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Project No: 1403-001ECO-PV

12 March 2014

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Dear Sirs,

ROCK ENGINEERING REPORT – MINING IN CLOSE PROXIMITY TO SURFACE STRUCTURES AND ROADS

1. INTRODUCTION:

The Mine Consultant (Henno Engelbrecht) requested Big C Rock Engineering to conduct a Baseline Risk Assessment to determine the risks and hazards related to the opencast operations mining in close proximity to the town of Pullenshope in the Mpumalanga province, and other buildings and national public roads.

Section 17.6(a) of the Mine Health and Safety Act requires the employer to ensure that no mining operations are carried out under or within a horizontal distance of 100m from buildings, roads, railways, reserves, boundaries, any structure what so ever or any surface, which it may be necessary to protect, unless a shorter distance has been determined safe

by risk assessment and all restrictions and conditions determined in terms of the risk assessment are complied with.

2. BACKGROUND.

2.1. LOCATION.

The proposed opencast mine is located approximately 2 km north-west of Pullens Hope, on the farm Roodepoort 151 IS, Mpumalanga.. The figure below illustrates the location of the opencast workings in relation to the town of Pullenshope. The town Pullenshope can be seen in Figure 1 and lies towards the South Eastern corner of the planned opencast operations. Other surface structures such as houses and national roads will be mined to in close proximity as the opencast pit expands.

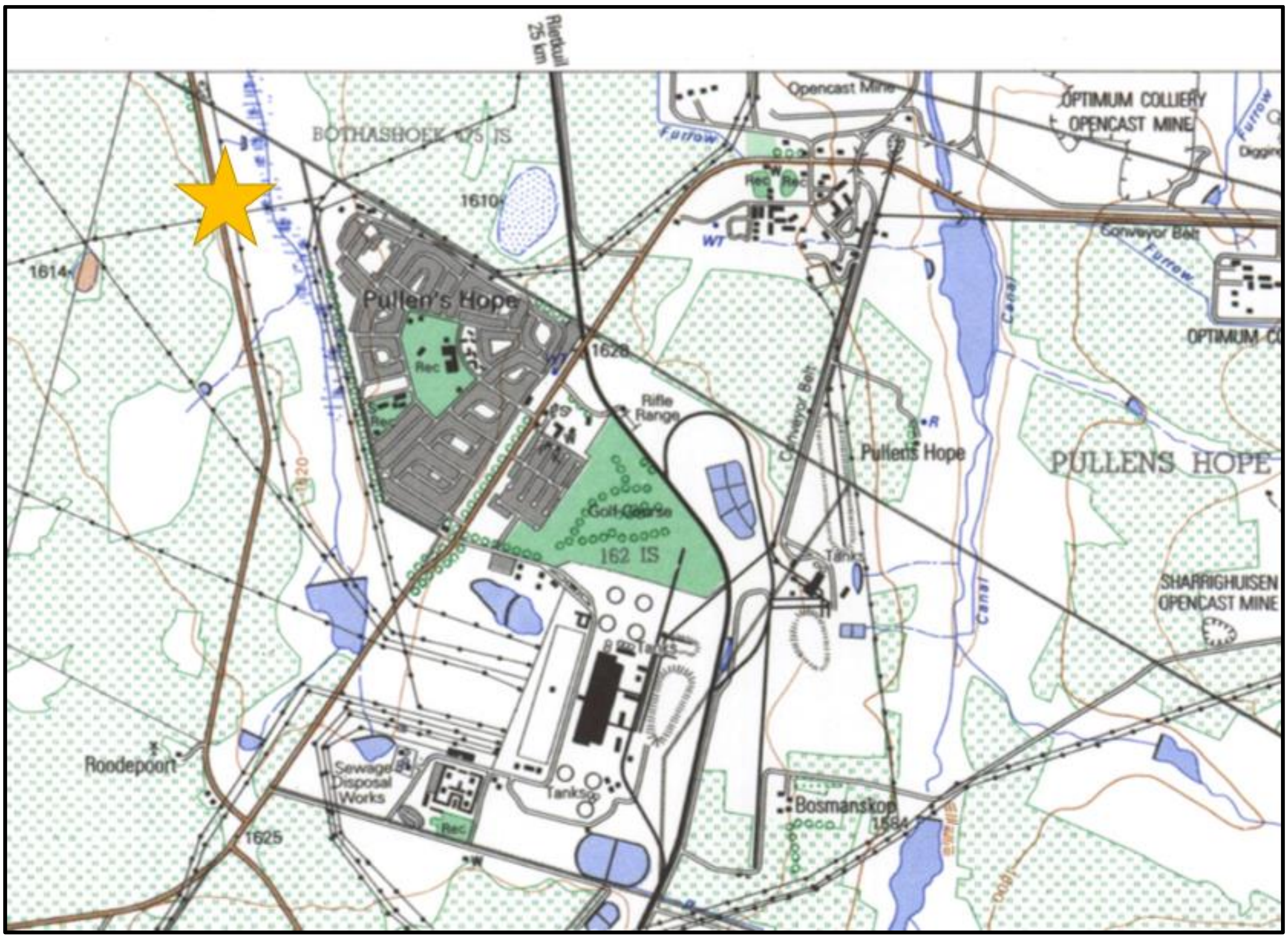


Figure 1: Illustration of location of the mine

2.2. BASIC GEOLOGY.

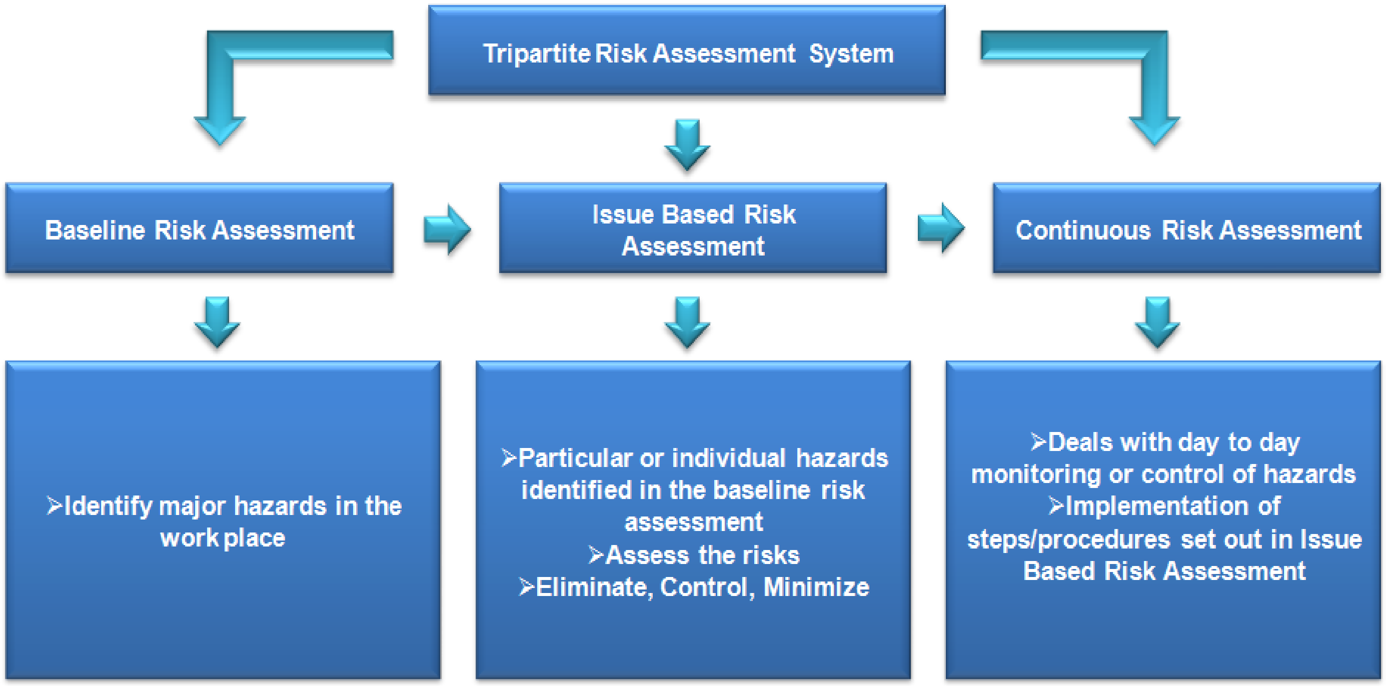
A generalised geological stratigraphy (Table 1) was derived from borehole log 2629BA00072, which is the NGA borehole with the closest proximity to the proposed open cast (information as per the geo-hydrological report).

Average depth	Average thickness	Description of strata layer
0 -5.8m	5.8m	Topsoil
5.8m – 15.8m	10m	Shale
15.8m – 24.8m	9m	Coal
24.8m – 28.8m	4m	Shale

Table 1: Generalized geological stratigraphy

2.3. RISK ASSESSMENT.

A Risk Assessment is a part of the three level risk assessment process adopted by mines in order to adhere to the requirements of section 11 of the Mine Health and Safety Act (MHSA). The tripartite risk assessment system is set out below in a flow diagram.



The Risk Assessment forms part of the application to the Department of Mineral Resources to mine in close proximity to the surface structures, within 100m.

3. DISCUSSION

In order to determine the minimum distance that the opencast operation can operate without causing damage to surface structures the following calculations will be considered. Note that only structural i.e. geotechnical considerations are made in this report.

Softs and hards behave differently under the same conditions and therefore these two strata zones must be separated and considered separately. The first 5.8m will be considered as softs where after the remaining hard material will be considered as 19m thick and additional 5m will be added to calculate varying highwall height into the equation.

3.1. SOFTS - FACTOR OF SAFETY.

The method is used for a quick evaluation of the slope stability by means of charts. The charts enable a good estimate of the stability of the slope. The method does not require any sophisticated software or analysis techniques.

Factor of Safety: A factor of safety is very similar to that of an underground safety factor, however different principles applies. It basically describes the stability of a structure. A factor of safety that is equal to 1 is considered in equilibrium. A factor of safety of above 1 is considered stable and below 1 is considered unstable.

Friction angle: The friction angle is the angle at which the surface has to be tilted for sliding to start of its own accord.

Cohesion: Cohesion is the initial resistance that has to be overcome before any sliding can commence.

The method is used to determine the factor of safety (FOS) for the slope and can also be used for a back analysis of slopes and the calculation of other parameters.

The following dense sand parameters were used in the calculations for the softs stability:

- Density of the material: 20kN/m^3
- Cohesion: 0 kPa
- Friction angle: 40 degrees
- Slope angle: 40 degrees

An initial repose angle was calculated with the above mentioned parameters as if no water had an influence on the slope and the slope is totally dry. The calculation used chart number 1. The repose angle was calculated at 40 degrees for a Factor of Safety of 1. Any calculated value below 1 (<1) indicates instability, above 1(>1) indicates stability and 1(=1) indicates equilibrium.

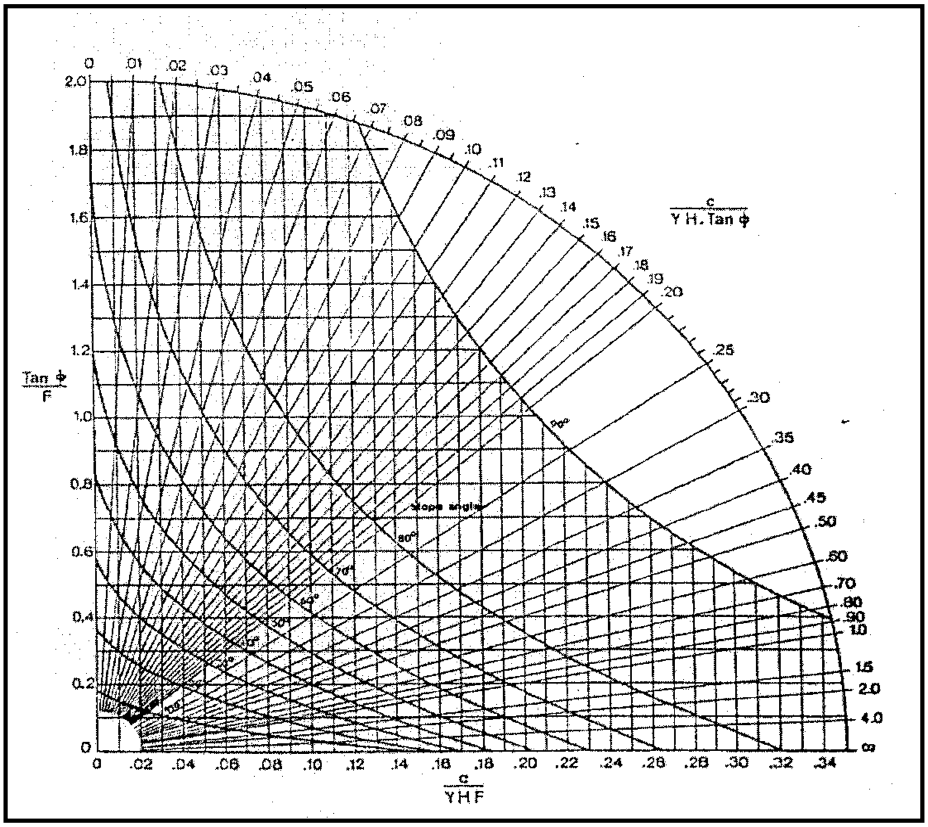


Chart 1: Circular failure chart number 1.

The softs therefore should be battered back at an angle of 40 degrees i.e. an 40 degrees slope angle will be considered stable hence no failures will occur and assuming that water will not affect the angle.

Using trigonometry calculations it was determined that the softs (5.8m in depth) must not be closer than 6.9m plus a further 5m (required to monitor crest conditions) resulting in a total of 11.9m.

3.2. HARDS – RESTRICTION LINE.

The calculation used to calculate the restriction line is based on the depth beneath surface rule which is set out as follows:

Restriction line radius length = depth/2.7 i.e. maximum depth of 24m/2.7 = 8.89m

The calculation indicates that mining on the hards must be restricted for a further 8.89m from the surface structures. It is required that a 5m bench be left between the hards and the softs and therefore the hards restriction will be calculated as 8.89m + 5m = 13.89m.

3.3. MINIMUM RESTRICTION REQUIRED.

The minimum restriction required from the highwall crest in order for total highwall collapse not to affect the surface structure is illustrated the Figure 2 below. The total distance required is 25.79m based on the height used for the softs (11.9m) and hards (13.89m) strata layers.

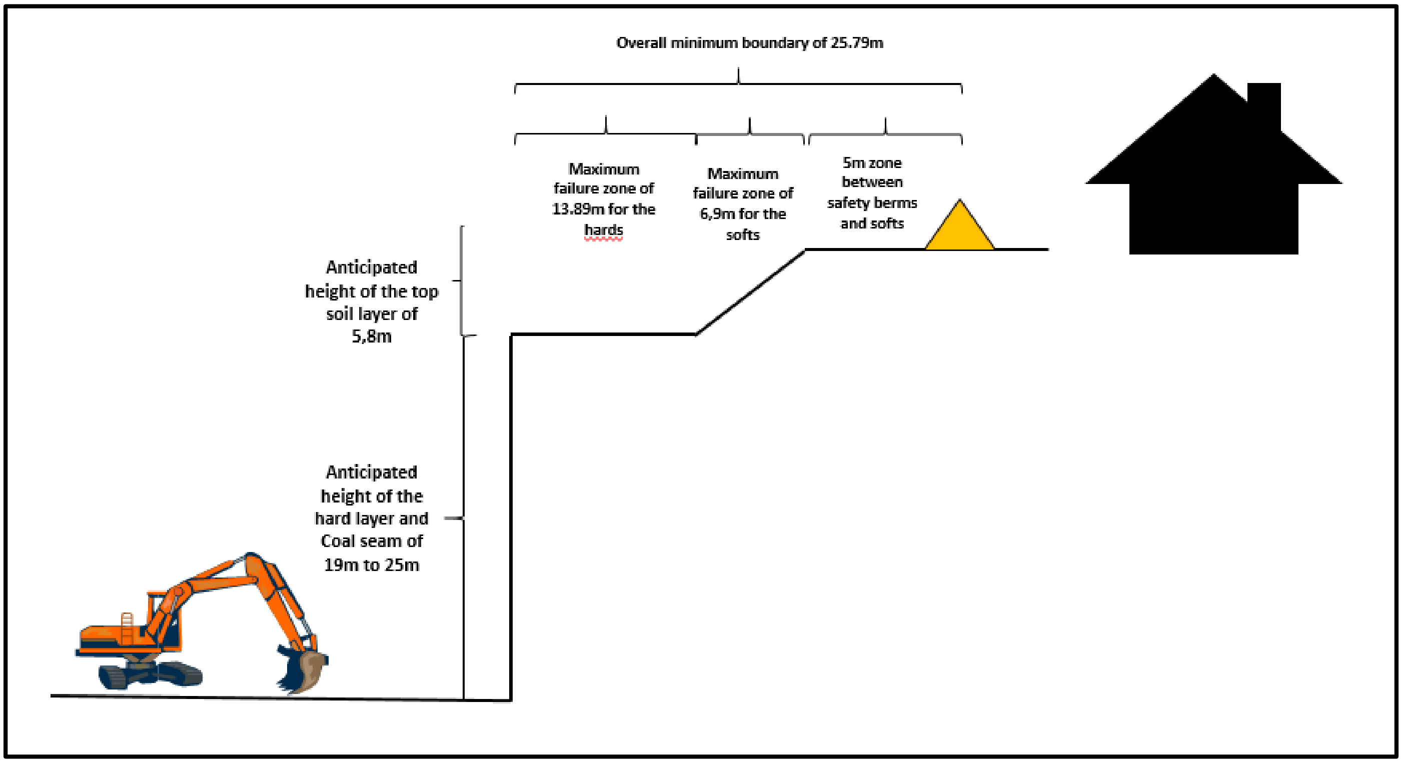


Figure 2: Illustration of the minimum restriction required

4. BASELINE RISK ASSESSMENT.

The terms used in this investigation is set out below as per the MHSA. These terms should be understood.

Hazard: Is the source or exposure to danger, example a geological discontinuity such as slips, dykes, cracks.
Risk: Is the likelihood or probability of a hazard to occur and can be explained as the consequence of the hazard.
Control: Is the measure(s) that should be implemented to minimize the probability of the risk of a hazard to occur.

It must be remembered that every geotechnical hazard in an opencast operation has a different challenge due to the ever changing geology. Hazards can occur in combination to create a larger problem than when anticipated separately.

4.1. RISK MATRIX USED.

To calculate the risk associated with each hazard a simple risk matrix were used namely:

Risk (R) = Probability (P) x Consequence (S) x Exposure (E)

Each of the variants (P, S and E) is given a value between 1 and 5 based on the worst case scenario level expected for each hazard. Level 1 indicates a low risk value whilst Level 5 indicates a high risk value (see risk matrix below in illustration 1).

Risk Value (R) = Probability (P) x Severity (S) x Exposure (E)

Probability	**Certain** that it will occur	5
	Likely that it will occur	4
	Possible that it may occur	3
	Rare but it can occur	2
	Very Unlikely, but still a small possibility that it may occur	1
Severity	Property loss (minor)	Of Concern (1)
	Causing multiple injuries and or property loss that result in production loss for the neighbouring party.	Serious (2)
	Causing fatalities to at least 1 person and or damage to equipment of less than R1 mil.	Very Serious (3)
	Causing multiple fatalities and or significant property loss > R1mil	Disaster (4)
	Causing fatalities, injuries or significant damage to neighboring properties and civilians resulting in the production and money loss in the macro environment.	Catastrophic (5)
Exposure	Continuous exposure	5
	Frequent exposure	4
	Occasionally exposed	3
	Rarely exposed	2
	Very rarely exposed	1
Risk Level	High Risk – High probability of occurring, immediate action needed	> 60
	Substantial Risk – medium probability of occurring, action needed	> 40 - 60
	Low Risk – very low probability of occurring	0 - 40

Illustration 1: Risk Matrix

4.2. BASELINE PROCESS USED.

For easy understanding all the steps used in the baseline risk assessment are set out below:

- Identification of all rock engineering hazards,
- Calculation of initial risk value using the risk matrix (before controls),
- Controls for each hazard,
- Calculation of final risk value using the risk matrix (after controls).

4.3. BASELINE RISK ASSESSMENT.

The following risk assessment was compiled for the opencast workings. The hazards were identified as per normal opencast conditions. Should new hazards arise they must be added to the risk assessment with related risk rating and controls.

Rock Engineering Hazards	Initial risk				Controls	Final Risk			
	P	C	E	R		P	C	E	R
Low strength of the overburden material	5	3	5	75	Implement a bench mining system based on a highwall design. Batter material back to an appropriate angle (40 degrees).	5	2	3	30
Medium strength of the overburden material	5	2	5	50	Depending on overall height of the highwall implement a bench mining system or conduct a proper highwall design. Implement a suitable blast design.	5	2	3	30
High strength of the overburden material	3	1	3	9	Conduct a proper highwall design. Implement a suitable blasting design.	3	1	2	6
Singular set of geological discontinuities – not dipping into cut	5	2	5	50	Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Construct catch berms.	5	1	2	10
Singular set of geological discontinuities – dipping into cut	5	3	5	75	Change highwall orientation if considered a major problem. Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Implement a suitable blasting design. Construct catch berms.	4	3	3	36
Multiple sets of geological discontinuities – not dipping into cut	5	2	5	50	Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Structure mapping of geological discontinuities to determine primary mode of failure. Implement a suitable blasting design. Construct catch berms.	5	1	1	5
Multiple sets of geological discontinuities – dipping into cut	5	4	5	100	Change highwall orientation if considered a major problem. Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Structure mapping of geological discontinuities to determine primary mode of failure. Implement a suitable blasting design. Construct catch berms.	3	3	2	18
Blocky highwall	5	2	3	30	Proper pre-slit design. Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Implement a suitable blasting design. Construct catch berms.	1	1	1	1
Very blocky highwall	5	4	3	60	Proper pre-slit design.	2	2	2	8

					Limit highwall height. Proper dressing of highwall. Regular inspections conducted by both personnel and strata control personnel. Implement a suitable blasting design. Construct catch berms.				
Singular dyke/sill structure	3	2	3	18	Proper dressing of affected area. Monitor area for water flow. Structure mapping if considered necessary to determine expected failure zones.	5	1	3	15
Multiple dyke/sill structures	3	4	3	36	Proper dressing of affected area. Monitor area for water flow. Structure mapping to determine expected failure zones. Proper geological information to be considered during planning.	3	2	2	12
Low height highwall (0m to 15m)	4	3	4	48	No-Go zone from toe of highwall of 3m. Proper dressing of highwall. Safety berms to be implemented away from the highwall crest.	4	1	4	16
Medium height highwall (16m to 25m)	5	3	4	60	No-Go zone of 3m – 5m. Proper dressing of highwall. Highwall design if required. Safety berms to be implemented away from the highwall crest.	4	2	3	24
High height highwall (26m to 40m)	5	3	5	75	No-Go zone of 5m. Proper dressing of highwall. Proper highwall design. Regular inspections by strata control personnel. Safety berms to be implemented away from the highwall crest.	5	2	4	40
Ground water presence – low (damp highwall)	5	2	5	50	Monitor ground water presence.	5	1	5	25
Ground water presence – medium (wet highwall)	5	3	5	75	Monitor ground water presence Regular inspections by the strata control personnel.	4	2	4	32
Ground water presence – high (water flowing from highwall)	5	4	5	100	Monitor ground water presence Increase no-go zone in areas where geological discontinuities pose a problem. Regular inspections by the strata control personnel. Concrete water retention wall.	4	3	3	36
Low exposure time of the highwall before rehabilitation (<6 months)	5	1	5	25	Adhere to no-go zones. Rehabilitate as soon as possible.	5	1	5	25
High exposure time of the highwall before rehabilitation (>6 months)	5	2	5	50	Increase no-go zones. Rehabilitate as soon as possible.	4	1	4	16
Blasting methods used does not include a proper pre-split design	5	3	5	75	Increase no-go zones. Proper dressing of highwalls. Regular inspections by the strata control personnel.	3	1	3	9

					Conduct proper pre-split design/revise current practices. Daily inspections by personnel.				
Blasting methods used does include a proper pre-split design	3	2	3	18	Regular inspections by the strata control personnel. Daily inspections by personnel.	5	1	5	25
Poor blasting practices	4	3	4	48	Revise blasting practices. Proper dressing of highwall after blasts. Demarcate no entry areas where failure is expected. Declare special/cautionary area where required and implement procedure. Regular inspections by the strata control personnel. Daily inspections by personnel. Construct catch berms.	3	1	3	9
Proper blasting practices	4	2	4	32	Regular inspections by the strata control personnel. Daily inspections by personnel. Construct catch berms.	5	1	5	25

5. CONCLUSION.

Total highwall collapse does not occur regularly in opencast operations especially in short term operations where the highwall is exposed for a short period (6 months) of time. It is not foreseen that the opencast operation will have a structural influence on surface structure as long the operations adhere to a no-go zone as calculated above of at least 25.79m (based on a maximum mining depth of 24-29m).

Yours Faithfully

Big C Rock Engineering CC

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