g. unstable landform)" as a risk related to "Landform Establishment Phase" and this is rated as moderate for the final voids. The nominated control is "assessment of final landform design and stability", which has been carried out in the documents provided to the review, and which confirms that the risk is at least moderate, but likely to be higher.

In the Context of Key Issues: Closure, Rehabilitation and Final Landform – including a Rehabilitation Strategy Providing Details of the Long-Term Monitoring and Management of the Geomorphic Landform Waste Rock Dumps

The likely evolved shapes of the final voids in the final landform have been modelled, with the implied prediction that they will become laid back through spontaneous progressive slope failures. There is inconsistency in the predicted long-term stable slope values, no quantified timeframe is suggested for this to occur, and no strategy is proposed to monitor or manage this process. It appears that there is no rehabilitation strategy for the final voids, other than for them to remain unfilled.

On the basis of observations during the site visit, it is apparent that slope deterioration begins as soon as slopes in the alluvium and saprolite are created, and it progresses actively thereafter through a host of mechanisms from soil dispersion to structure-controlled mass movement. Such is the poor geotechnical nature of the alluvium and saprolite materials, that slope remediation/stabilisation through reinforcement and retention is almost impossible. The only plausible remediation/rehabilitation strategy for the deteriorating slopes would be to proactively shape them to values consistent with those determined to be ultimately long-term stable.

As noted in Section 3, there is some discrepancy in the predicted ultimate slopes, with the criterion based on a FOS of 1.5 giving steeper ultimate slopes than the ultimate slope criterion of 20 degrees, in most cases. As these slopes determine the retreat distance of the final pit crest, and adopting steeper predicted slopes would underestimate the retreat distance, confirmation of the predictions should be sought.

8. Suggestions for Additional Information and Clarification

The documents provided for review variously identify pit slope failure mechanisms. These are listed below, along with recognition of the uncertainties associated with the analyses provided, and suggestions for additional information to reduce these uncertainties.

8.1 Mass Movements Within the Alluvium and Saprolite of a Nominally Circular Failure Nature

Uncertainty 1

The limit equilibrium analyses employed in the WSP geotechnical assessment (WSP, 2021) are reasonable, however, the stability assessment outcomes are sensitive to the adopted strength for the alluvium and saprolite materials, which could have been characterised with greater certainty. There is a general tendency to simply adopt strength parameters that have been reported in previous assessments. Some new testing data was obtained in the WSP assessment, but the adopted strength parameters in this assessment disregard test data from an earlier PSM report, which fall significantly below the adopted strength envelope. The opportunity to inform strength parameter selection through observational data and back-analysis of failures in the alluvium and saprolite in the existing Wyoming and Caloma pits, was not taken.

Notwithstanding this, the subsequent AMC report on the long-term stability of the Wyoming One pit (AMC, 2021a) did seek to undertake back-analysis of a failure hosted by the saprolite, to infer a saprolite strength. These parameters obtained were significantly lower than those adopted in other analyses, and are a better reflection of the poor performance that has occurred in the Wyoming and Caloma pits to date. AMC used these to predict long term stability in the area affected by the observed failure, but then chose to use higher values elsewhere, with no justification as to why different parameters should be used for different areas in what they seem to identify as the same unit.

Uncertainty 2

The WSP geotechnical report (WSP, 2021) used the preliminary pit design *sar_c5c11_201203* to determine suitable pit slope angles for use in the final design *des_sar_combined_210422*. There are no subsequent analyses of the final design, to confirm what the final factors of safety are, although the updated pit design was used in the long-term stability assessment of the SAR north pit.

Uncertainty 3

All of the stability analyses use groundwater assumptions based on the preliminary Jacobs groundwater report. These assumptions, that the alluvium and saprolite would remain unsaturated, and not host ponded water, lead to best case predictions. There is insufficient data in the documents provided to this review to consider the reasonableness of this, however, the outcomes of all stability analyses are likely to be sensitive to it.

Possible Clarifications

Consideration should be given to:

- Seeking advice as to why AMC chose not to use the saprolite strength parameters determined from a back-analysis of the southeast corner of WY1 for saprolite in all areas of WY1;
- Seeking advice from WSP in regard to the lower inferred saprolite strength in the AMC WY1 report as to whether this would change the geotechnical model they used for the SAR pit analyses;
- Requesting a revised geotechnical assessment based on an improved geological model which
    - differentiates saprolite of different origin and performance on the basis of detailed mapping of the saprolite in the existing pits, and
    - assigns appropriate values to the different areas/types of saprolite and alluvium, ideally derived from back analyses of observed failures that have already occurred.
- Having WSP review their previous recommended pit slope angles in the saprolite and alluvium in light of the final Jacobs groundwater report and the AMC WY1 report, and perform revised slope stability analyses on the final pit design using revised slope values (if appropriate) and including a sensitivity analysis to account for uncertainty in groundwater conditions (if this cannot be dismissed).

8.2 Unravelling of the Slopes in the Alluvium and Saprolite, Possibly Exploiting Rock Fabric

Uncertainty 1

Although "unravelling" is a pertinent mechanism that will contribute to instability, its significance and importance is not well established. The presence and role of fabric in the saprolite is not well established, and inconsistent between the existing Wyoming One pit and the proposed SAR pits.

Further, although unravelling cannot be readily captured in limit equilibrium assessments, unravelling and erosion can act to destabilise slopes that ultimately fail through mass movement, of the type considered by limit equilibrium.

Some idea of how mechanisms of unravelling and erosion might work in conjunction with processes of mass movement can be had from observation of the performance of existing slopes, such as these in the existing Tomingley pits. Importantly, whilst limit equilibrium analyses can infer nothing about the timing or occurrence of slope failures, unravelling is a rate-dependent process, and so, greater observational consideration of unravelling phenomena could inform the discussion of likely long-term slope behaviour.

Possible Clarifications

Consideration should be given to:

- requesting a revised geotechnical assessment based on an improved geological model which
    - differentiates saprolite of different origin and performance on the basis of detailed mapping of the saprolite in the existing pits, and
    - specifically considers the role that unravelling play in conjunction with other slope deterioration mechanisms, to accelerate or promote slope instability.

8.3 Failure Initiating in the Weathered and Fresh Rock, Hosted by Structural Defects

Uncertainty 1

The structural data from the downhole geophysics and from the logging of defects in the bore core appear to be inconsistent, leading to a suspicion that one or both are incorrect.

Uncertainty 2

Little appreciation is given to the different types of defect that exist, and how these might affect stability in different areas.

Uncertainty 3

A poorly justified single shear strength value is used for all defects, regardless of their type.

Uncertainty 4

No specific account is taken of the Roswell fault which reportedly runs through the SAR north pit.

Uncertainty 5

The contact between the Cotton Formation and Mingelo Volcanics is not characterised.

Uncertainty 6

The potential role of the east-west trending dolerite dykes in affecting instability is not adequately considered.

Possible Clarifications

Consideration should be given to:

- Requesting a revised geotechnical assessment based on an improved geological model which:
    - reconciles the apparent inconsistency between the different sources of defect data derived from the boreholes;
    - presents an inventory of any past failures in the rock mass in the existing pits;
    - presents defect/structure data derived from detailed mapping of exposed rocks in the existing pits;
    - presents a summary of significant defects, by type; identifies any tendency for instability that might be associated with them; and, assigns an appropriate shear strength to them, either derived from test data of back analysis;
    - revises the assessment of put stability based on the most up-to-date pit profiles available.

8.4 Long-Term Pit Slope Performance of the Final Voids

Uncertainty 1

Long-term stable slope angles and pit crest retreat distances are variously estimated based on: a value of 20 degrees; the slope corresponding to a slip circle with a factor of safety of 1.5; the slope predicted by undertaking long-term erosion modelling. Estimates from each approach are generally inconsistent with each other, undermining confidence in the reported retreat distances.

Uncertainty 2

The reports considered in this review generally describe open pits with “aggressive” designs, low factors of safety, and in the case of the Wyoming One pit, the need for on-going monitoring and management. They imply that pit stability is marginal, and that failures at various scales will be ongoing, ultimately leading to final landforms that have much flatter side slopes than those at present. However, they do not describe the timeframe over which this is likely to occur, or what the transitional processes will look like; that is, they do not give a clear prognosis for landform performance in the years immediately following mine closure and abandonment.

Uncertainty 3

References are variously made to informing future performance through inspections at the time of mine closure, and to maintenance and rehabilitation strategies to limit slope instability in the future, however, little is provided to suggest what this might look like. That is, what commitment will be needed to ensure the legacy pits will perform acceptably.

Possible Clarifications

- Consideration should be given to requesting a supplementary report describing:
  - The most likely scenario for a long-term final landform, after taking account of all of the different approaches to predicting it;
  - The likely timeframe over which it will be achieved;
  - The processes that are likely to achieve the long-term stable landform (scale, frequency, risks) if it will be left to evolve spontaneously (rather than deliberately shaped at the time of mine closure).

9. References

AMC. (2021a). *Report Wyoming One Slope Stability Analysis, Tomingley Gold Operations Pty Ltd (Wyoming One Slope Stability Analysis - Appendix 6).* AMC Consultants Pty Ltd Reoprt 121045 dated 10 November 2021.

AMC. (2021b). *Roswell Slope Stability Analysis (SAR North Pit Long Term Slopes Stability Analysis - Appendix 9).* AMC Consultants Pty Ltd Project 121046 dated 27 August 2021.

Landloch. (2021). *Tomingley Gold Operations Project, Wyoming 1 Open Cut and SAR North Voids Assessment of Long Term Stability to Erosion (Open Cut Erodibility Assessment - Appendix 7).* Landloch Pty Ltd Report 3453.21a dated 17 December 2021.

RGS. (2021a). *Technical Report, Tomingley Gold Eastern Cutback Project, Geochemical Assessment (Caloma Eastern Cutback Geochemical Assessment - Appendix 10).* RGS Environmental Consultants Pty Ltd Report 3BR002_2021054 dated 21 December 2021.

RW Corkery. (2021). *Environmental Impact Statement, Tomingley Gold Operations Pty Ltd (Additional Information Supporting the Project Description - Appendix 4).* R.W Corkery & Co Pty Limited, Report 616/35.

WSP. (2021). *Tomingley Gold Extension Project, San Antonio and Roswell Geotechnical Report (SAR Open Cut Geotechnical Assessment - Appendix 8).* WSP Australia Pty Ltd report PS117942-GEO-REP-005, RevB dated 1 April 2021.

10. Limitations

Douglas Partners (DP) has prepared this report for this project at Newell Highway, Tomingley in accordance with DP's proposal dated 8 August 2022 and acceptance received from Stephen O'Donoghue from Department of Planning and Environment (NSW). The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Department of Planning & Environment (NSW) for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

DP's advice is based upon the data presented in reports by others as described in this report and based on a brief site inspection. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

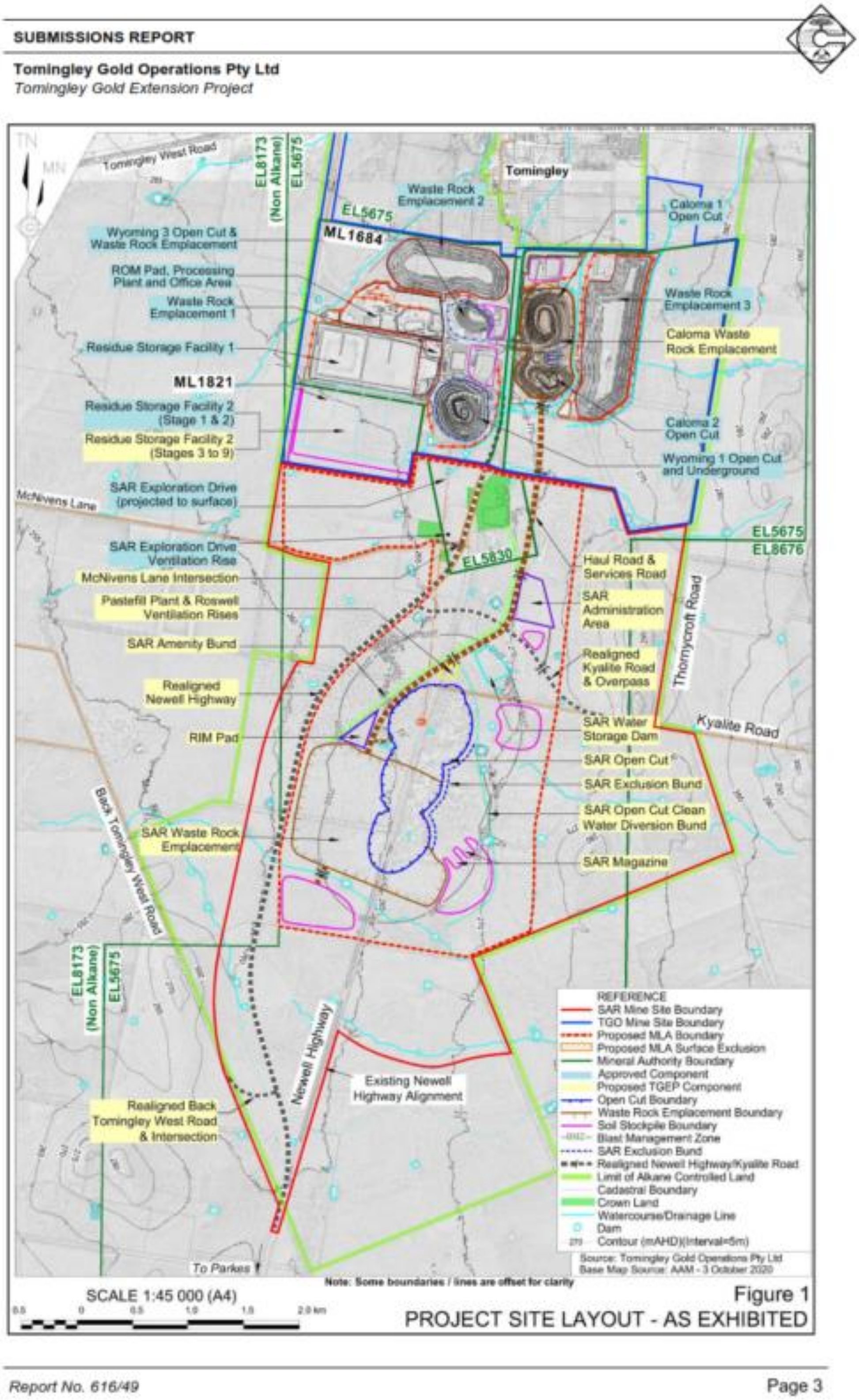
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Project Site Layout (Extract from Submissions Report)


SUBMISSIONS REPORT

Tomingley Gold Operations Pty Ltd
Tomingley Gold Extension Project

Report No. 616/49

Page 3

Project Site Layout (Extract from Submissions Report)