APPENDIX 18

BLAST DESIGNS AND CONTROL RECOMMENDATIONS REPORT

Specialists in Blast Optimisation, Digital Technology, Environmental Impact

Blast designs and control recommendations

Hotazel Project

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A J Rorke – Explosives Application Specialist

+27 83 676 1408
BlastVision (Pty) Ltd
Registration 2020/108449/07
10 Dorries Drive
Froggy Farm
Simon's Town 7975
tony@blastvision.tech

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1 Introduction

The designs in this document are aimed at productive blasting, whilst achieving the environmental controls that are needed for mining safely at the proposed Hotazel Project.

The information that has been used to establish these designs include

- Rock type descriptions
- Proposed mining area methods including planned bench height and hole diameter
- Distribution of sensitive receptors surrounding the mine, including a planned PV solar farm to the south east of the proposed mining area
- A report by Blast Management & Consulting (BMAC) covering the blast and vibration assessment scoping.

The blast designs provided in this report (including timing and stemming requirements) are based on proven and reliable methodology.

1.1 Scope

1. Undertake a desktop study for this work.
2. Establish community locations with respect to the pit and any other infrastructure that might be impacted.
3. Obtain the necessary rock properties so that the blast designs are appropriate for the rock. The proposed mining method will have an impact on the blast designs and the associated environmental impact.
4. Undertake the blast design review and provide designs that will satisfy the prescribed limits that have been defined
5. Relate the blast designs to blast fragmentation and thus give an indication of what will be likely downstream.
6. Submit a report on completion

2 Mining description

The planned mining operation will be an opencast mine comprising mainly banded ironstone and manganese ore. The manganese ore is partially weathered in the higher-grade UMO and unoxidized in the lower grade LMO.

The opencast mining will extend the pit towards the east (away from Hotazel Town) and increased depth. Mining is planned on 15 m benches with 171 mm diameter holes, but a 10 m option is also examined in this report.

Figure 2-1 provides a map showing the proposed mining area with the outskirts of Hotazel Town on the north-western side of the operation and the proposed solar farm to the south-east.

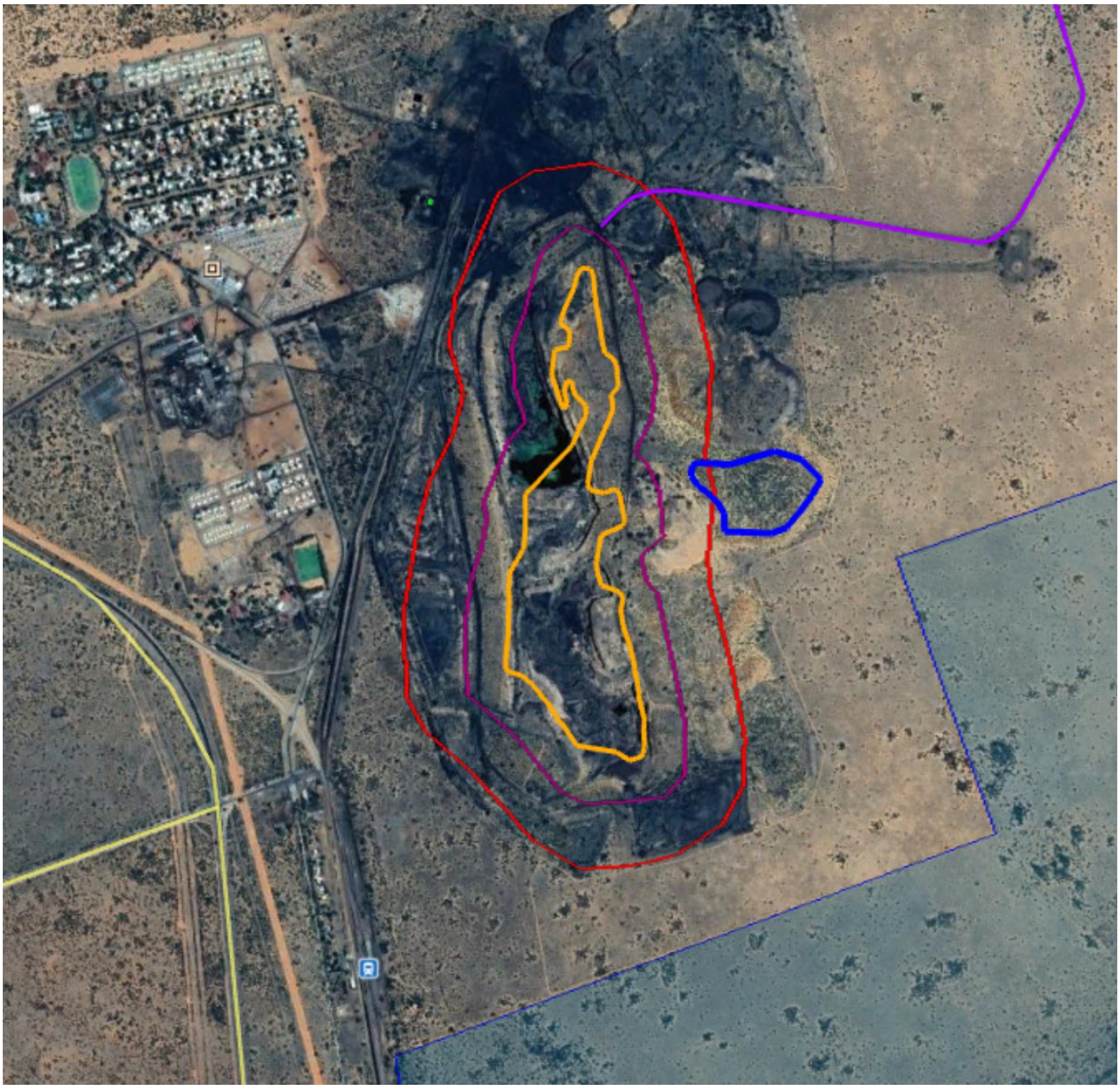

Figure 2-1. Proposed new pit area (yellow). The nearby infrastructure is also shown. Proposed solar farm is shaded blue. The 100 m fly rock limit line is the purple polygon. The 300 m fly rock limit is the red polygon. These fly rock limits are estimated based on the information in Appendix 2 – Fly rock range and calculation method. The access road is shown as a purple line and a planned dam is outlined in blue.

2.1 Environmental

Receptors that will require strict blast control and effective design include:

1. Houses
2. Structures including towers and industrial buildings
3. Roads
4. Railway lines
5. Powerlines
6. Telephone towers
7. A solar farm (proposed)

The major control effort will be for limiting fly rock to within a maximum risk range of 300 m. Air blast will be controlled by the same measures that are applied for fly rock control.

2.2 Applied environmental limits

The following limits have been applied and are explained in more detail in the appendices.

1. **Ground vibration**: A maximum peak particle velocity (PPV) of 6 mm/s is applied for the closest house.
2. **Air blast**: A peak air blast level of 120 dBL is applied
3. **Maximum fly rock range**: Three fly-rock limits are applied using a factor of safety of two for the safety of people, these being 100 m maximum for all blasts, a 300 m alert or exceedance range for which a special internal investigation is needed if fly rock occurs in this range at distances more than 100 m, and a 500 m clearance zone. The 100 m and 300 m limits are shown in Figure 2-1.

The planners involved in the day to day blast designs and application need to understand the contents of the two appendices in this report describing how vibration level and fly rock range are predicted.

3 Blast designs

The designs are aimed at meeting the prescribed limits and achieving the required fragmentation. These must be read in conjunction with the special control measures that are needed because of the nearby infrastructure and community.

The designs presented in the following pages are based on the following choices:

1. 10 m benches and 171 mm blast holes
2. 15 m benches and 171 mm blast holes
3. 15 m benches and 254 mm blast holes – single charge decks
4. 15 m benches and 254 mm blast holes – double charge decks

The need for containing blast induced vibration will add complexity to the design of the 15 m benches with 254 mm diameter holes.

3.1 Visual summary of blast designs

A visual set of cross-sections for the BIF designs provided in the following Tables is given in Figure 3-1.

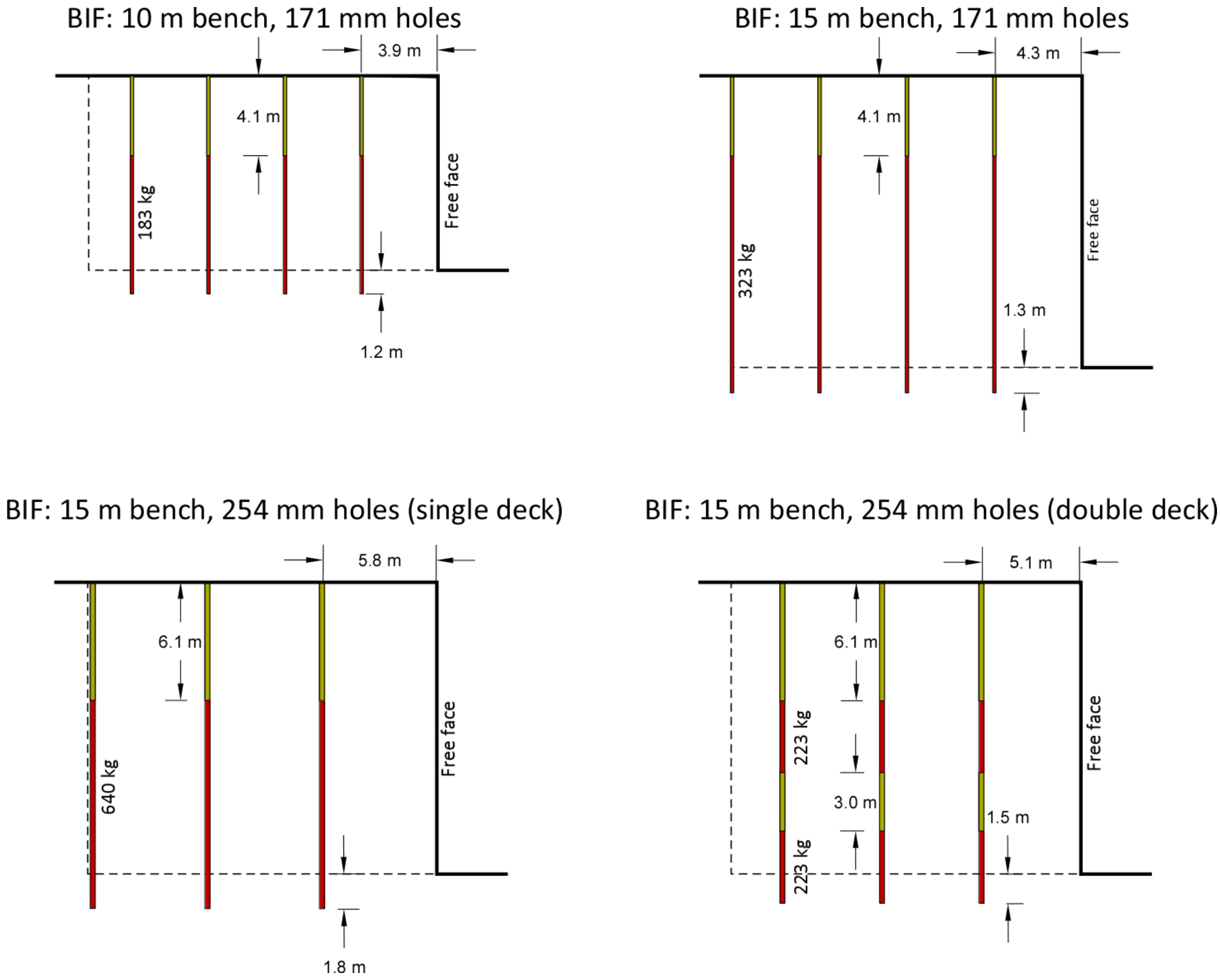

Figure 3-1. The four different design options are illustrated in these scaled cross-sections for the BIF blasting. The drawings provide proportions and illustrate the charging configuration for the double deck charging option for 254 mm holes (bottom right).

The designs for manganese ore, dyke and calcrete vary in the parameters dimensioned in these cross-sections. The preferred Option is for 171 mm holes on 15 m benches (Top right in Figure 3-1). This provides the optimal explosives distribution for even fragmentation and optimal stemming length as a proportion of bench height for fly rock and air blast control.

A potential optimisation to the designs in the softer rock types (UMO and weathered calcrete) that will improve uniformity of fragmentation, reduced fines and lower risk of fly rock and air blast in the soft rock is the introduction of a 1.5 m air deck in each hole, either at the top or bottom of the hole. This is illustrated in Figure 3-2 for top or bottom air decks.

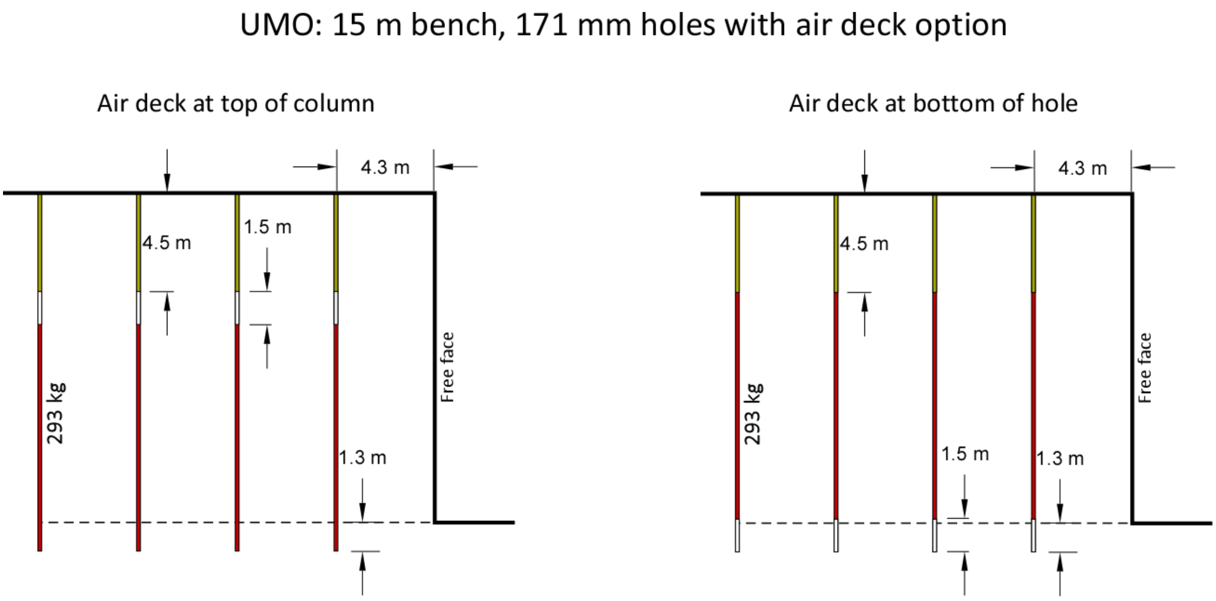

Figure 3-2. Option for top air decks (left) and bottom air decks (right).

The air-decked options should be examined during a blast optimisation process, as they will affect powder factor and fragmentation result with burden, spacing and stemming length values remaining constant.

The air decked options are not detailed in the Tables below but represent a variation that can be applied for the designs for softer rock (UMO) in Table 3-4.

3.2 Vibration estimates

The method for predicting or estimating vibration is given in Appendix 1. Two constants are used in the vibration Tables in the following pages. These are k and beta. The vibration prediction equation using k and beta are described on Page 28. Site specific constants will need to be developed to predict vibration more accurately, but the estimates given for the designs on the following pages are likely to be within about 10 % of the actual measured values.

3.3 Design for 10 m bench blasting with 171 mm holes (One charge deck per hole)

Table 3-1. Blast design for drilling on 10 m benches using a 171 mm diameter hole. The powder factor and drilling productivity lines have been highlighted for easy reference.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	171	171	171	171	171
Bench height (m)	10	10	10	10	10
Stemming length (m)	4.4	4.1	4.4	4.1	4.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.3	1.2	1.7	1.3	1.3
Hole depth (m)	11.3	11.2	11.7	11.3	11.3
Burden (m)	4.3	3.9	5.6	4.4	4.3
Spacing (m)	4.9	4.5	6.5	5.1	4.9
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.16	1.16	1.16	1.16	1.16
Charge length (m)	6.8	7.1	7.3	7.3	7.2
Charge mass/linear metre (kg/m)	26.6	26.6	26.6	26.6	26.6
Total charge mass per hole (kg)	182.5	189.1	193.4	193.2	191.9
Powder Factor (kg/m3)	0.87	1.06	0.53	0.85	0.91
Explosive RWS (%)	80	80	80	80	80
Explosive absolute energy (kJ/kg)	3.05	3.05	3.05	3.05	3.05
Energy/m3 (kJ/m3)	2.65	3.24	1.61	2.59	2.78
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	18.63	15.91	31.32	20.06	18.63

Table 3-2. Vibration estimates based on commonly applied attenuation constants K and beta of 1143 and -1.65 respectively. Vibration levels that can be tolerated by people in general are highlighted in green. All structures will be safe from any blast vibration induced damage in the green zone. See Appendix 1 for method for calculating ground vibration.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
Distance	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
50	131.9	135.9	138.4	138.3	137.5
150	21.5	22.2	22.6	22.6	22.4
200	13.4	13.8	14.0	14.0	14.0
250	9.3	9.5	9.7	9.7	9.7
300	6.9	7.1	7.2	7.2	7.1
400	4.3	4.4	4.5	4.5	4.4
500	3.0	3.0	3.1	3.1	3.1
600	2.2	2.3	2.3	2.3	2.3
700	1.7	1.7	1.8	1.8	1.8
800	1.4	1.4	1.4	1.4	1.4

Table 3-3. Safety zones calculated for fly rock for safety of people (factor of safety of 2). The design stemming lengths are 4.1 m or greater. The green zone represents safe distances for stemming lengths of 4.1 m or greater See Appendix 2 for fly rock range and safety circles determination. Determined from the minimum stemming length equation on Page 31.

Shape factor (1.3 for rock fragment)	1.3
Factor of safety	2
Safety Distance (m)	Min. stem length (m)
100	7.1
200	5.0
300	4.0
400	3.4
500	3.0
600	2.6
700	2.4
800	2.2

3.4 Design for 15 m bench blasting with 171 mm holes (One charge deck per hole)

Table 3-4. Blast design for drilling on 15 m benches using a 171 mm diameter hole. The powder factor and drilling productivity lines have been highlighted for easy reference.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	171	171	171	171	171
Bench height (m)	15	15	15	15	15
Stemming length (m)	4.5	4.1	4.5	4.1	4.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.4	1.3	1.8	1.4	1.4
Hole depth (m)	16.4	16.3	16.8	16.4	16.4
Burden (m)	4.6	4.3	6.0	4.8	4.6
Spacing (m)	5.3	4.9	6.9	5.5	5.3
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.18	1.18	1.18	1.18	1.18
Charge length (m)	11.9	12.2	12.3	12.3	12.3
Charge mass/linear metre (kg/m)	27.1	27.1	27.1	27.1	27.1
Total charge mass per hole (kg)	323.1	329.9	334.2	334.1	332.7
Powder Factor (kg/m3)	0.88	1.05	0.54	0.84	0.90
Explosive RWS (%)	80	80	80	80	80
Explosive absolute energy (kJ/kg)	3.05	3.05	3.05	3.05	3.05
Energy/m3 (kJ/m3)	2.68	3.19	1.65	2.58	2.76
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	22.44	19.36	36.79	24.06	22.44

Table 3-5. Vibration estimates based on commonly applied attenuation constants K and beta of 1143 and -1.65 respectively. Vibration levels that can be tolerated by people in general are highlighted in green. All structures will be safe from any blast vibration induced damage in the green zone. See Appendix 1 for method for calculating ground vibration.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
Distance	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
50	211.3	215.0	217.3	217.2	216.5
150	34.5	35.1	35.5	35.5	35.3
200	21.5	21.8	22.1	22.1	22.0
250	14.8	15.1	15.3	15.3	15.2
300	11.0	11.2	11.3	11.3	11.3
400	6.8	7.0	7.0	7.0	7.0
500	4.7	4.8	4.9	4.9	4.8
600	3.5	3.6	3.6	3.6	3.6
700	2.7	2.8	2.8	2.8	2.8
800	2.2	2.2	2.2	2.2	2.2

Table 3-6. Safety zones calculated for fly rock for safety of people (factor of safety of 2). The design stemming lengths are 4.1 m or greater. The green zone represents safe distances for stemming lengths of 4.1 m or greater See Appendix 2 for fly rock range and safety circles determination. Determined from the minimum stemming length equation on Page 31.

Shape factor (1.3 for rock fragment)	1.3
Factor of safety	2
Safety Distance (m)	Min stem length (m)
100	7.2
200	5.0
300	4.0
400	3.4
500	3.0
600	2.7
700	2.4
800	2.2

3.5 Design for 15 m bench blasting with 254 mm holes (One charge deck per hole)

Table 3-7. Blast design for drilling on 15 m benches using a 254 mm diameter hole. The powder factor and drilling productivity lines have been highlighted for easy reference.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	254	254	254	254	254
Bench height (m)	15	15	15	15	15
Stemming length (m)	6.6	6.1	6.6	6.1	6.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.9	1.8	2.5	2.0	1.9
Hole depth (m)	16.9	16.8	17.5	17.0	16.9
Burden (m)	6.4	5.9	8.3	6.7	6.4
Spacing (m)	7.3	6.8	9.5	7.7	7.4
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.18	1.18	1.18	1.18	1.18
Overall Charge length (m)	10.3	10.7	10.9	10.9	10.9
Charge deck length (m)	10.3	10.7	10.9	10.9	10.9
Charge mass/linear metre (kg/m)	59.8	59.8	59.8	59.8	59.8
Total charge mass per hole (kg)	616.2	640.3	650.4	654.0	649.0
Powder Factor (kg/m3)	0.89	1.05	0.55	0.84	0.91
Explosive RWS (%)	85	85	85	85	85
Explosive absolute energy (kJ/kg)	3.24	3.24	3.24	3.24	3.24
Energy/m3 (kJ/m3)	2.87	3.40	1.79	2.73	2.95
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	41.15	36.31	67.26	45.59	42.08

Table 3-8. Vibration estimates based on commonly applied attenuation constants K and beta of 1143 and -1.65 respectively. Vibration levels that can be tolerated by people in general are highlighted in green. All structures will be safe from any blast vibration induced damage in the green zone. See Appendix 1 for method for calculating ground vibration.

VIBRATION	Calcrete	BIF	UMO Oxidised	LMO	Dyke
Distance	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
50	360.0	371.6	376.4	378.1	375.7
150	58.8	60.6	61.4	61.7	61.3
200	36.6	37.7	38.2	38.4	38.1
250	25.3	26.1	26.4	26.6	26.4
300	18.7	19.3	19.6	19.7	19.5
400	11.6	12.0	12.2	12.2	12.2
500	8.1	8.3	8.4	8.5	8.4
600	6.0	6.2	6.2	6.3	6.2
700	4.6	4.8	4.8	4.9	4.8
800	3.7	3.8	3.9	3.9	3.9

Table 3-9. Safety zones calculated for fly rock for safety of people (factor of safety of 2). The design stemming lengths are 6.1 m or greater. The green zone represents safe distances for stemming lengths of 6.1 m or greater See Appendix 2 for fly rock range and safety circles determination. Determined from the minimum stemming length equation on Page 31.

Shape factor (1.3 for rock fragment)	1.3
Factor of safety	2
Distance (m)	Min stem length (m)
100	12.2
200	8.5
300	6.9
400	5.9
500	5.2
600	4.6
700	4.2
800	3.9

3.6 Design for 15 m bench blasting with 250 mm holes (Two charge decks per hole)

Table 3-10. Blast design for drilling on 15 m benches using a 254 mm diameter hole using two charge decks per hole separated by a 3 m waste deck. The powder factor and drilling productivity lines have been highlighted for easy reference.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	254	254	254	254	254
Bench height (m)	15	15	15	15	15
Stemming length (m)	6.6	6.1	6.6	6.1	6.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.6	1.5	2.1	1.7	1.6
Hole depth (m)	16.6	16.5	17.1	16.7	16.6
Burden (m)	5.3	5.1	7.1	5.6	5.3
Spacing (m)	6.1	5.8	8.2	6.4	6.1
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.18	1.18	1.18	1.18	1.18
Overall Charge length (m)	7.0	7.4	7.5	7.6	7.5
Charge deck length (m)	3.5	3.7	3.8	3.8	3.8
Charge mass/linear metre (kg/m)	59.8	59.8	59.8	59.8	59.8
Total charge mass per hole (kg)	418.6	445.4	450.5	454.5	450.0
Charge mass per deck (kg)	209.3	222.7	225.2	227.3	225.0
Powder Factor (kg/m3)	0.85	1.00	0.52	0.84	0.92
Explosive RWS (%)	85	85	85	85	85
Explosive absolute energy (kJ/kg)	3.24	3.24	3.24	3.24	3.24
Energy/m3 (kJ/m3)	2.76	3.24	1.67	2.73	2.97
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	29.57	26.94	50.92	32.30	29.57

Table 3-11. Vibration estimates based on commonly applied attenuation constants K and beta of 1143 and -1.65 respectively. Vibration levels that can be tolerated by people in general are highlighted in green. All structures will be safe from any blast vibration induced damage in the green zone. See Appendix 1 for method for calculating ground vibration.

VIBRATION	Calcrete	BIF	UMO Oxidised	LMO	Dyke
Distance	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
50	147.7	155.5	156.9	158.1	156.8
150	24.1	25.4	25.6	25.8	25.6
200	15.0	15.8	15.9	16.1	15.9
250	10.4	10.9	11.0	11.1	11.0
300	7.7	8.1	8.2	8.2	8.2
400	4.8	5.0	5.1	5.1	5.1
500	3.3	3.5	3.5	3.5	3.5
600	2.4	2.6	2.6	2.6	2.6
700	1.9	2.0	2.0	2.0	2.0
800	1.5	1.6	1.6	1.6	1.6

Table 3-12. Safety zones calculated for fly rock for safety of people (factor of safety of 2). The design stemming lengths are 6.1 m or greater. The green zone represents safe distances for stemming lengths of 6.1 m or greater See Appendix 2 for fly rock range and safety circles determination. Determined from the minimum stemming length equation on Page 31.

Shape factor (1.3 for rock fragment)	1.3
Factor of safety	2
Distance (m)	Min stem length (m)
100	12.2
200	8.5
300	6.9
400	5.9
500	5.2
600	4.6
700	4.2
800	3.9

3.7 Optimal choice

The designs provided in the preceding Tables will affect the overall drill and blast cost. The powder factor and productivity values provided in the Tables are the main cost drivers and the choice will depend on final cost.

However, from a technical aspect, the optimal design is given in Table 3-4. A 15 m bench with 171 mm holes complies with a vibration limit of 6 mm/s and a fly rock safety zone of 300 m. The proviso is that the mitigation measures outlined in this report are applied in every hole. The design in Table 3-4 gives the best explosives distribution for even fragmentation with stemming lengths being a smaller proportion of bench height.

The larger 254 mm holes will allow for lower drill and blast costs, but it is harder to achieve back damage control and associated boulders that will need secondary treatment.

4 Estimate of fragmentation

The fragmentation models are base on the geotech information provided. Rock fragmentation is strongly impacted by the structure in the rock mass. The structure has been estimated and the results presented here are preliminary. The fragmentation prediction in Table 4-2 to Table 4-5 are based on the designs in this report. For a better prediction of fragmentation, a site visit will be needed.

The rock properties that have been applied for these predictions are given in Table 4-1. A description of the methods for calculating the rock blastability index is given in Appendix 3.

Table 4-1. Rock properties used for the fragmentation estimates. A rock mass description of 40 applies for a semi-massive rock. A Rock mass description of 10 applies for a highly structured rock. A joint spacing factor of 20 applies to joints/bedding layers being more than one metre apart. A joint spacing factor of 10 applies to joints/bedding being equal to or less than 100 mm apart. A joint orientation factor of 15 applies to joints that are near-horizontal. A rock blastability index of 63 applies to rock that is harder to fragment, whereas and blastability index of 31 applies to rock that fragments easily. The rock blastability index feeds into the Kuzram fragmentation model.

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
Uniaxial compressive strength (MPa)	80	300	50	200	250
Rock density (g/cm^3)	2.6	4	3	4	2.75
Young's Modulus (GPa)	40	70	40	50	70
Rock mass description	40	30	10	30	30
Joint spacing factor	20	15	10	10	15
Joint orientation factor	15	15	15	15	15
Rock Blastability Index	47	63	31	58	46

4.1 10 m bench, 171 mm holes (One charge deck per hole)

Table 4-2. Fragmentation estimate based on the Kuzram fragmentation model that has been modified to include the KCO model for more accurate fines prediction

Design name	Calcrete Size (mm)	BIF Size (mm)	UMO Oxidised Size (mm)	LMO Size (mm)	Dyke Size (mm)
P80	291	404	195	256	408
P70	217	307	144	193	310
P60	167	240	110	150	242
P50	129	188	84	117	189
P40	97	144	64	90	145
P30	70	105	46	66	106
P20	45	69	30	44	70

4.2 15 m bench, 171 mm holes (One charge deck per hole)

Table 4-3. Fragmentation estimate based on the Kuzram fragmentation model that has been modified to include the KCO model for more accurate fines prediction

Design name	Calcrete Size (mm)	BIF Size (mm)	UMO Oxidised Size (mm)	LMO Size (mm)	Dyke Size (mm)
P80	293	421	195	264	423
P70	227	331	149	205	332
P60	182	268	118	165	268
P50	146	217	94	133	217
P40	116	173	74	106	173
P30	88	133	56	82	133
P20	62	94	39	58	94

4.3 15 m bench 254 mm holes (One charge deck per hole)

Table 4-4. Fragmentation estimate based on the Kuzram fragmentation model that has been modified to include the KCO model for more accurate fines prediction

Design name	Calcrete Size (mm)	BIF Size (mm)	UMO Oxidised Size (mm)	LMO Size (mm)	Dyke Size (mm)
P80	328	469	215	295	469
P70	245	358	159	223	358
P60	190	281	122	174	281
P50	147	221	95	137	221
P40	113	171	72	106	171
P30	82	127	53	79	127
P20	54	85	35	54	85

4.4 15 m bench 254 mm holes (Two charge decks per hole)

Table 4-5. Fragmentation estimate based on the Kuzram fragmentation model that has been modified to include the KCO model for more accurate fines prediction

Design name	Calcrete Size (mm)	BIF Size (mm)	UMO Oxidised Size (mm)	LMO Size (mm)	Dyke Size (mm)
P80	407	562	273	343	538
P70	276	394	183	237	377
P60	193	284	127	169	271
P50	134	202	88	120	193
P40	89	139	60	83	133
P30	55	88	37	53	85
P20	28	47	20	29	45

5 Special control measures

Special control measures are needed to keep vibration and air blast levels below the threshold level at which human reaction will become negative and complaints will occur. These levels are well beneath the normally prescribed limits. Humans are much more sensitive to vibration induced by both air blast and ground shaking than their homes.

Fly rock control is the most critical aspect that needs special attention because of the surrounding infrastructure, people and houses.

5.1 Fly Rock and air blast control

A simple but reliable rule is that air blast control is achieved by effective measures for fly rock control. Air blast and fly rock are caused by high pressure energy escaping from the surface of a blast through blowouts caused but inadequate stemming, under-burdened faces or weak rock using under-designed stemming length.

5.1.1 General control

1. Use screened aggregate for stemming material. The fragment size must be about 10% of the hole diameter.
2. Cross check the explosives mass being charged and stop the MMU operator before a hole is accidentally over-charged. The checking is best done with a length of nylon rope that is marked to the desired length between the top of the charge and the hole collar before explosives have started gassing.
3. Remove excess emulsion from blastholes that have been over-charged. The tolerance should be not more than 5 % of the designed stemming length.
4. Measure and track cup densities to make sure that gassing rates are according to charging specification.
5. Use only electronic delay detonators and not any non-electric nor detonating cord initiation systems.
6. Apply blast timing designs that ensure only one hole fires per 8 ms and that holes fire in sequence.

7. Measure and document the length from the top of the explosives to the collar (stemming length) for every hole in the blast after gassing has been completed. This is a critical process and requires adequate staffing. The pressure to blast should not allow the blasting crews to short-cut this operation. One hole in a blast that is under-stemmed will result in a high risk of excess flyrock ejection. A standard is proposed where, if the measured length is shorter than 5% of the design stemming length, the miner responsible for the blast must arrange to have emulsion removed from the hole according to a safe operating procedure until the stemming length in that hole is corrected.
8. The people who stem the holes must be trained in reporting any reduction from normal in the amount of stemming material that is applied. A hole that is blocked in the collar region by a rock that has fallen into the hole will take a much lower stemming volume. Over-looking occurrences of hole blockage in the stemming region is risky and it is advised that the stemming operation is supervised by a person who is keenly aware of the risk.
9. Blast timing delays must be long with delay values that are about 20 ms/m or more in the softer rock types. This can be achieved reliably and with good blast results using electronic detonators. Slow blast timing will help to reduce confinement in the blast and associated upward displacement. Fragmentation is not impacted negatively by the application of longer delays.
10. Report stemming length measurements in every post-blast report so that a managed response can be applied if stemming QC drops below standard. Effective electronic recording systems are available that are easy to use and provide useful statistical evaluation of drilling, charging and stemming quality of holes. The use of a risk value based on minimum stemming length will be useful in the report. The calculation method is provided in the Appendix 2.
11. Every blast must be videoed from a safe distance. The information is useful in checking on ejection control from the blast surfaces and help in providing useful visual information for confirming or negating flyrock and air blast issues.
12. If the measured air blast at the closest monitoring point exceeds 120 dB, or high-velocity ejection plumes are seen in the blast video, the blast should be investigated, the cause established and documented. This will help in gaining control of the risk and sensitise the team to issues related to stemming control.
13. Predicting vibration, fly rock and air blast should be done for each blast. The guidelines in the Appendices can be used.
14. Check wind direction. If it is blowing from the blast towards nearby houses, consider delaying the blast for more favourable wind conditions. Useful smartphone Apps, such as *Windy* or *WindFinder*, provide reliable wind forecasts so that blasts can be scheduled to avoid unfavourable wind days.
15. Secondary blasting may not be applied. Toes and boulders will need to be addressed using mechanical methods or non-explosive products.
16. Final-wall blasting will require special attention, with presplit holes being stemmed and fired one at a time and all buffer holes being stemmed.

5.1.2 Face profiling

Fly rock from blast free faces presents a high risk if front row burdens are not properly controlled and measured. Modern techniques are available for measuring front row burdens and deigning the charge length in each front row hole accordingly. These include laser profiling, 3D digital imaging technology and drone surveying.

It is important that every free face is surveyed before front row holes are charged. Any portion of blasthole with a burden that is less than 80% of the designed burden must not be charged.

5.1.3 Choked blasting

Choked blasting is an alternative method for preventing face bursting and fly rock from free faces. This method requires a loading standard where the minimum width of blasted material left against the faces is equal to the bench height.

5.2 Vibration

Blast vibration is governed by the distance from blasting and the charge mass fired per delay. The controllable is the charge mass fired per delay. The vibration predictions in the designs in Section 3 of this report are all based on only one hole or one charge deck firing at a time.

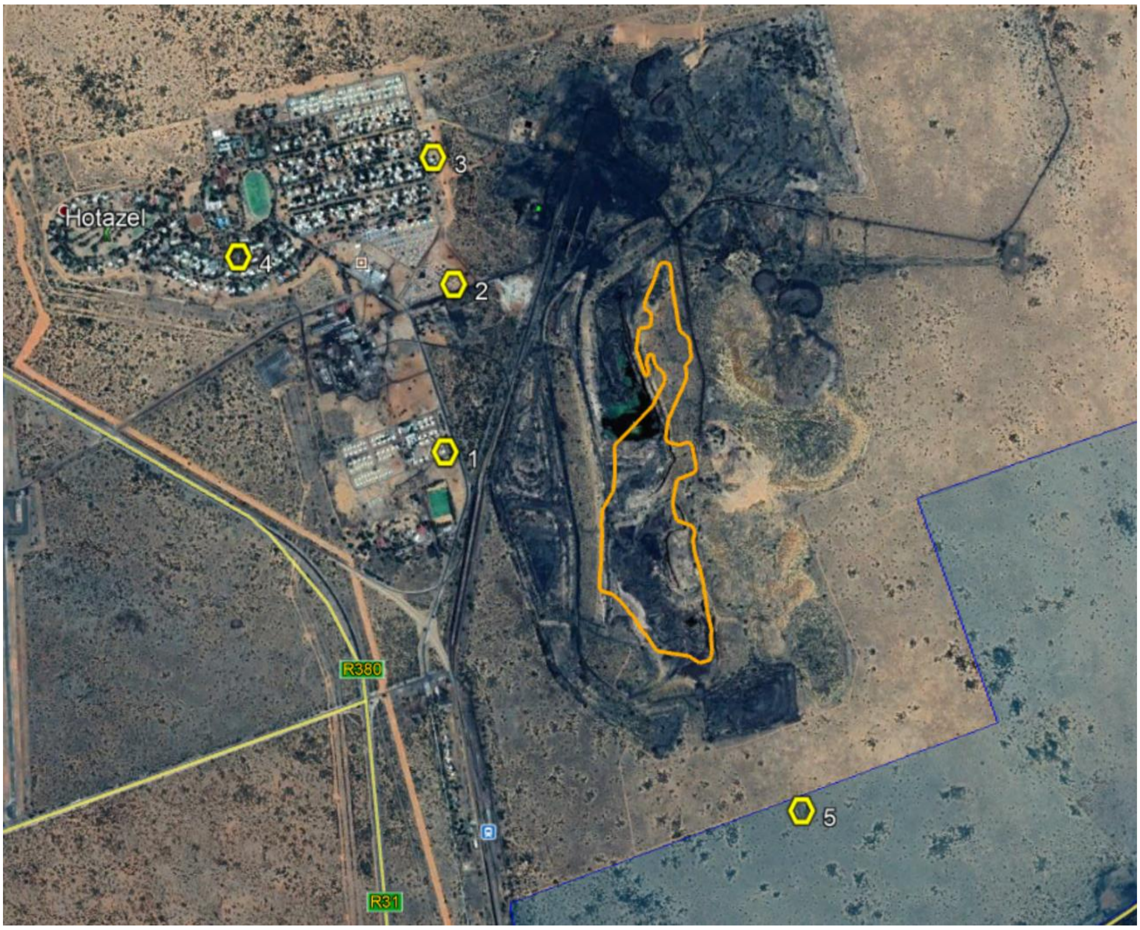

Figure 5-1. Proposed approximate positions for five permanent seismic stations for vibration and air blast monitoring. Station 5 is needed for monitoring in a different direction from blasting and will serve the purpose of checking vibration at the PV farm. Stations 1 to 3 will check vibration and air blast at the closest homes to blasting. Station 4 provides a back-up and a more distant monitoring point for attenuation verification.

5.2.1 Blast timing

Shocktube detonator assemblies are inaccurate and cannot deliver a guaranteed one-hole initiation per delay. Therefore, electronic detonators must be applied, and blast timing designs must be undertaken by on-site planning engineers on a blast by blast basis to achieve the single hole initiation requirement.

5.2.2 Vibration monitoring

Adequate vibration history for the site does not exist. Therefore, vibration monitoring will be needed for each blast from the start of blasting. The information will be used to develop site specific scaled distance constants that will calibrate the vibration attenuation rate and thus allow accurate predictions of vibration, especially when blasting occurs closer to private residences. For this purpose, the information needed for each blast is vibration data, the distance from the monitoring point to the blast and the charge mass fired per delay.

Ideally, the installation of permanent seismic stations at a few points within Hotazel will provide reliable and comparable data.

6 References

Chiappetta, R., Bauer, A., Dailey, P. and Burchell, S., 1983. The Use of High-Speed Motion Picture Photography in Blast Evaluation and Design, Proceedings of the Ninth Annual Conference on Explosives and Blasting Technique. Dallas, TX. International Society of Explosives Engineers.

ISEE Blaster's Handbook, 18th Edition, 2015.

Lilly P.A. 1986. An empirical method of assessing rock mass blastability. The AusIMM/IE Aust Newman

McKenzie, C., 2009, Flyrock Range & Fragment Size Prediction. International Society of Explosives Engineers 2009G Volume 2. Source: www.OneMine.org

Workman, J.L. and Calder, P. N., 1994, Flyrock prediction and control in surface mines. International Society of Explosives Engineers, 1994. Source: www.OneMine.org

Zeeman, D, 2020, Blast and vibration assessment report – proposed Hotazel Project, DMR reference number NC30/5/1/1/2/12148 PR

7 Appendix 1 –Vibration limits and calculation method

7.1 Damage definition

A common damage definition is used for defining the USBM limit and is globally applied to describing damage to homes.

This common definition of damage categories to houses has been developed so that accurate comparisons and quantifiable assessments can be made. These damage categories are described by several published reports (Siskind, 2005, Dowding, 1985 and Oriard, 1999).

- **Threshold (Cosmetic)**
  Extension of hairline plaster cracks. Usually difficult to see.
  Usually start to appear at 76 mm/s.
- **Minor**
  Superficial. Will not affect the strength of a building. Broken windows, dislodging of loose objects, new hairline cracks. Occur at PPV levels of about 114 mm/s or above or air blast above 150dB.
- **Major (Structural)**
  Serious weakening of the structure (Large cracks, shifting of foundation, distortion of the superstructure). Occurs at PPV levels above 200 mm/s and above 180 dB.

The USBM limiting criterion (described in the following pages) is very conservative and defines the limit above which the risk of threshold damage increases. What most people do not appreciate, very often including people with technical knowledge, is that the USBM limit defines limits that are far below the PPV values that cause the kind of major damage that most homeowners blame blasting for.

7.2 Limits and human response

Brick and mortar homes in Hotazel are formally constructed. They will withstand ground vibration much more than the USBM limit, which defines a limiting curve for peak particle velocity (PPV) in terms of vibration amplitude and vibration frequency at which the risk of cosmetic damage begins to increase.

Air blast is commonly more of a problem to nearby homeowners than vibration, because it is felt through the response of large surfaces such as ceilings, doors and windows. Homeowners usually confuse these effects as being caused by ground vibration. The result is that complaints are more frequent for blasts where the low frequency component of air blasts is high in magnitude.

Although buildings can withstand ground vibration amplitudes of 12.7 mm/s or more, depending on the frequency, human beings are easily disturbed at lower vibration amplitudes. Table 1 provides typical human response to ground vibration.

Ground vibration levels at a structure of 0.76 to 2.54 mm/s are quite perceptible, but the risk of damage is non-existent. Levels in the 2.54 to 7.6 mm/s can be disturbing and levels above 7.6 mm/s can be very disturbing, although permanent damage is highly unlikely. These levels have been determined for continuous vibration (Dowding 2000, Siskind, 2005).

Human perception is also affected by frequency. The approximate human response curves for continuous vibration are combined with the USBM limiting curve for damage in Figure 7-2. These curves slope in the opposite direction. In other words, humans are more tolerant of low frequency vibrations and less tolerant of high frequency vibration, which is opposite to how buildings respond to frequency.

For avoiding damage to buildings, the USBM limiting curve should be applied. However, to avoid constant complaints from neighbours, ground vibration should preferably be kept at least beneath the very disturbing level.

The German standard DIN4150 has a limiting level of about **6 mm/s** at 40 Hz (Siskind, 2005, Schillinger 2006). This limit is specifically intended to minimise perception-related complaints and does not bear on building structural response. This is a different approach to the USBM limit that is based on structural response only. The German DIN4150 limit is beneath the "very disturbing" level of 7.6 mm/s and represents a sound target to aim for to avoid neighbour complaints.

Table 7-1. Human response to continuous vibration (Chiappetta, 2000)

Effects on Humans	Ground Vibration Level mm/s
Imperceptible	0.025 – 0.076
Barely perceptible	0.076 – 0.254
Distinctly perceptible	0.254 – 0.762
Strongly perceptible	0.762 – 2.540
Disturbing	2.540 – 7.620
Very disturbing	7.620 – 25.400

The target of 6 mm/s affects the subjective nature of people and will not have any impact on buildings. It should be considered only as an aim to limit unfounded complaints.

So, the USBM limit of 12.7 mm/s at frequencies between 4Hz and 14 Hz, which increases linearly above 14Hz to a maximum of 50.8 mm/s at 50 Hz and above, remains the most statistically and tested way of eliminating the risk of blast-induced damage to properly constructed brick and mortar buildings.

However, an important component of curbing the problem of increasing complaints and demands is to limit the irritation that is caused by blasting.

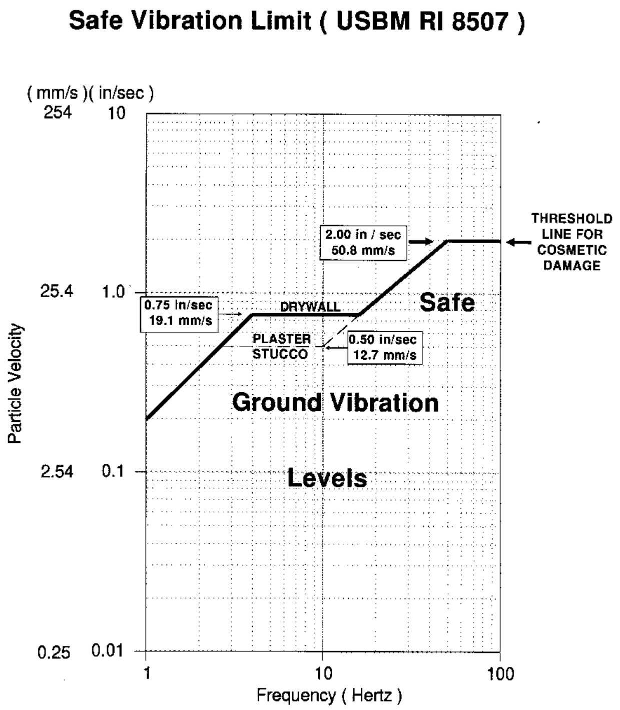

Figure 7-1. USBM curve that is generally used globally. (After Chiappetta, March 2000).

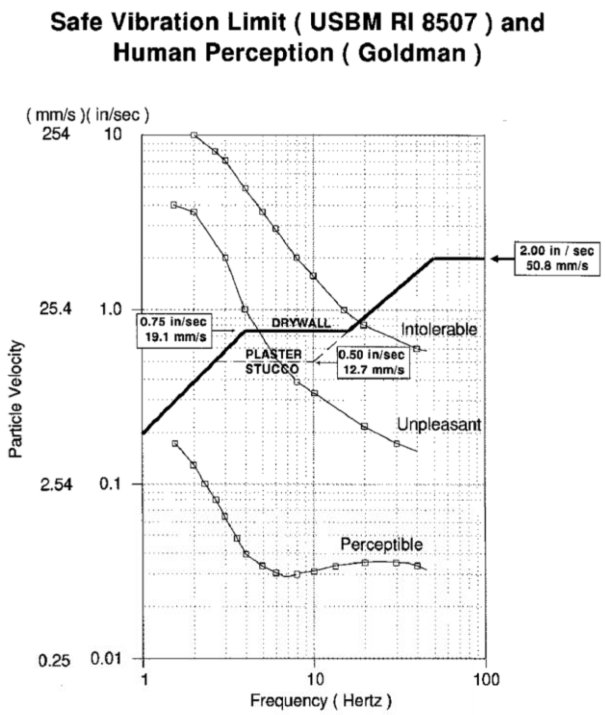

Figure 7-2. Human response curves to continuous vibration compared to potential damaging limits for houses. (After Chiappetta, 2000)

7.3 Other forces that impact homes

Dowding (1985) has reported on extensive research on natural stresses that houses are subjected to and cite these as common causes of cracking:

1. Differential thermal expansion
2. Structural over-loading
3. Chemical changes in mortar, bricks and plaster
4. Shrinkage and swelling of wood
5. Differential foundation settlement

The example shown in Figure 7-3, which is one of many he has published, shows the typically large difference between high naturally induced strains from temperature fluctuation and the much lower blast induced strains. This highlights the subjective, but incorrect observations made by homeowners who blame blasting for large cracks, since they can hear and feel blasting related vibrations, but do not hear or feel the large strains caused by, for example, temperature or wind variations.

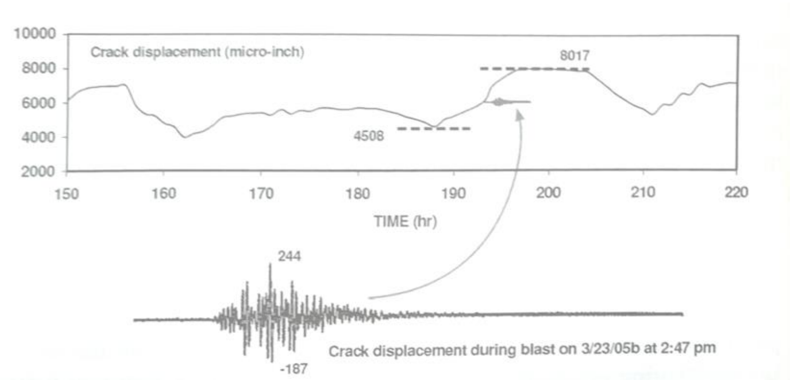

Figure 7-3. Comparison of a response across a crack from blasting vibration (measured at 10.5 mm/s) compared to thermally induced displacement of 91.4 mm (After Dowding, 2008). The blast vibration response is minor compared to the daily temperature response, thus highlighting the question of what the actual causes of damage may be.

7.4 Predicting vibration

It is possible to predict, with a degree of confidence, the peak amplitude of the ground vibration wave by scaling the distance from the blast as a function of the charge mass fired per delay in the blast. This is referred to as the scaled distance relationship and takes the following form (Borg et.al.):

Equation 1

$$PPV = k\left(\frac{R}{\sqrt{W}}\right)^{-\beta}$$

Where C is the peak amplitude or peak particle velocity, R is the distance between the blast and the point of concern and W is the charge mass detonated per delay or instance in time. The constants k and β are site-specific constants that are a function of the transmission properties of the rock mass. These constants will need to be determined from vibration measurements at the mine when blasting commences as described by the vibration mitigation control measure on Page 28. For this report there is no historical vibration data measured and global constants have been applied for Equation 1.

k = 1143

β = -1.65

7.5 Predicting air blast

Due to varying atmospheric conditions, it is more difficult to predict air blast levels with certainty. Persson et.al. (1994) have published a general-purpose attenuation equation that can be used as an approximate guide:

Equation 2

$$p = 7 \times 10^4 \left(\frac{W^{\frac{1}{3}}}{R} \right)$$

Where *p* is the predicted air blast amplitude in Pascals, W is the exposed charge mass per delay in kg and R is the distance from the source in metres.

Equation 2 is only relevant for exposed charge masses. Under normal blasting conditions, the charges will be confined, and air blast levels will be much lower. For limiting disturbance to neighbours, air blast amplitudes must be lower than 120 dB at any recording station.

7.5.1 Tolerance

In most countries, an air blast of 125 dBL is required, with a maximum of 134 dBL to ensure no damage. A limit of 120 dBL is significantly lower than the 125 dBL limit, but by applying the limit of 120 dBL, it will be possible to tolerate an occasional exceedance to 125 dBL and allow for corrective action without exceeding potentially damaging levels.

A limit of 120dBL will be easily achievable if the control measures detailed in Section 4 of this report are consistently applied.

8 Appendix 2 – Fly rock range and calculation method

8.1 Fly rock range determination

Fundamental kinematic equations (described by Workman and Calder, 1994) ca be used for estimating fly rock range. These equations assume no energy losses along the trajectory.

Wind resistance, fragment size and fragment shape play a role in modifying the trajectory of the fragment. Independent work that has been published by two researchers (McKenzie 2009 and Lundborg et al, 1975) provide more realistic fly rock prediction ranges based on wind resistance and fragment shape and size

8.2 Fly rock control

8.2.1 Scaled depth of burial

The equations presented in this appendix can be used in spreadsheets by the planners to check their designs for safety.

A scaled depth of burial of 1.4 in harder rock (BIF, Dyke and LMO) and 1.5 in the softer calcrete and UMO rock. These are suitable value for safe blasting closer to houses. Safety in terms of flyrock is dependent on quality of stemming material and accurate stemming application.

The scaled depth of burial (Chiappetta et. al, 1983) is commonly used for determining a stemming length for a desired containment outcome based on hole diameter and explosive energy. The corresponding stemming length can be calculated from the scaled depth of burial equation:

Equation 1

$$SD = \frac{Ls + \left(\frac{k}{2} \times \emptyset\right)}{(Mc \times k \times \emptyset)^{0.33}}$$

Or

Equation 2

$$Ls = \frac{SD \times (Mc \times k \times \emptyset)^{0.33}}{\left(\frac{k}{2} \times \emptyset\right)}$$

Where:

Ls is the length of the stemming in metres.
SD is the scaled depth of burial.
Mc is the charge mass per metre in kilograms. The explosives density therefore plays a role in determining stemming length.
Ø is the charge diameter in metres?

k is a constant which can be set at 8 for holes from 102 mm and less in diameter and 10 for holes greater than 102 mm. This represents the charge length in the top of the column that impacts flyrock.

A graphic printed in the 18th Edition of the ISEE Blaster's Handbook provides a visual guide to the effects of differing scaled depth of burial values. This is shown in Figure 8-1.

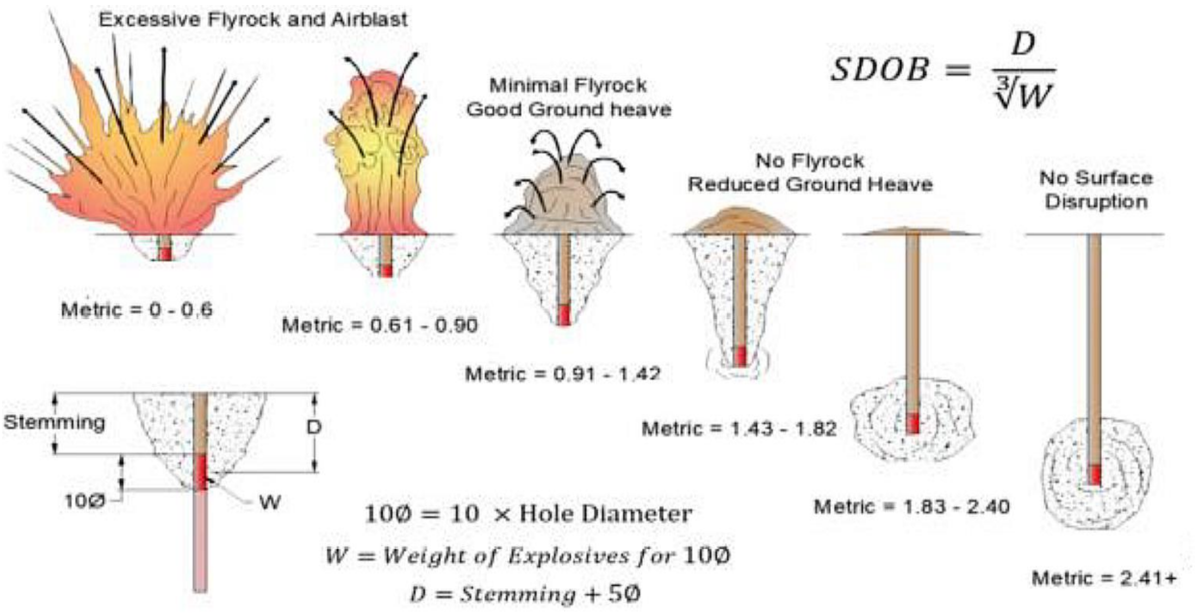

Figure 8-1. Scaled depth of burial (SDOB) and impact on flyrock (Taken from ISEE Blaster's Handbook, 18th Edition, 2015). For effective control in flyrock sensitive areas, a scaled depth of burial of 1.4 is advised to achieve a high factor of safety.

8.2.2 Minimum stemming length determination

An alternative minimum stemming length can be established for different factors of safety and fragment shape using an equation proposed and tested by McKenzie (2009). The numbers produced by the minimum stemming calculation provide an indication of hazard or risk that can be used in assessing actual measured stemming lengths.

Equation 3 (after McKenzie, 2009)

$$SL_{min} = \left(0.028\frac{(k\rho_{exp})^{0.33}\varphi^{1.308}}{\left(Dist/_{FoS}\right)^{0.46}F_s^{0.308}} - 0.0005 \times k \times \varphi\right)$$

Where SL_{min} is the minimum stemming length in metres, FoS is the factor of safety (set to 1.5 for equipment and structures and 2 for houses and people) and F_s is the shape factor which is normally about 1.3 for rock fragments. For a sphere, a shape factor of 1 can be used. A sphere will have a lower wind resistance and therefore travel further. Explosives density ρ_{exp} is stated in g/cm^3 and diameter, φ, is in millimetres.

In the definition of the minimum stemming length equation, McKenzie emphasises that "*It must be remembered that if one blasthole in a pattern is badly loaded, the safety of all in the vicinity is compromised. The failure in a blast which produces flyrock is not so much the error in charging which produced the flyrock, but the lack of awareness and failure to respond appropriately to the error by those in charge of loading and firing the shot*".

Therefore the shortest stemming length in a blast will govern the flyrock risk from the blast.

Using a factor of safety of 2, a sphere shaped fragment (for maximum range) and the design parameters of a 165 mm hole and a fully coupled charge with density 1.18 g/cm^3, the minimum stemming lengths values have been calculated and provided in the designs in Section 3 on Page 7. The numbers provide an indication of safety based on the minimum stemming length that has been applied in the blast

Important: The minimum stemming length values are valuable in assessing the safety of a blast knowing what the applied minimum stemming length is. They can also be used for establishing tolerances dependent on distance to the nearest sensitive receptors. By documenting the measured stemming length in each hole in the blast reports, a flyrock risk number can be included in the report based on the stemming length measurements.

9 Appendix 3 – Definition of blastability index

The rock blastability index is used as input into the rock fragmentation model and deciding on burdens in your design. The blastability index that has been used for the proposed designs for Cut 2 in Appendix 2 is 56.

To be able to design effectively to reach the optimal energy needed in a blast and predict what fragmentation can be expected from a design, it is necessary to reduce all the geological variables into one variable to rate the rock. We know rock structure is the most important variable for blasting, but density, plasticity and intact rock strength also play a role. The intact rock strength becomes more important as the rock mass becomes more massive.

Different rock ratings:

1. Rock Mass Rating (RMR); which is used for pit slope designs and rock support designs
   a. Uses strength and elastic properties of the rock
   b. Uses joint spacing, joint orientation, joint condition and persistence
   c. Uses water content along the joint planes
2. Rock Quality (Q)
   a. Uses strength and elastic properties of the rock
   b. Uses the RQD value which is derived from core samples
   c. Uses water content along the joint planes
3. Rock Blastability Index (RBI) developed originally by Lilly, 1986.
   a. Uses strength and elastic properties of the rock
   b. Uses joint spacing and joint orientation

All three are rated on a percentage scale with the hardest material to blast being at 100%.

In most cases, the rock blastability index is used for blast design to estimate fragmentation, although in the absence of face mapping to determine the rock blastability index of a block, the RMR or Q-values may be available and can be applied. To establish the RBI, the following variable are used.

1. Rock density
2. Rock mass description
3. Joint spacing
4. Joint orientation
5. Rock UCS

The rock blastability index has a range between 0 and 100 with 100 being exceedingly difficult to blast. The equation used to define the rock blastability index is based on the following values.

Rock Mass Description (RMD)

This has a significant influence on the rock blastability index. It is important that the description closely matches the joint plane descriptions. Larger values mean more difficult blasting and the need for higher powder factors.

10 = Friable
20 = Highly jointed
30 = Moderately jointed
40 = Highly absorbent or plastic
50 = Massive

Joint Plane/Bedding Plane Spacing (JPS)

The closer the joint planes are spaced apart, the finer the joint-controlled fragmentation will be. Closer joint spacing usually means easier blasting and lower energy needed in a blast.

10 = planes spaced closer than 100 mm
25 = planes spaced 100 mm to 1000 mm
50 = planes spaced more than 1000 mm apart

Joint Plane/Bedding Plane Orientation (JPO)

The joint plane orientation influences how the rock breaks out at the toe of a blast.

10 = Horizontal
20 = Dips out of face to vertical
30 = Strikes normal to face
40 = Dips into the face

Calculation:

$$RBI = 0.5\{RMD + (UCS \times 0.5) + (0.025 \times \rho - 50) + JPS + JPO\}$$

RBI is the rock blastability index ranging between 0 and 100%
UCS is the uniaxial compressive strength of the intact rock in MPa.
ρ is the density of the rock in kg/m^3.

The constants in the rock blastability index were derived from an iron ore mine, but provide an approximation that will work, especially when comparisons are made from area to area in Cut 2.

APPENDIX 19

TRAFFIC IMPACT ASSESSMENT

Merchelles Collective (Pty) Ltd
Reg. No. 2016/481395/07

PO Box 4695 Halfway House 1685, South Africa
Building 1, Maxwell Office Park, Magwa Crescent West
c/o Allandale Road & Maxwell Drive, Waterfall City, Midrand

Tawana Hotazel Mine Project, Northern Cape

Traffic Impact Assessment Report

Report No: 2

Submitted to :

Prime Resources (Pty) Ltd
The Workshop 70
7th Avenue
Parktown North
2193

06 January 2022 GP080

DOCUMENT CONTROL SHEET

Project Title: **Hotazel Mine Traffic Baseline Study and Impact Assessment**
Project No: GP080
Document Ref. No: GP080 Hotazel Mine TIA Report

DOCUMENT APPROVAL

ACTION	DESIGNATION	NAME	DATE	SIGNATURE
Prepared	Transport Engineer	Lerato Kgoa BSc (Eng) Civil	07 January 2022	
Reviewed	Senior Engineer	Ryno Nel Pr Eng	07 January 2022	

RECORD OF REVISIONS

DATE	REVISION	AUTHOR	COMMENTS
03 December 2021	Draft	Lerato Kgoa	Draft TIA issued to Prime Resources for comment
06 January 2022	01	Lerato Kgoa	Draft TIA Rev 01 updated according to Prime Resources' comments
07 January 2022	02	Lerato Kgoa	Final TIA issued to Prime Resources

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LIST OF ACRONYMS

COTO	Committee of Transport Officials
DMRE	Department of Mineral Resources and Energy
HMM	Hotazel Manganese Mine
HV	Heavy Vehicle
LDV	Light Delivery Vehicle
LOS	Level of Service
MoE	Measure of Effectiveness
MR	Mining Right
SIA	Surface Infrastructure Area
SIDRA	Signalised and unsignalised Intersection Design Research Aid
TIA	Traffic Impact Assessment
THM	Tawana Hotazel Mining (Pty) Ltd
V/C	Volume to Capacity ratio

1 INTRODUCTION

1.1 Appointment

Prime Resources (Pty) Ltd was appointed to undertake the Environmental Authorisation and other requisite permitting processes as part of the Mining Right Application for the proposed Tawana Hotazel Mine (THM). The mine is located south-east of the town of Hotazel in Northern Cape Province and THM will comprise of opencast manganese mining incorporating the historical opencast void using typical methods.

Merchelles Collective (Pty) Ltd has been subsequently appointed by Prime Resources to conduct a Traffic Baseline Study and Impact Assessment for the proposed mining site.

1.2 Background

The Department of Mineral Resources and Energy (DMRE) has accepted an application for a Mining Right (MR) made by Tawana Hotazel Mining (Pty) Ltd (THM) in terms of Section 22 of the Mineral and Petroleum Resources Development Act, 2002 (MPRDA).

The types of minerals applied for are all (Code UN); Iron and Iron bearing minerals including hematite, goethite, specularite and limonite (Code (Fe) Type (B)) and Manganese and manganese bearing minerals (Code (Mn) Type (B)).

The THM covers portions of two farms within the Joe Morolong Local Municipality (JMLM) in the Northern Cape Province, namely, Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel.

The THM largely incorporates the historical Hotazel Manganese Mine (HMM), and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining.

The overall area applied for is approximately 154 Ha (inclusive of the MR application area and access road). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure.

The locality of the project is indicated in Figure 1-1 below.

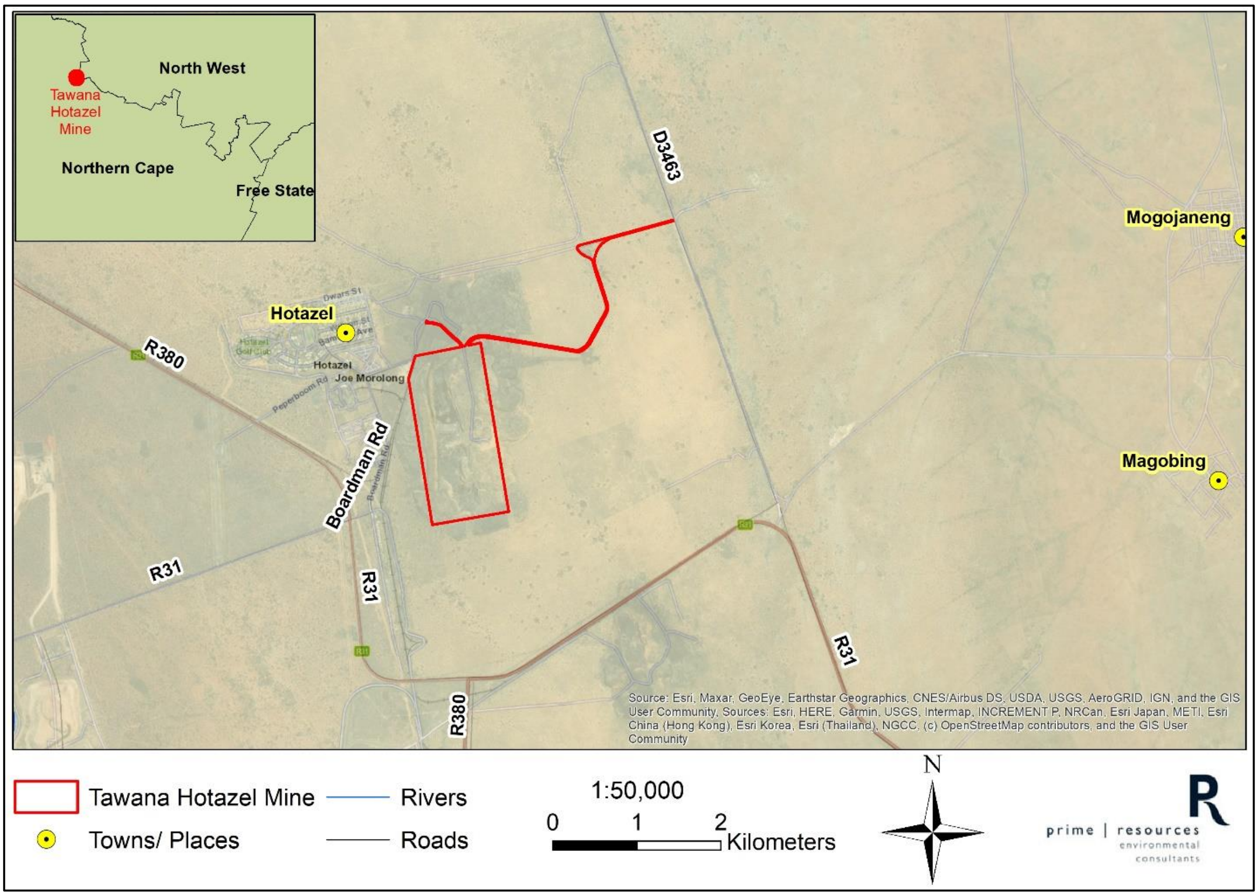


Figure 1-1: Locality Map of the Tawana Hotazel Mine

1.3 Objectives

The Traffic Baseline Study and Impact Assessment Report is a specialist assessment that is input to the Environmental Impact Assessment (EIA) of the development. This report investigates the impact of the development-related traffic on the existing road network and the receiving environment with the primary focus being on traffic operating conditions and road infrastructure. The report will cover traffic aspects during the construction, operational and decommissioning periods of the mining facility, including the evaluation of any new road upgrades that are required to alleviate potential impacts in terms of roadway capacity, road safety and road conditions.

1.4 Warrants and Extent of Study

To identify the level of investigation for the TIA, the following guidelines taken from the Manual for Traffic Impact Studies of the Department of Transport were followed:

- **Threshold Value (in terms of trips generated) for Traffic Impact Studies:** A traffic impact assessment is required to quantify negative impacts that the development may have within the transport environment for input to the EIA process.
- **Extent of Analysis:** For this Traffic Baseline Study and Impact Assessment, the operations of four critical intersections will be evaluated. This represents a study area which extends approximately 5km to the south and 1.8km to the west of the site.
- **Assessment Years:** The base year for analysis was taken as year 2020. The opening year for the facility will be taken as year 2024.

2 METHODOLOGY

The TIA is conducted in accordance with the Manual for Traffic Impact Studies of the Department of Transport and with reference to the COTO TIA Guidelines. In addition, the methodology makes provision for the assessment of impacts against the criteria that apply to environmental assessments, as provided by Prime Resources.

The quantification of impacts is calculated for each phase of the operation i.e., Construction, Operation, Decommissioning and Rehabilitation (Post-closure).

The methodology for the Traffic Impact Assessment includes the following tasks:

- Conduct a site visit to assess the road network around the study area, including the accesses onto the external road network and key intersections onto the public road network.
- Confirm the transportation methods of the raw materials to/off site.
- Undertake traffic count surveys in the area and conduct a Base Year capacity assessment of the road network.
- Compile a list of technical information to be obtained from the engineering team, for the construction, operations and decommissioning phases of the mine, as follows:
    - Details of the traffic/truck volumes expected to operate to/from the mine.
    - Origin / Destination of the traffic/truck volumes.
    - Sources of raw material (if any) that will be transported to site.
    - Location of and delivery methods of the final products.
    - Details of staff movements and transport means.
    - Details regarding abnormally dimensioned machine components required during the construction and operation of the plant (if any).
- Assign the above development related trips to the road network for the Construction Phase and thereafter Opening Year of the mine. Conduct capacity analysis of critical intersections.
- Forecast traffic growth for a 5-Year Design Horizon and conduct capacity analysis.
- Determine environmental impacts of the development-related traffic, safety hazards and other issues identified from the site visit.
- Make recommendations on any road infrastructure upgrades that are required to mitigate impacts and address road safety issues.

3 STATUS QUO ASSESSMENT

3.1 Study Area

The proposed Hotazel mine area is located south-east of the town of Hotazel in John Taolo Gaetsewe District Municipality in the Northern Cape province of South Africa. The town, which is 147 km north of Postmasburg and 60 km north-west of Kuruman, predominantly serves the surrounding mines (Wessels Mine, Tsineng Mine, Tshipi Mine, etc).

For the Hotazel Project, the proposed Mining Rights area is 145 ha and will comprise of the opencast pit, in-pit waste dump, vehicle yard and haul road. From a transport perspective, the site may be adequately serviced by road, rail and NMT infrastructure. The development site and study area to be considered for the traffic evaluation is illustrated in Figure 3-1 below.

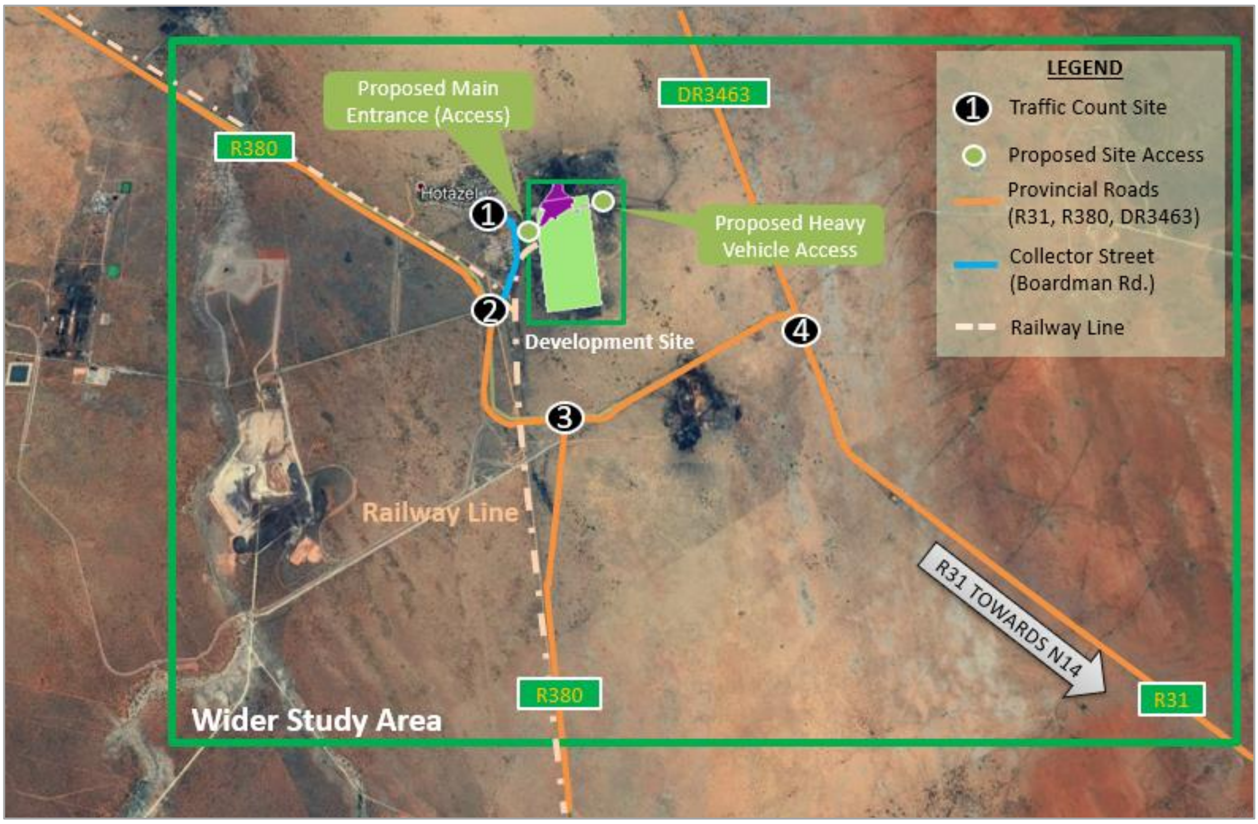


Figure 3-1: Development Site and Extent of Study Area

3.2 Data Collection

12-Hour manual classified traffic count surveys were undertaken at four intersections as described below and shown graphically in Figure 3-1.

1. **Count Site 1: Broadman Rd and Mine Access Rd Intersection** – a four-way stop-controlled junction providing access towards the proposed mine from the Hotazel town and nearby residences.
2. **Count Site 2: R31 and Broadman Rd Intersection** – critical intersection providing access to Hotazel town off the provincial route R31.
3. **Count Site 3: R31 and R380 Intersection** – critical intersection (T-junction) of two provincial routes located 3km south of the development site.

4. **Count Site 4: R31 and DR3463 Intersection** – critical junction linked to the proposed heavy vehicles (HV) mine access road off DR3463.

The traffic surveys were conducted on a typical workday, namely Thursday 26 November 2020, covering a 12-hour period from 06:00 to 18:00. The traffic data comprises of classified, turning movement volume counts with vehicles classified as light, minibus-taxi, bus and heavy vehicles per direction in 15-minute intervals.

The collected traffic data will be utilised to undertake capacity evaluations at the above-mentioned intersections, deduce traffic patterns on the road network and project future traffic demand on impacted roads.

3.3 Existing Road Network

The site is well-located in terms of road infrastructure, being located adjacent to some of the major mobility north-south and east-west roads in the area (R31 and R380). It is anticipated that trips to the development site will originate from the towns of Hotazel, Tsineng, Kathu and Kuruman.

The road network connecting the site to the surrounding towns and suburbs is illustrated in Figure 3-2 below and described in subsequent sections.

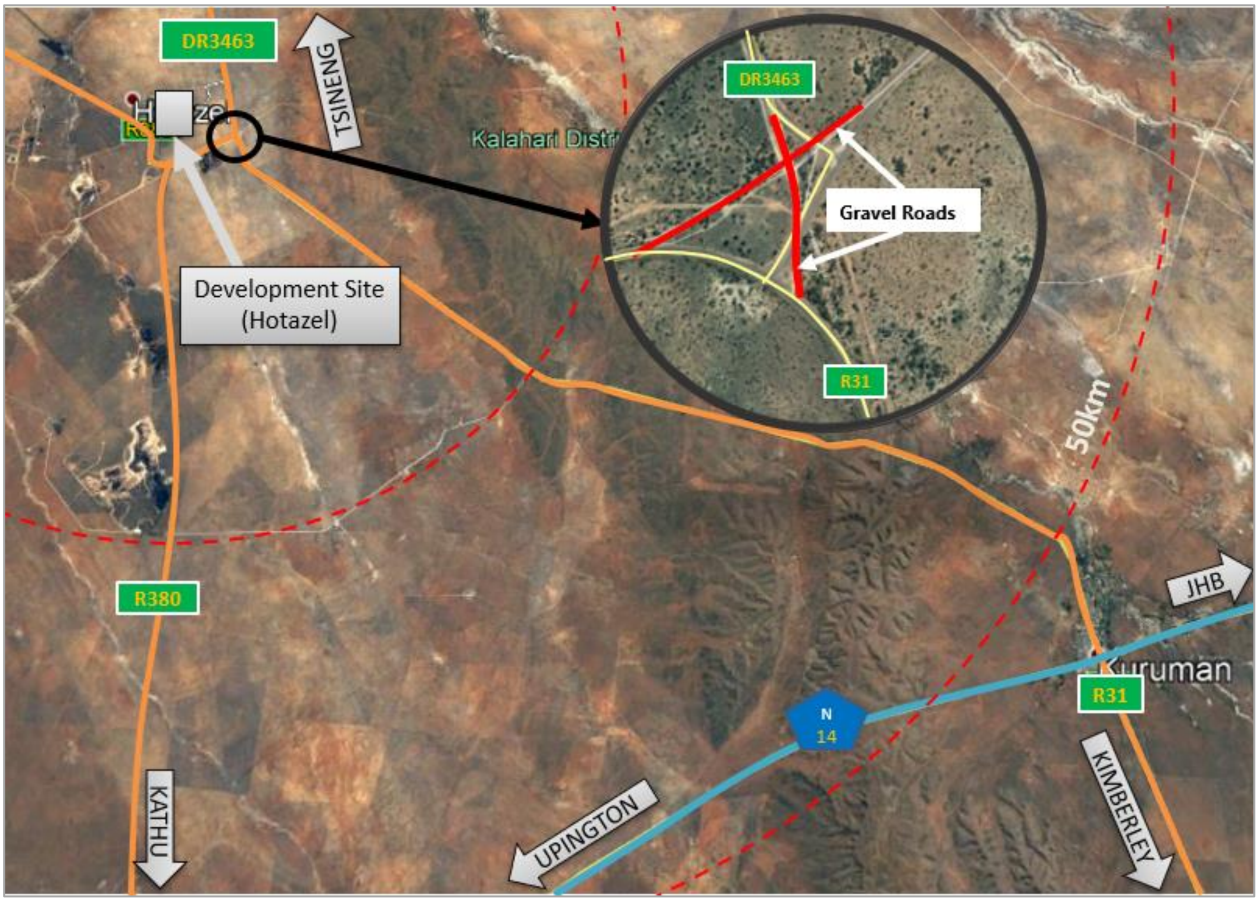


Figure 3-2: Existing Road Network around Development Site

3.3.1 Connecting Roads

3.3.1.1 N14

The N14 is a Class 1 national road under the jurisdiction of SANRAL that cuts across the mining corridor in the Northern Cape linking Upington in the west and ultimately to Gauteng in the east. The road has a 2-lane single carriageway configuration and is located over 50km south-east of the development site. The overall pavement structure appears to be in fair condition, however, in the section near the R31 Intersection, the road has no shoulders and edge breaks were observed, indicating a worn road wearing surface.

Figure 3-3: N14 2-lane single carriageway

3.3.1.2 R31

The R31 is a provincial road that can be classified as a Class R2 Rural Major Arterial linking the towns of Hotazel, Kuruman and Kimberley. The road is surfaced and tends to carry significant HV traffic volumes. The pavement condition of the road is poor having severe edge breaks and surface bleeding. Longitudinal cracks and potholes were also observed on the road.

Figure 3-4: R31 in the vicinity of DR3463 Intersection

3.3.1.3 R380

The R380 is a provincial road that can also be classified as a Class R2 Rural Major Arterial running north-south and linking Hotazel, Kathu and Postmasburg. The road is surfaced and has similar features as the R31 where the pavement condition of the road is poor; characterised by severe edge breaks. A section of the road is currently being rehabilitated by the Northern Cape Department of Roads and Public Works.

Figure 3-5: R380 Provincial Road

3.3.1.4 DR3463

Road D3463 is a provincial district road and can be classified as a Class R3 Rural Minor Arterial. The road is a low volume surfaced road providing access to mining activity in the north. The road is surfaced up to its intersection with a local road towards Tsineng, where after it continues as a gravel road. The pavement is in fair condition.

Figure 3-6: DR3463 Provincial Road

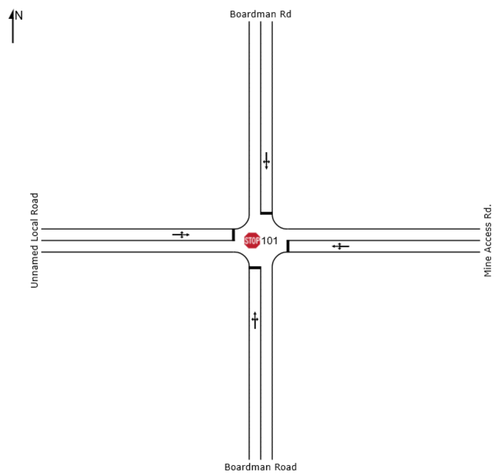
3.3.1.5 Broadman Road

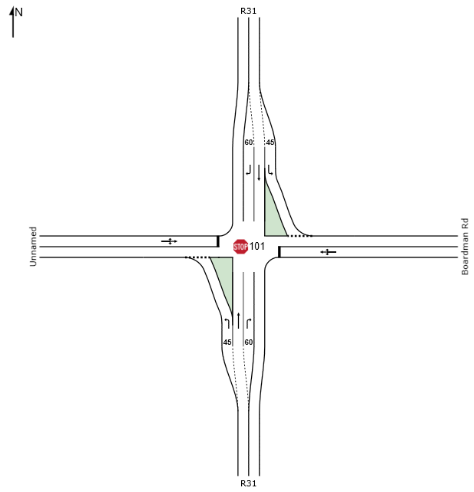
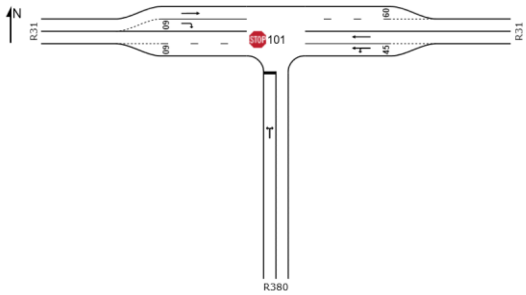
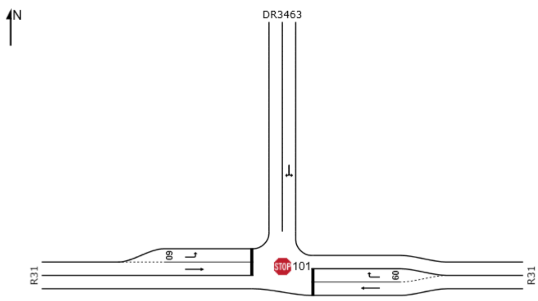
Broadman Rd. is a collector-distributor road running in the north-south direction in Hotazel town. The road intersects with the R31 and provides direct access into Hotazel and towards the development site. Broadman Rd. also comprises several at-grade rail intersections as well as NMT infrastructure such as side walks and raised pedestrian crossings.

Figure 3-7: Broadman Road, in the vicinity of Hotazel Police Station

3.3.2 Road Intersections

The following access intersections were considered critical to the study area:

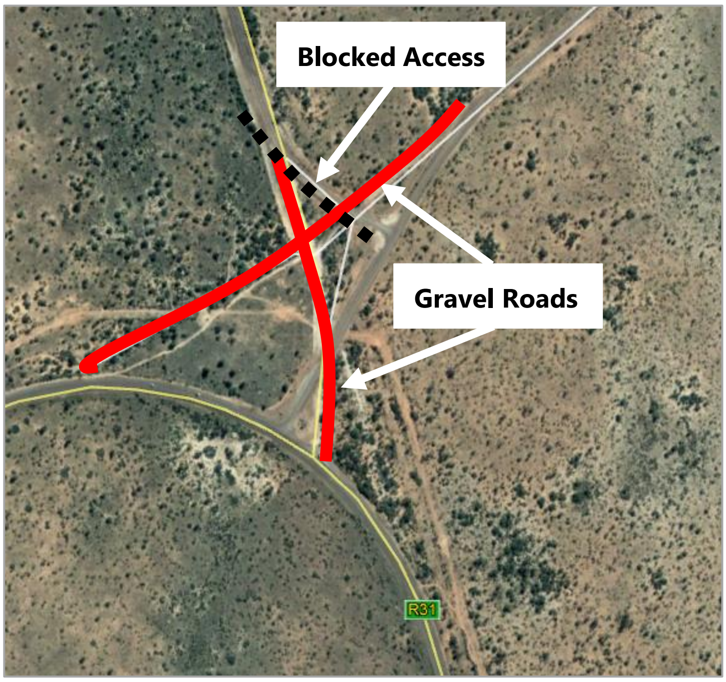
SITE NO.	INTERSECTION	INTERSECTION CONFIGURATION
1	BROADMAN RD. & ROAD A. I/S **Intersection Control:** All Way Stop Control **Major Rd.:** Broadman Rd. **Description:** Raised intersection with brick paving. Provides direct access to the site from Broadman Rd. 	

SITE NO.	INTERSECTION	INTERSECTION CONFIGURATION
2	R31 & ROAD B. I/S **Intersection Control:** Two Way Stop Control **Major Rd.:** R31 **Description:** Provides access to town and the site from the provincial road. 	
3	R31 & R380 I/S **Intersection Control:** Two Way Stop Control **Major Rd.:** R31 **Description:** Provides access to other mining towns. 	
4	R31 & D3463 I/S **Intersection Control:** Two Way Stop Control **Major Rd.:** R31 **Description:** Provides access to other mining towns and alternate access to the development site. 	

3.3.3 Salient Road Issues

During the site inspection that was undertaken on 19 November 2020, the following road safety issues were observed:

1. At the intersection of R31 and DR3463:
    a. Sight distance from the eastern approach (DR3463) is inadequate for right-turn movements towards Tsineng. This is due to the R31 (main road) curving at the intersection location. The sight distance could be improved through complete removal of trees and grass in the vicinity of the intersection.
    b. Gravel roads traverse the intersection as shown below:



The roads appear to have developed due to motorists taking a shortcut coming from road DR3463 onto the R31. Along DR3463, access onto this gravel road has been blocked off with wooden pole barriers.

2. Along Broadman Road:

There are several at-grade rail and road intersections along this road resulting in a combination of vehicular, rail and pedestrian traffic as shown below:

3. At the intersection of R31 and R380:
    a. Pavement settlement on the western approach of the intersection caused by large volumes of heavy vehicles from Tshipi Mine. The pavement structure was likely under designed for current heavy vehicle volumes.
    b. Sight distance from the western approach of the intersection is inadequate and motorists must drive further into the intersection so see clearly before turning. See illustration below.

3.4 Proposed Access Roads

Figure 3-8: Proposed Access Roads Layout for THM

Existing on-site roads will be utilised as access roads into the mine with two main access points as shown in Figure 3-8 above. The main entrance access road will be off Broadman road facilitating access for light vehicles and light delivery vehicles. The transport route to the east, connecting to road DR3463 will facilitate access for heavy vehicles.

The existing main entrance access road has a cross-section width varying between 11.0m and 16.0m. The road width narrows to 8.0m at gates and the pavement condition is fair. The existing access road is shown in Figure 3-9 below. This access road is currently utilised by light and heavy vehicles.

Figure 3-9: THM Main Entrance Access Road

The proposed heavy vehicle access road has a cross-section width varying between 9.0m and 20.0m. The pavement condition of this road was observed to be poor. Figure 3-10 below shows the existing road in the vicinity of road DR3463. Currently, access onto road DR3463 is closed-off with a sand heap.

Figure 3-10: THM Heavy Vehicle Access Road

3.5 Existing Traffic Volumes

The 12-hour traffic count volumes are presented in a stick model of the road network in Figure 3-11 overleaf followed by the AM and PM peak hour traffic volumes in Figure 3-12 and Figure 3-13. The peak hour traffic volumes are shown as light vehicles and heavy vehicles with buses included in the heavy vehicle volume.

In the vicinity of the development site, it is observed that Broadman Rd. carries low traffic volumes with majority of the commuters travelling from the Hotazel residential areas to the Hotazel Manganese Mine (HMM) plant located west of the intersection of Boardman Rd. and Road A during the AM peak period. The low volumes can be attributed to the low population level, which was 1756 in 2011 (Stats SA).

Along the R31, only 7% of the traffic stream turns towards the Hotazel town during the AM peak indicating that the town does not attract significant work trips. The afternoon peak reflects the same number of trips leaving the town.

The majority of observed traffic volumes is through traffic along the R31 from Kuruman passing Hotazel and going towards the Black Rock Mine Offices and Plant in the town of Santoy further north.

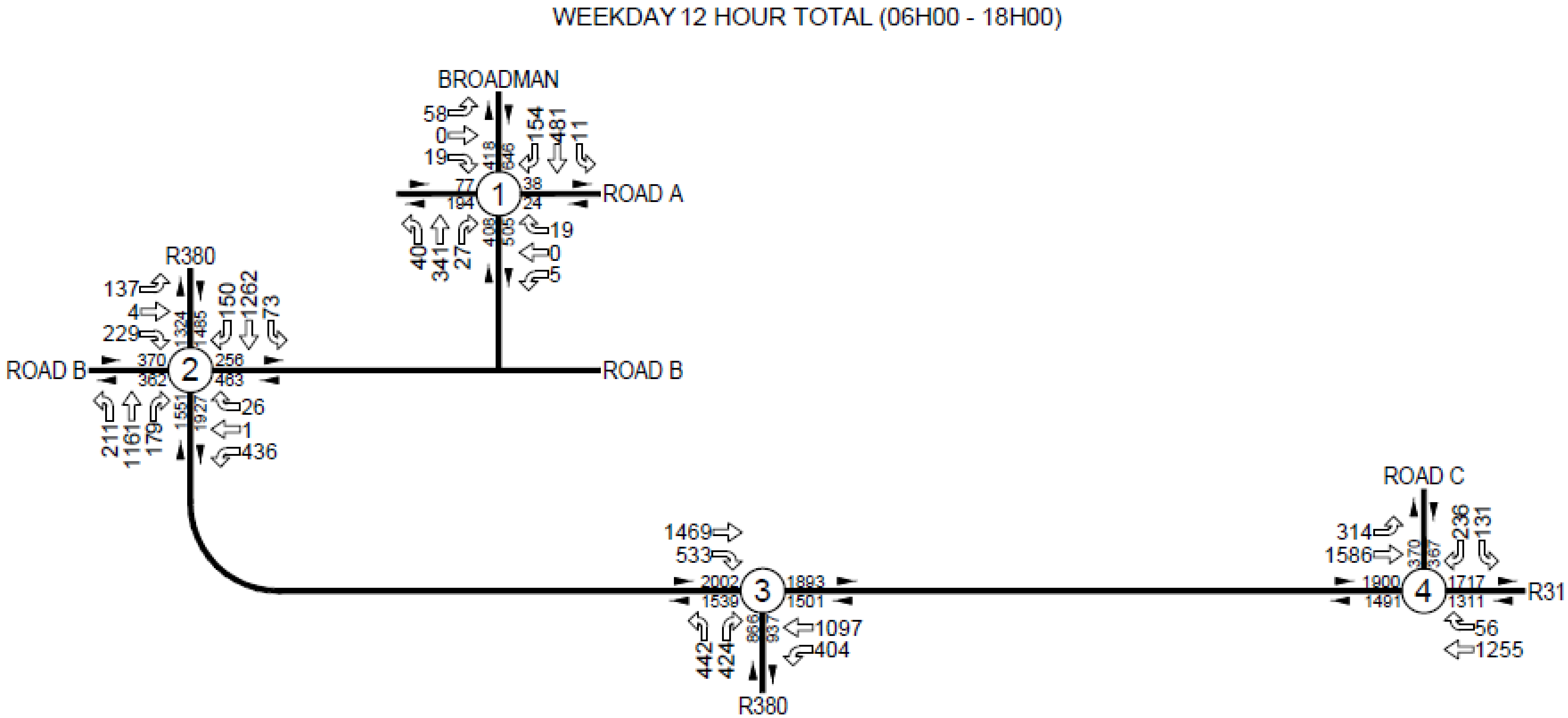


Figure 3-11: Base Year 2020 12-Hour Traffic Volumes

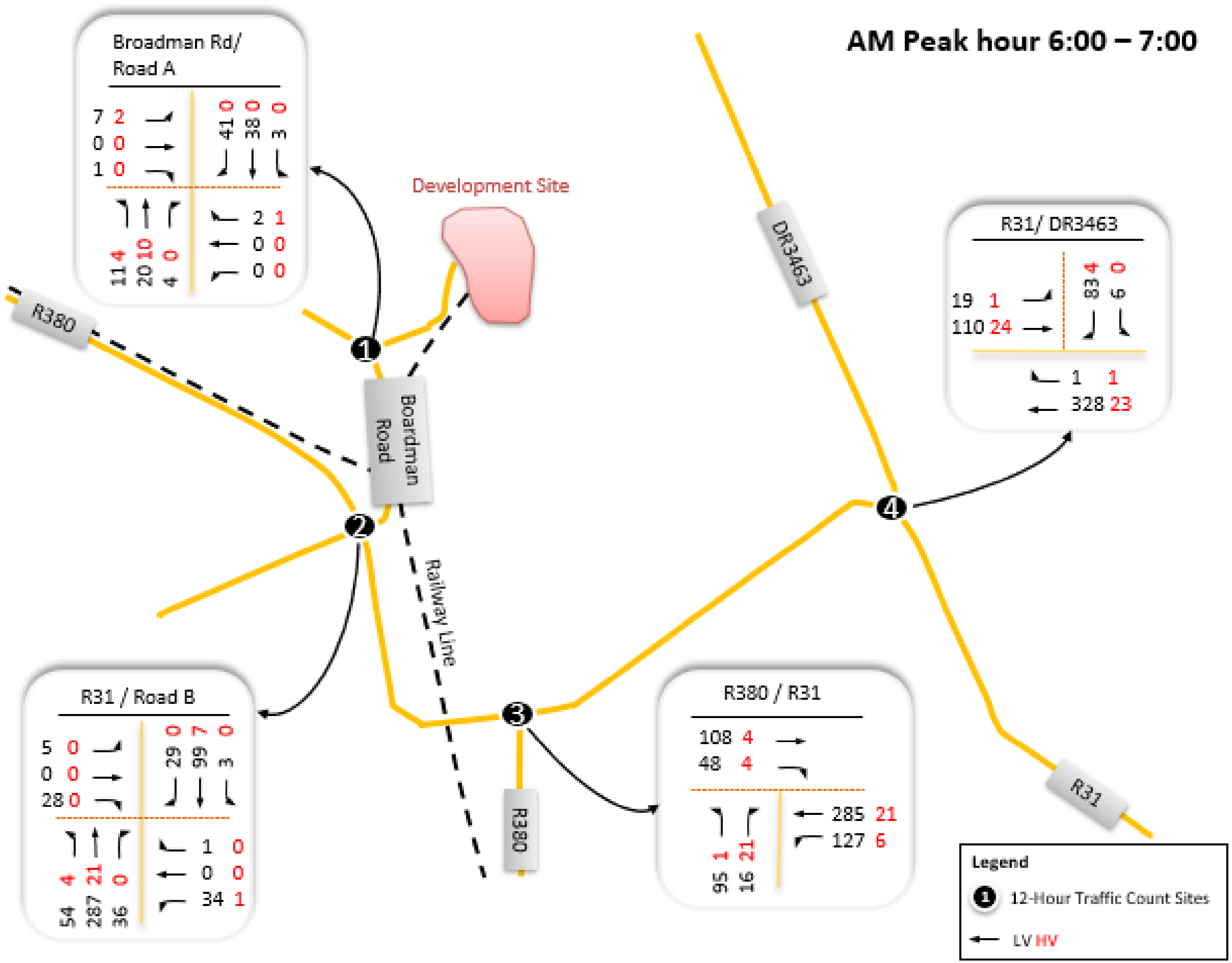


Figure 3-12: Base Year 2020 AM Peak Hour Traffic Volumes

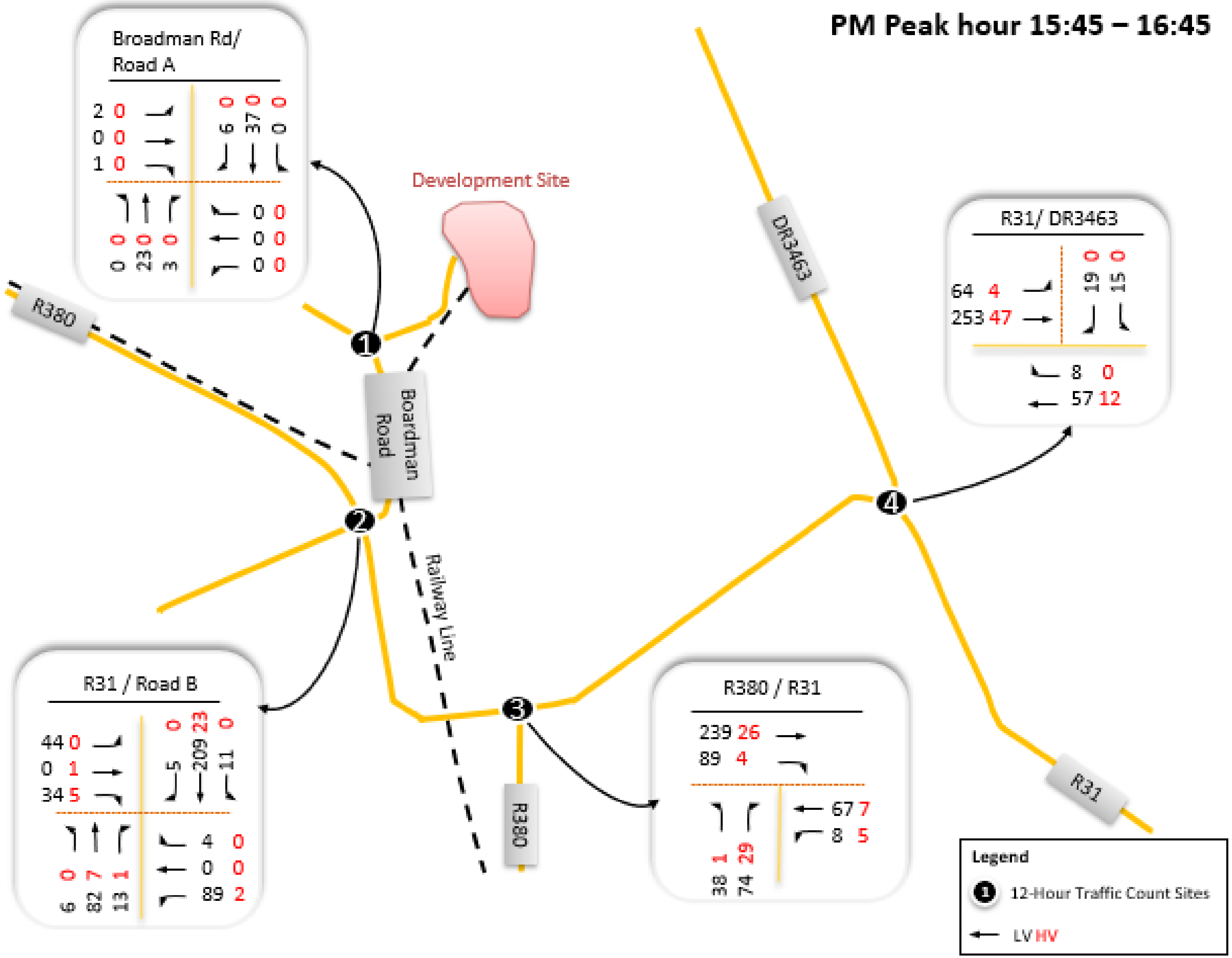


Figure 3-13: Base Year 2020 PM Peak Hour Traffic Volumes

3.6 Base Year Capacity Evaluation

The four critical intersections discussed above were analysed and evaluated using the SIDRA traffic analysis software. The operating performance was evaluated under existing traffic conditions and lane configuration during the AM and PM peak hours. The AM Peak Hour was taken as 06:00-07:00 and the PM Peak Hour as 15:45-16:45.

The operational performance of each intersection was evaluated in terms of delay experienced on each approach as well as capacity of the junction to process the current traffic flows. The performance measurement is the Level of Service (LOS) defined by the Highway Capacity Manual in which letters A through F are used. LOS A depicts free flow conditions while LOS F denotes a breakdown in traffic flow. These definitions are based on Measures of Effectiveness (MoE) for the type of facility, which in this case is an intersection. Typical MoE's include speed, travel-time, density and delay for the associated volume of vehicles that use the facility. The COTO TIA Manual indicates that a LOS C is acceptable for rural classes 3 - 5 roads.

The Volume Demand to Capacity Ratio (v/c) is a measure that compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). For example, V/C = 1.00 indicates that the roadway facility is operating at its capacity. The LOS and V/C results for the capacity assessment of the existing intersections are shown in Table 3-1 below.

Table 3-1: Base Year 2020 - SIDRA Capacity Analysis

			OPERATIONAL CONDITIONS							
				Approach				Intersection		
SITE ID	INTERSECTION	Peak Period	Approach	Demand	V/C	Delay	LOS	V/C	Delay	LOS
1	Boardman Rd. and Road A	AM	South	59	0.084	12.8	B	0.05	13.1	B
			East	6	0.024	21.3	C			
			North	96	0.095	9.5	A			
			West	13	0.001	8.7	A			
		PM	South	32	0.037	10.1	B	0.03875	21.4	B
			East	4	0.021	27.4	D			
			North	52	0.056	9.8	A			
			West	5	0.041	38.3	E			
2	R31 and Road B	AM	South	473	0.192	1.4	A	0.10	8.1	A
			East	44	0.045	8.9	A			
			North	92	0.03	2.7	A			
			West	40	0.151	19.5	C			
		PM	South	128	0.056	1.1	A	0.14775	6.7	A
			East	113	0.143	10.2	B			
			North	292	0.147	0.4	A			
			West	100	0.245	15	C			
3	R31 and R380	AM	South	156	0.271	12.8	B	0.18	5.7	A
			East	516	0.191	1.7	A			
			West	193	0.08	2.7	A			
		PM	South	167	0.379	17.3	C	0.196667	6.6	A
			East	102	0.043	0.9	A			
			West	421	0.168	1.6	A			
4	R31 and DR3463	AM	East	415	0.354	8.6	A	0.20	8.1	A
			South	109	0.06	5.6	A			
			West	181	0.182	10.1	B			
		PM	East	91	0.069	8.8	A	0.135667	7.8	A
			South	45	0.026	5.7	A			
			West	433	0.312	8.8	A			

3.6.1 Discussion of Base Year Results

The intersections were found to operate as follows:

1. Site 1: Broadman Rd. & Road A I/S

   The four-way stop controlled intersection operates well within capacity at LOS B during the AM and PM peak hours. The I/S is a raised brick paved intersection encouraging motorists to slow down on approach, making it safe for pedestrians and cyclists.

2. Site 2: R31 & Road B I/S

   The two-way stop-controlled intersection has a generous geometric design with left turn slip lanes along the major road (R31). The I/S therefore has adequate capacity and operates satisfactorily during both the AM and PM peak hours at LOS A.

3. Site 3: R31 & R380 I/S

   The intersection of the two provincial roads has adequate capacity to process current traffic volumes operating at satisfactory LOS A during the AM and PM peak hours. The approach on R380 operates at a slightly low LOS C which may be attributed to the queue of heavy vehicles on this approach.

4. Site 4: R31 & DR3463 I/S

   The two-way stop-controlled intersection appears to be recently improved with left and right turn lanes along the R31 and the I/S operates well within capacity at LOS A during the AM and PM peak hours.

3.6.2 Recommended Upgrades

The identified critical intersections have adequate capacity to process current traffic volumes and movements safely and efficiently on the road network. No capacity improvements are triggered.

4 TRAFFIC IMPACT ASSESSMENT

The additional traffic is expected to impact on the environment in three aspects or phases. There will be traffic generated during the construction phase of THM infrastructure and the impact of this traffic is generally of a short duration. The second aspect refers to the traffic generated post construction and this traffic is referred to as operational traffic. Operational traffic is generally long term and lasts for the duration that the mine continues to be active, generally 30 years. The third phase is the decommissioning phase, when the ore-extracting activities of the mine have ceased, and mine reclamation is being completed.

4.1 Site Access

Access to the mine is proposed via two main roads, one road intersects with Provincial Road D3463 from Kuruman to Severn and enters the mine at the northern easter corner, while the other road is from Hotazel town in the west and enters the mine from the north. The two access roads are shown spatially in Figure 4-1 below.

The main transport route to the northeast (Access Road 2) will be for Heavy Vehicles (HVs), and the main entrance to the west (Access Road 1) will be for Light Delivery Vehicles (LDV's). In addition, on-site access roads will be constructed for use by the secondary support fleets and earthmoving haul trucks, with ramps that lead in and out of the pit and haul roads for the transportation of processed products and waste amongst others.

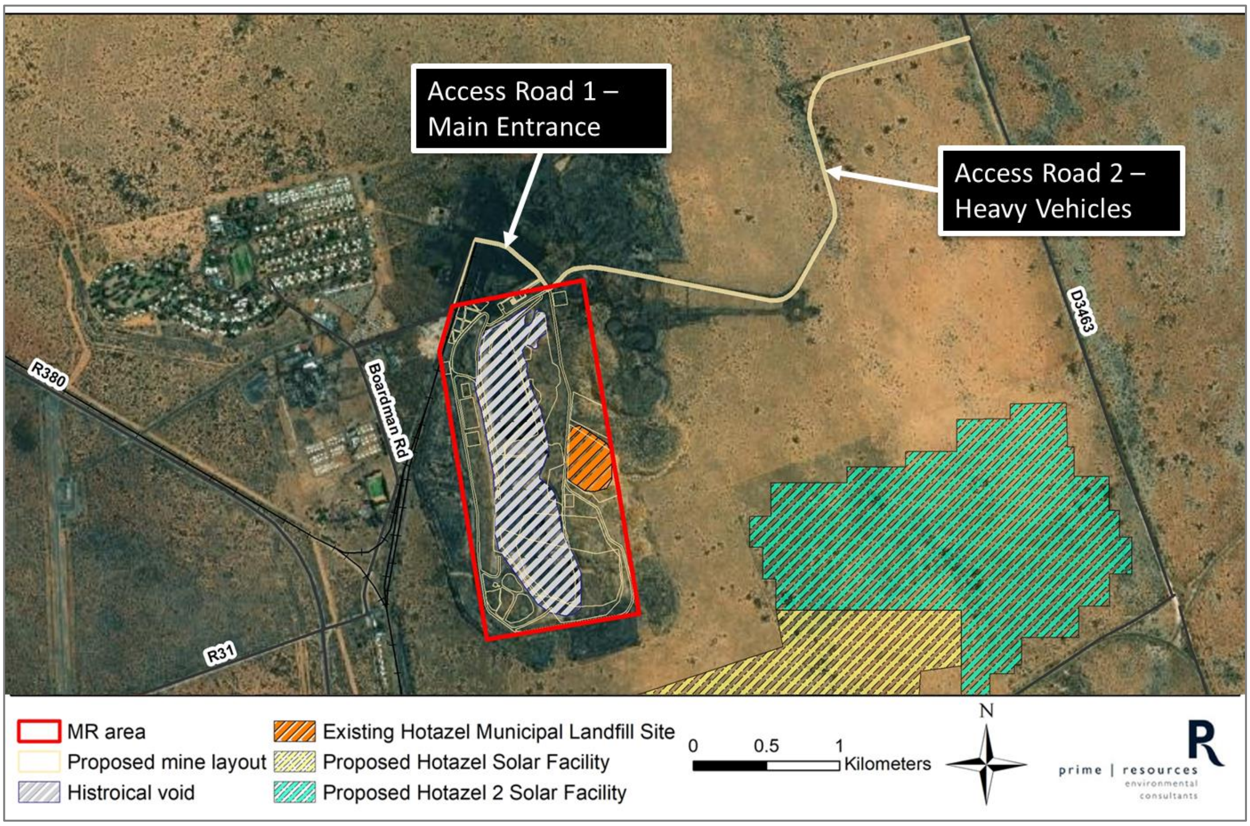


Figure 4-1: Locations of access roads

To improve mobility around the mine and to potentially reduce road user costs, a ring road (haul road) around the mine pit has been proposed. The ring road will also intercept stormwater which will be channelled to the stormwater ponds and is indicated on the proposed mine layout in Figure 4-2 overleaf.

Figure 4-2: Proposed Mine Layout

4.2 Construction Phase Traffic

This traffic relates to the traffic expected during the construction of the facilities to be built as part of the THM project.

4.2.1 Trip Generation and Distribution

The THM construction related vehicle trips will be generated from construction of the following infrastructure:

- Access roads and parking facilities
- Office blocks
- Bulk civil services – water supply, sewer and septic tanks
- Power supply
- Weighbridge
- PCD & Stormwater ponds
- Diesel refuelling bay
- Plan/vehicle yard and workshop

All construction activities will be spread over a minimum period of 12 months. The construction phase traffic is expected to dissipate shortly after completion of construction of the mining infrastructure.

Table 3-1 provides the estimated new trips that will be generated during the construction phase for the AM and PM Peak hours based on the anticipated staff movements and materials transportation.

Table 4-1: Trip Generation during Construction

Transport Mode	Estimated Construction Traffic	AM Peak Hour		PM Peak Hour	
		In	Out	In	Out
Private Vehicles (Cars/ Bakkies)	• Construction Supervisors and Management x 10 • Mine employees x 4 • Visitors x 1	15	0	0	15
Public Transport (Minibus taxis/ Buses)	• Security personnel x 5 • Civil contractors x 25 • Fencing labour x 10 • Plastic dam labour x 8 • Evaporator labour x 5 • Mine construction labour x 20	12	12	12	12
Heavy Vehicles	• Materials delivery (concrete, steel and other supplies)	10	10	10	10

Transport Mode	Estimated Construction Traffic	AM Peak Hour		PM Peak Hour	
		In	Out	In	Out
Total		**37**	**22**	**22**	**37**

For the purposes of distributing the above trips to the road network, the following assumptions are made:

- Staff/construction labour will arrive from the nearby residential areas of Hotazel, Tsineng, Mothibistad and Kuruman accessing the site via the R31, D3463 and Boardman Rd.
- Engineers and contractors are assumed to arrive from Kuruman, Kathu and Johannesburg via the R31 and R380.
- The delivery of construction materials is assumed to arrive from major economic nodes of Johannesburg, Vryburg and Kimberley via the N14, R31 and R380.
- The delivery of abnormal loads will require an Abnormal Load Route Determination study and is not dealt with further in this study.

The construction related trips were subsequently distributed to the road network as shown in Figure 4-3 Figure 4-4 below.

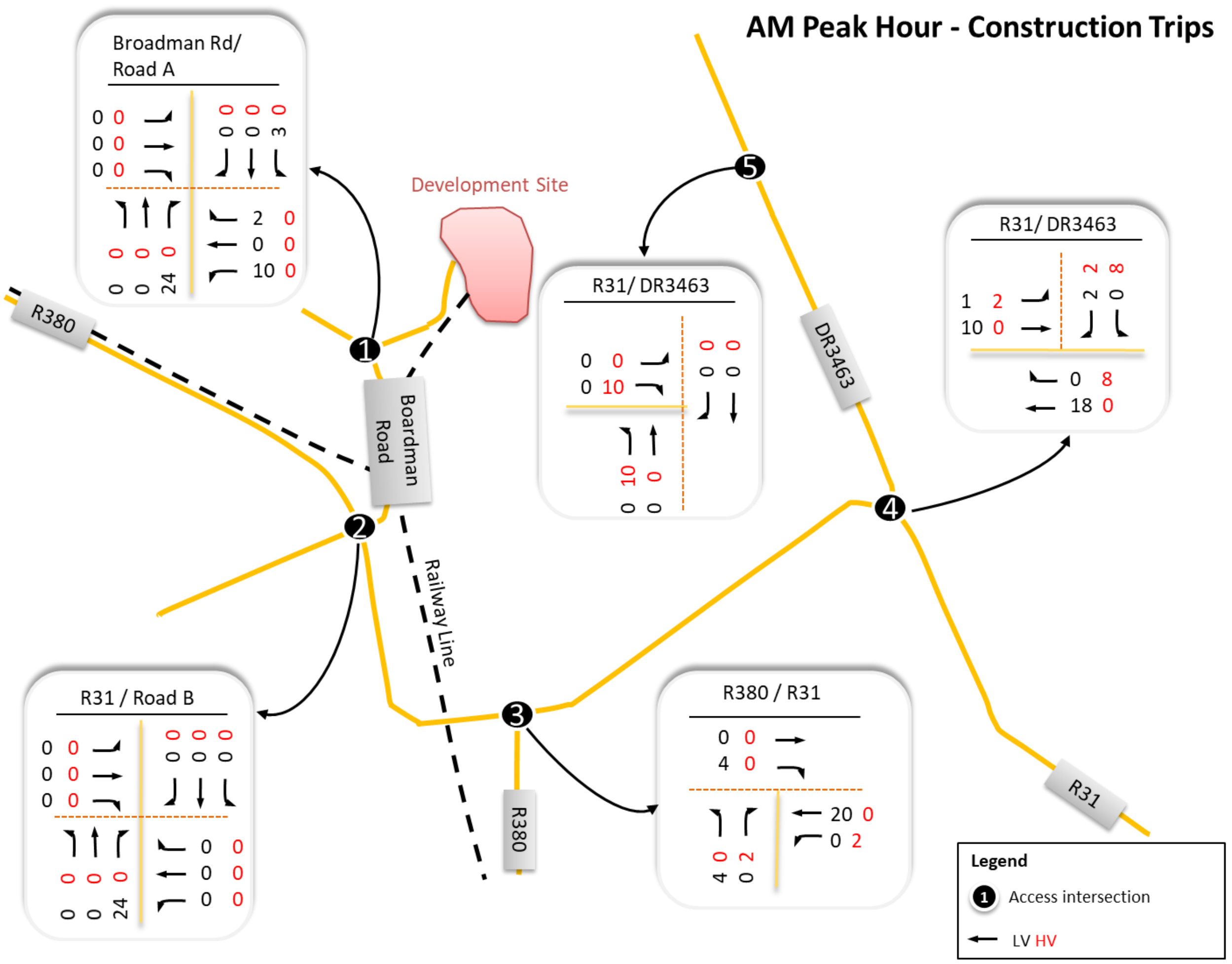


Figure 4-3: Distribution of construction phase trips - AM Peak

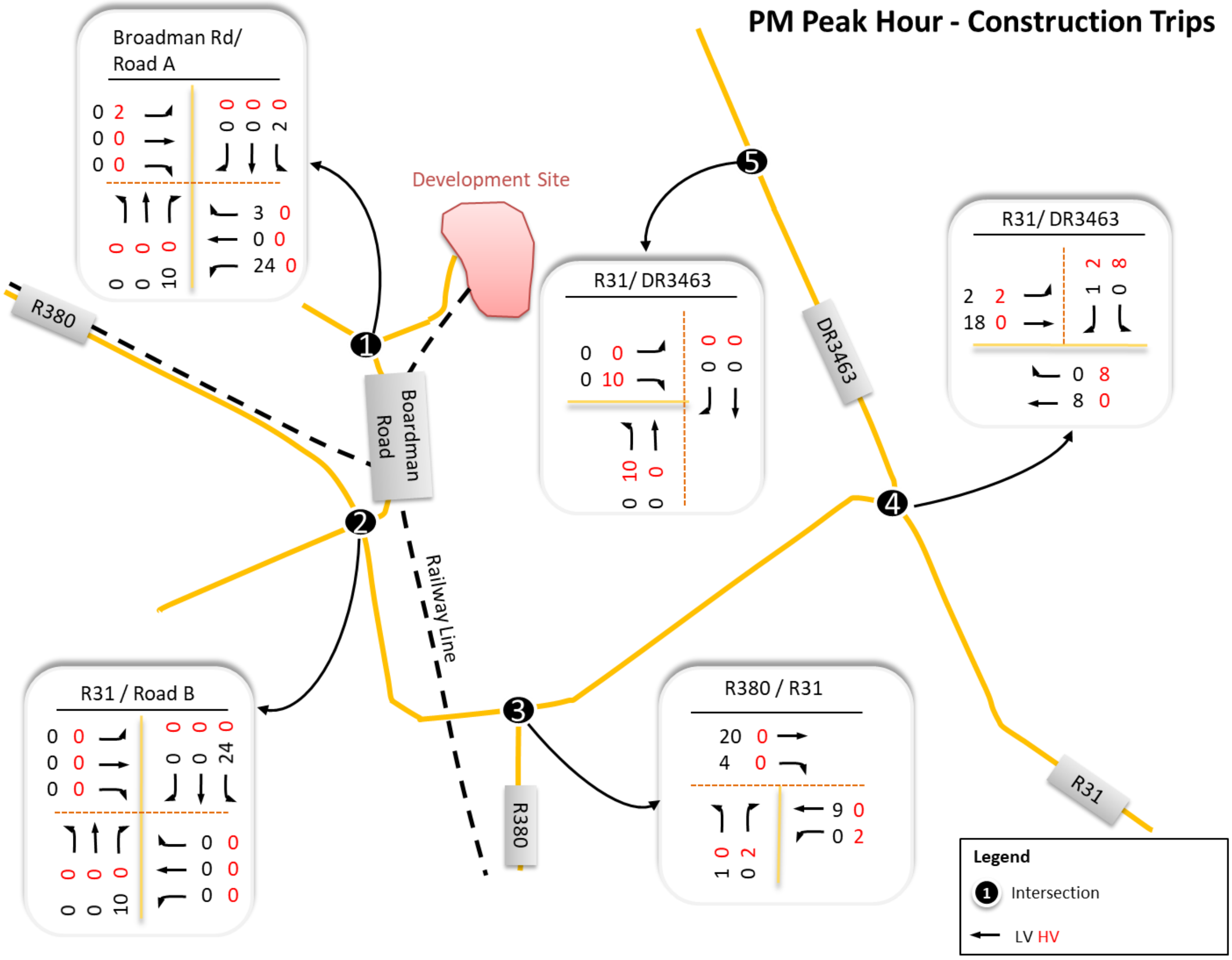


Figure 4-4: Distribution of construction phase trips - PM Peak

4.3 Operational Phase Traffic

The THM is expected to start operations in Year 2024, after all approvals have taken place and the supporting infrastructure facilities have been constructed.

4.3.1 Transportation of materials

Ore materials from the mine will be transported with heavy vehicles from THM to Lohatla for further distribution to customers via rail. The transportation of materials from the mine will generate potentially 80 to 100 heavy vehicle trips daily and it will be assumed that 20% of these trips will occur during the peak hours.

The heavy vehicles make use of the following routes to travel between THM and Lohatla:

- DR3463
- R31
- R380
- N14
- R325

4.3.2 Trip Generation and Distribution

The following assumptions were made to determine the trip generation at THM, based on the anticipated scale of mining activity:

- It is estimated that the mine will employ approximately 177 employees, categorised as per Table 4-2 below.
- The mine will operate in two shifts namely 06:00 – 18:00 and 18:00 – 06:00.
- Top and Senior management, including specialists will work core hours between 08:00-17:00 and will thus impact the transport network during the normal peak hour traffic periods.
- Shift workers will arrive on site around 05:30 for the first shift and leave at 18:30; and will arrive at say 17:30 for the second shift and leave at say 06:30. Thus the trips occurring during the peak hour that would have an impact on the network are the shift workers arriving for the second shift at 17:30 and leaving at 06:30.
- Management and Professional staff will arrive from Kuruman, Kathu and Johannesburg via the R31 and R380.
- Semi-skilled and unskilled labour will arrive from the nearby residential areas of Hotazel, Tsineng, Mothibistad and Kuruman accessing the site via the R31, D3463 and Boardman Rd.
- A minibus taxi (MBT) carries maximum 15 passengers and a standard bus carries maximum 55 passengers

Table 4-2: Trip Generation during Mine Operations

Occupation Levels	Total per day	Total per shift	Private Vehicle	Public Transport	Total Peak Hour Trips
Top management	3	Work normal office hours	100 %	0 %	3
Senior management	4	Work normal office hours	100 %	0 %	4
Professionally qualified and experienced specialists and mid-management	10	Work normal office hours	100 %	0 %	10
Skilled technical and academically qualified workers, junior management, supervisors, foremen and superintendents	45	23	65 %	35 % (100% MBT)	15 car trips 1 MBT

Occupation Levels	Total per day	Total per shift	Private Vehicle	Public Transport	Total Peak Hour Trips
Semi-skilled and discretionary decision-making	50	25	0 %	100 % (50% MBT, 50% Bus)	2 MBT 1 Bus
Unskilled and defined decision-making	65	33	0 %	100 % (15% Walk, 40% MBT, 45% Bus)	5 Walk Trips 2 MBT 1 Bus
Total	**177**	**81**			**39**

The generated trips will have an impact on the surrounding road network as shown in Figure 4-5 below.

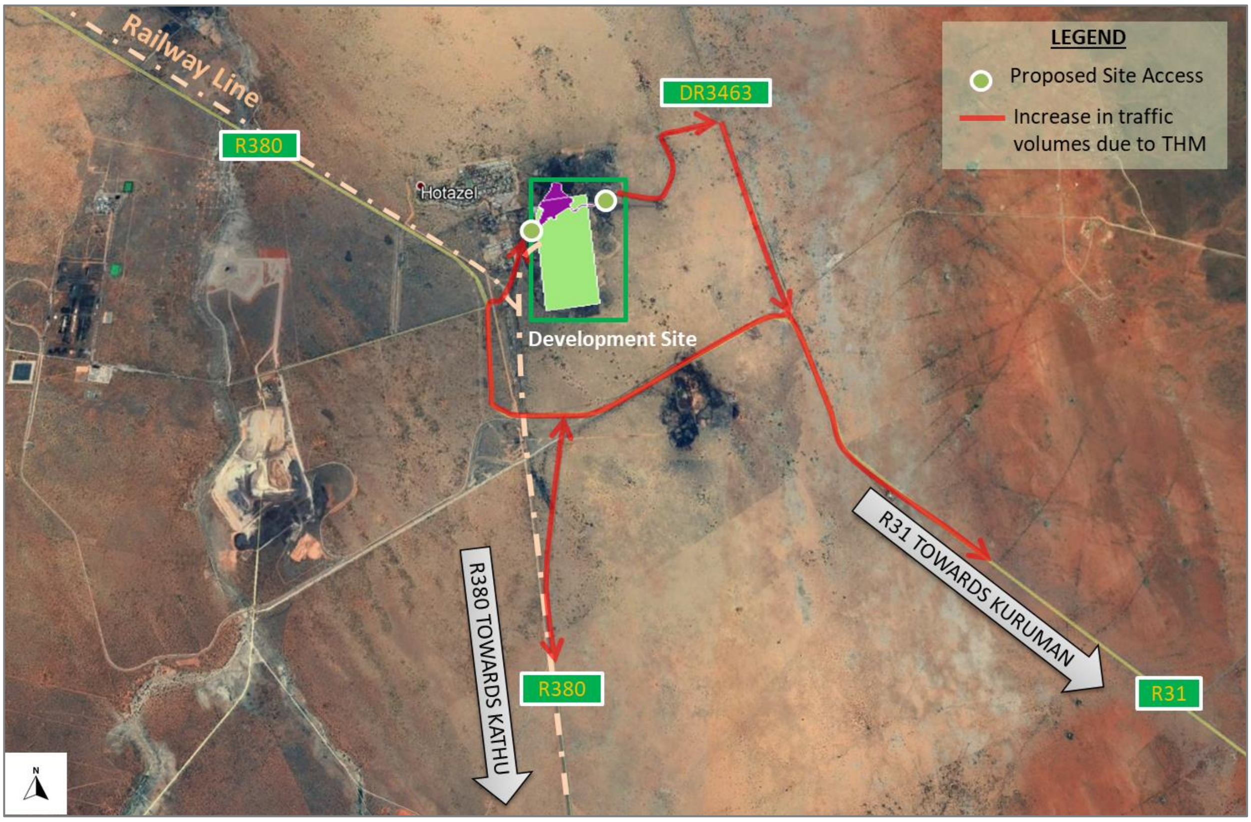


Figure 4-5: Trip increases on the road network

Including 10 heavy vehicles trips transporting materials to Lohatla, an estimated total of **49 trips/hour** can be expected to arrive/depart at the mine during the morning and afternoon peak hours. These trips were subsequently distributed to the road network as shown in Figure 4-6 and Figure 4-7 below.

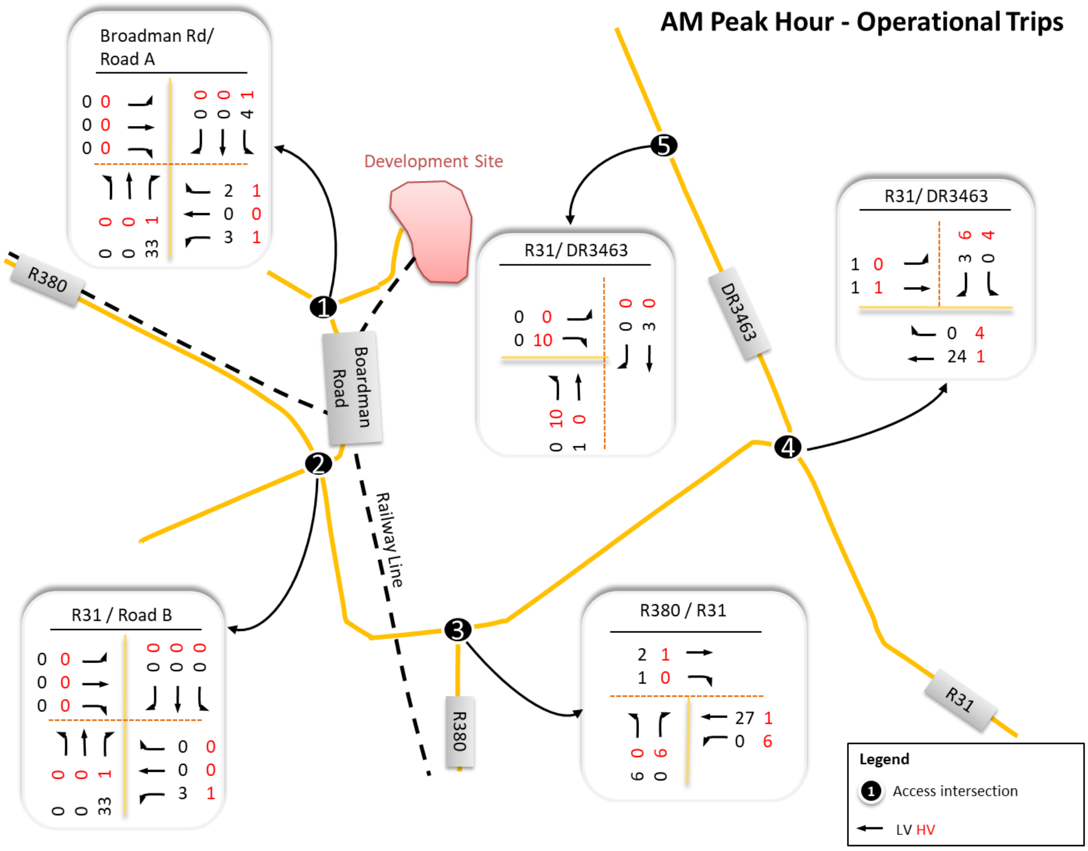


Figure 4-6: Distribution of operational phase trips - AM Peak Hour

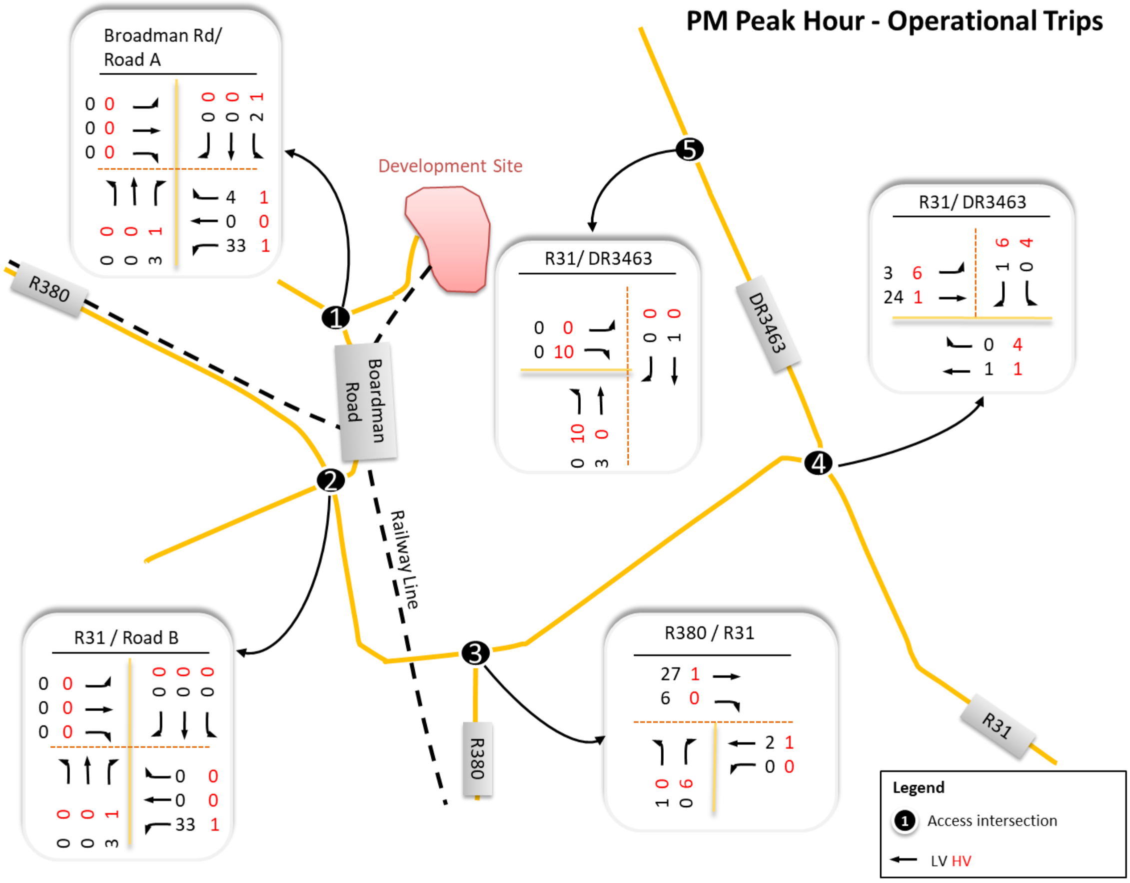


Figure 4-7: Distribution of operational phase trips - PM Peak Hour

4.3.3 Capacity Evaluation

To evaluate the capacity of impacted road intersections to process the additional trips, the base year SIDRA models were updated with new traffic volumes and the operational traffic added to the AM and PM traffic volumes.

The opening year of the mine was considered as 2024 and traffic growth was estimated based on the GDP trend of the past 10 years as shown in Figure 4-8 below. The GDP growth average is 0.9% and background traffic was conservatively grown at 1.0% to project 2024 volumes.

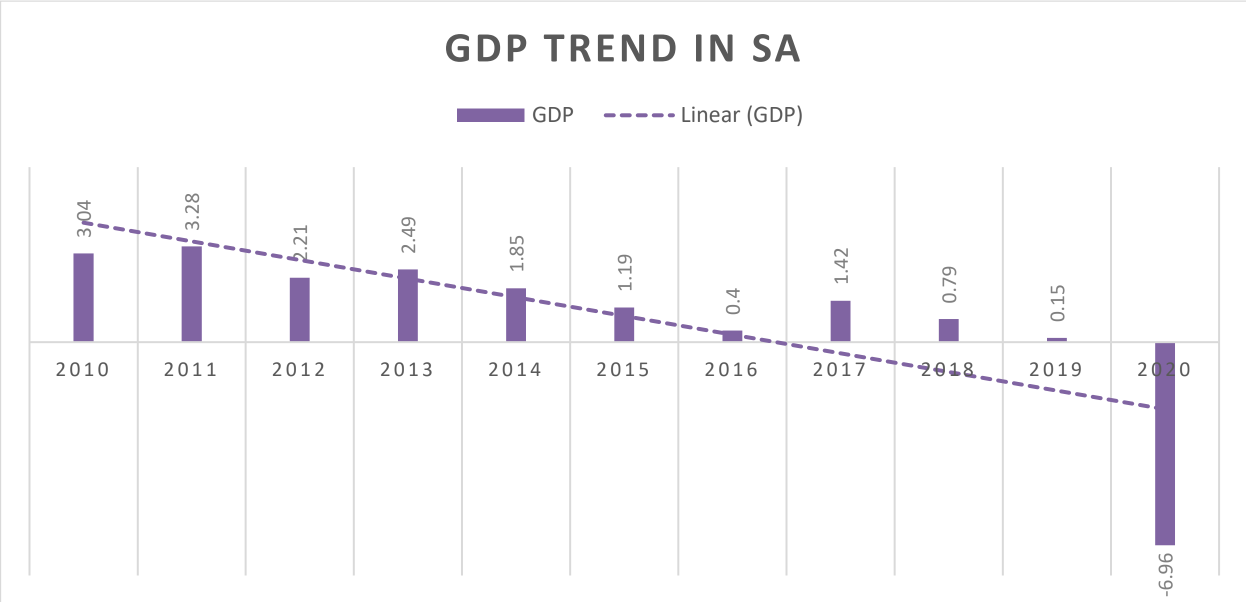


Figure 4-8: Average GDP Growth in South Africa

The results from the SIDRA modelling are shown in Table 4-3 below.

Table 4-3: Opening Year 2024 - SIDRA Capacity Analysis

SITE ID	INTERSECTION	Peak Period	OPERATIONAL CONDITIONS							
				Approach				Intersection		
			Approach	Demand	V/C	Delay	LOS	V/C	Delay	LOS
1	Boardman Rd. and Road A	AM	South	103	0.139	12.2	B	0.20	14.6	B
			East	17	0.077	24.9	C			
			North	113	0.135	10.7	B			
			West	13	0.203	39.4	E			
		PM	South	38	0.049	10.7	B	0.117	12.4	B
			East	53	0.117	15.3	C			
			North	58	0.075	10.8	B			
			West	5	0.01	13.6	B			
2	R31 and Road B	AM	South	535	0.2	1.7	A	0.20	3.5	A
			East	51	0.054	9	A			
			North	95	0.031	2.8	A			
			West	42	0.183	22.2	C			
		PM	South	138	0.058	1.4	A	0.288	5.3	A
			East	159	0.2	10.3	B			
			North	303	0.153	0.4	A			
			West	104	0.288	17.1	C			
3	R31 and R380	AM	South	180	0.379	15.9	C	0.38	4.6	A
			East	579	0.216	1.7	A			
			West	206	0.092	2.9	A			
		PM	South	182	0.49	21.9	C	0.49	6.3	A
			East	117	0.051	1.2	A			
			West	480	0.193	1.6	A			
4	R31 and DR3463	AM	East	467	0.403	8.9	A	0.40	8.8	A
			South	130	0.076	5.7	A			
			West	199	204	10.6	B			
		PM	East	102	0.075	9.6	A	0.358	8.8	A
			South	60	0.038	5.9	A			
			West	492	0.358	9	A			

4.3.4 Discussion of Opening Year Results

The intersections were found to operate as follows:

5. Site 1: Broadman Rd. & Road A I/S

   The four-way stop controlled intersection operates well within capacity at LOS B during the AM and PM peak hours. During the AM peak, the right turning vehicles on the western approach will experience some delay due to increased turning volumes towards THM, however, the demand on this approach does not warrant any improvements.

6. Site 2: R31 & Road B I/S

   The two-way stop-controlled intersection has a generous geometric design with left turn slip lanes along the major road (R31). The I/S has adequate capacity to process additional trips and operates satisfactorily during both the AM and PM peak hours at LOS A.

7. Site 3: R31 & R380 I/S

   The intersection of the two provincial roads has adequate capacity to process additional traffic volumes operating at satisfactory LOS A during the AM and PM peak hours. The approach on R380 operates at a slightly low LOS C which is attributed to the significant queue of heavy vehicles on this approach.

8. Site 4: R31 & DR3463 I/S

   The intersection operates well within capacity at LOS A during the AM and PM peak hours.

4.3.5 Recommended Upgrades

The identified critical intersections have adequate capacity to process current and future traffic volumes generated by the proposed THM development. Additional traffic volumes will be adequately and safely processed on the surrounding road network. No capacity improvements are triggered.

4.4 Decommissioning Phase Traffic

The mine is expected to continue ore extraction for the next 30 years. Once this activity comes to an end, the mine will be rehabilitated, decommissioned and closed. During rehabilitation, a few trucks can be expected to operate to/from site, related to vegetation watering and monitoring, including maintenance.

From a transport perspective, the rehabilitation and decommissioning phase will have minimal impact on the road network.

5 ASSESSMENT OF IMPACTS

5.1 Impact Rating

The following risk assessment model will be used for determination of the significance of impacts.

SIGNIFICANCE = (MAGNITUDE + DURATION + SCALE) x PROBABILITY

The maximum potential value for significance of an impact is 100 points. Environmental impacts can therefore be rated as high, medium or low significance on the following basis:

- High environmental significance 60 – 100 points
- Medium environmental significance 30 – 59 points
- Low environmental significance 0 – 29 points

Table 5-1: Scale used to determine overall ranking Environment Impact

Magnitude (M)	Duration (D)
10 – Very high (or unknown)	5 – Permanent
8 – High	4 – Long-term (ceases at the end of operation)
6 – Moderate	3 – Medium-term (5-15 years)
4 – Low	2 – Short-term (0-5 years)
2 - Minor	1 - Immediate
Scale (S)	**Probability (P)**
5 – International	5 – Definite (or unknown)
4 – National	4 – High probability
3 – Regional	3 – Medium probability
2 – Local	2 – Low probability
1 – Site	1 – Improbable
0 – None	0 – None

5.2 Potential Transport Impacts

The following likely transport impacts related to the construction and operational phases of the development have been identified:

5.2.1 Road and Intersection Capacity due to additional traffic loading

Construction Phase: The development will generate an additional 59 trips/hr along the R31 and Boardman Road during the peak hours. The existing road network has capacity to process these additional trips.

Operational Phase: The development will generate an additional 49 trips/hr, along the R31 and Boardman Road during the peak hours. The existing road network has capacity to process these additional trips.

The average car produces 6 tons of CO_2 emissions per year. The impact of an additional 49 vehicles to the network for the duration of the operations will therefore produce 294 tons of CO_2.

5.2.2 Pavement Condition

Heavy vehicles can be expected to travel to the site utilising the R31, R380 and DR3463 during the construction period. This this will be for a short duration and thus impact to the pavement on the surrounding road network will be minor.

The overall pavement condition on road DR3463 is in fair condition, while the pavement condition can be considered as poor on the R31. As a national road, the maintenance and rehabilitation of the R31 is the responsibility of the South African National Roads Agency SOC Ltd (SANRAL) and mitigation measures should be developed in conjunction with the road agency.

To this end, the THM Baseline Traffic Study was shared with SANRAL to initiate engagement with the agency regarding their future for the upgrading of the R31, as well as to assess the impact of additional heavy vehicles from the proposed mining activity. Feedback had not been obtained from SANRAL at the time of publishing this report.

It is recommended that SANRAL be registered as a commenting authority on the TIA.

5.2.3 Dust Generation

The proposed main entrance access road to the mining development (near Hotazel) appears to be a stabilised road with some dust palliative in place. The most common stabilising agent used in road construction is cement and this may be verified during construction.

The surface condition of all existing access roads is likely to deteriorate over time during construction and operation of the mining development, causing dust pollution and thus dust mitigation strategies may be required. Abatement strategies for dust pollution include wetting the topsoil of the road by spraying water at regular intervals and/or adding gravel to the top layer of soil to create a hard surface amongst other measures.

In addition, the extraction of mineral ore using specialized heavy equipment and machinery will result in emissions of fugitive dust from haul roads and this dust generation should be managed by spraying water.

5.2.4 Noise Pollution

Construction vehicles generate noise both while on the road and during operation on site. The noise levels of most earthmoving and material handling equipment are greater than 85 dB. Although noise levels drop quickly with distance from the source, the development is located adjacent the town of Hotazel with residential properties being within a 1 km radius of the mining site. The impact of noise on the environment is therefore considered low and may require some abatement strategies, such as restricted travel during night-time conditions.

5.2.5 Disturbance to Fauna and Flora

The proposed heavy vehicle access road connecting to road DR3463 will be widened at identified sections and will result in the removal of vegetation and trees. This will result in the disturbance and fragmentation of natural fauna and flora which should be mitigated by limiting vegetation clearing to the necessary area of construction of the access road and after construction disturbed areas should be replanted with native trees, shrubs and herbaceous plants. This will compensate for impacts.

5.2.6 Reduced Road Safety

Specific causes of negative effects foreseen in terms of road safety include abnormal loads delivering mining equipment, increased visitor traffic, and increased heavy vehicle traffic. Negative effects will include reduced visibility due to dust, and reduced driving comfort due to increased potholes and pavement rutting. These effects are caused mainly by the access roads not having an all-weather hard surface.

The extent of the road safety impact will be low due to relatively low volumes of heavy and abnormal loads, stretched out over a long period during construction and operations. The significance of incidents may however range from damage to fatality and therefore some mitigation measures ought to be considered.

Abatement measures to improve road safety conditions for all include:

- Limiting heavy deliveries to daytime to avoid the risk of collision due to poor sight.
- Limiting abnormal loads to daytime and dry weather, providing escort, and applying stop-go control at locations of restricted road width will largely avoid the risk of collision in these instances.
- Regular grading of the road surface of the main access road will improve road safety and driver comfort.

5.3 Impact Assessment

The rating of each impact before mitigation measures is provided in Table 5-2 below.

Table 5-2: Impact Assessment - Construction Phase

Receptor / Resource	Process / Activity	Environmental Impact	Effect of Impact	Magnitude (M)	Duration (D)	Scale (S)	Probability (P)	Significance		Mitigation and Measurement Measures	Impact Monitoring	
								Value	Rating		Monitoring	Time frame for monitoring
1. Capacity on the road network and CO_2 emissions	Additional vehicle trips generated by activity at the new development	Traffic congestion and increased CO_2 emissions.	Negative Impact	2	4	2	2	24	Low	Encourage the use of public transport by staff to reduce trips and emissions.	Monitoring of queue lengths at the access intersection to ensure improvements are effectual	Monthly monitoring during construction and quarterly during operations.
2. Pavement Condition	Increase in heavy vehicles volumes during the construction and operational phases	Deterioration in pavement quality resulting in unsafe driving conditions.	Negative Impact	2	2	2	3	18	Low	Trucks should not be overloaded, and wheel/axle loading should be in accordance with legislation (TMH3).	Monitoring of truck loading for compliance	Monthly monitoring during construction. Daily monitoring during operations.
3. Dust Pollution	Increase in vehicle volumes along access road to the main entrance (gravel road)	Dust pollution to residential properties adjacent to access road.	Negative Impact	4	3	2	3	27	Low	• Reducing the speed limit to lower the amount of dust generated by moving vehicles. • Adding a gravel layer to the road. • Installing a permeable paver to lock the gravel in place and prevent pulverisation of the rock overtime.	Monitoring of dust levels along the main entrance access road.	Daily monitoring during the construction phase.
4. Noise Pollution	Transportation of materials and supplies by heavy vehicles during the construction phase	Noise pollution to nearby residential areas within earshot.	Negative Impact	4	2	2	3	24	Low	• Notify persons likely to be affected. • Work within normal work hours as far as possible	Monitoring of complaints laid by affected persons.	Monthly monitoring during construction.
5. Disturbance to Fauna & Flora	Removal of vegetation and trees for widening of heavy vehicle access road	Fragmentation of habitat for native fauna and flora	Negative Impact	4	2	1	5	35	Medium	• Limit vegetation clearing to what is necessary for widening access road • Revegetation of disturbed areas with native trees, shrubs and herbaceous plants	None.	

6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the study:

1) The proposed Tawana Hotazel Mine covers portions of two farms within the Joe Morolong Local Municipality (JMLM) in the Northern Cape Province; namely, Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel.
2) The site is well-located in terms of road infrastructure, being located adjacent to the major mobility north-south and east-west roads in the area namely R380 and R31.
3) The site has a railway line running adjacent to it; however, the line is decommissioned and during the operational phase, ore extracted from the opencast mine will be transported on road to Lohatla for rail loading.
4) The THM site will therefore be accessed via road only by construction vehicles during the construction phase and by employees and heavy vehicles during the operational phase. The main access to the site will be via Boardman Road and a secondary access from road DR3463.
5) The development will generate an additional 59 trips/hr and 49 trips/hr for the Construction and Operational phases respectively, and the surrounding road network infrastructure has capacity to process the additional traffic volumes safely and efficiently.

The following recommendations are made:

1) Improvement of sight distance at the intersection of R31 and DR3463 through complete removal of trees and grass in the vicinity of the intersection. This will provide for safe turning movement of heavy vehicles at this intersection.
2) Improvement of sight distance at the intersection of R31 and R380 through complete removal of trees and grass in the vicinity of the intersection. This will provide for safe turning movement of heavy vehicles at this intersection.
3) Upgrading of the proposed Main Entrance access road connecting to Boardman Rd. as follows:
    i. Surfacing of road (this will also address dust generation impacts)
    ii. Provision of sidewalks and a taxi layby
4) Implementation of the proposed mitigation and monitoring measures for CO_2 emissions, pavement condition, dust generation, noise generation and disturbance to fauna and flora.
5) Improvement of road safety through:
    a. Limiting heavy deliveries to daytime.
    b. Limiting abnormal loads to daytime and dry weather, providing escort, and applying stop-go control at locations of restricted road width.
    c. Regular grading of the road surface of the access roads.

All other environmental impacts due to traffic generation are considered minor and it is recommended that the THM proceed with development from a Traffic Engineering Perspective.

7 REFERENCES

COTO, 2012. *THM 16 Volume 1: South African Traffic Impact and Site Traffic Assessment Manual.* Vol 1 ed. Pretoria: SANRAL.

COTO, 2012. *TMH 16 Volume 2: South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual.* Vol 2 ed. Pretoria: SANRAL.

The South African National Roads Agency SOC Limited, 2013. *Drainage Manual.* 6th ed. Pretoria: SANRAL.

Declaration of Independence by Specialist

I, Rochelle Rajasakran, in my capacity as a specialist consultant, hereby declare that I –

- act as an independent specialist;
  Where **"independent"** in relation **a specialist** means the following, as defined in GN982 of 2014 (*as amended*):
  - (a) that such EAP, **specialist** or person has no business, financial, personal or other interest in the activity or application in respect of which that EAP, specialist or person is appointed in terms of these Regulations; or
  - (b) that there are no circumstances that may compromise the objectivity of that EAP, specialist or person in performing such work;

  excluding -
  - (i) normal remuneration for a specialist permanently employed by the EAP; or
  - (ii) fair remuneration for work performed in connection with that activity, application or environmental audit;
- will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability; and
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.

Signature of the Specialist

Merchelles Collective (Pty) Ltd

Name of Company:

25/08/2021

Date

APPENDIX 20

GEOCHEMICAL ASSESSMENT

Prime Resources (Pty) Ltd
The Workshop 70–7th Avenue Parktown North 2193
PO Box 2316 Parklands 2121
T +27 11 447 4888 **F** +27 86 604 2219 **E** prime@resources.co.za
www.resources.co.za

prime | resources
environmental
consultants

TAWANA HOTAZEL MINING (PTY) LTD

GEOCHEMICAL ASSESSMENT FOR MINING- AND RELATED ACTIVITIES ASSOCIATED WITH THE PROPOSED TAWANA HOTAZEL MINE, NORTHERN CAPE PROVINCE

JUNE 2021

PREPARED FOR:

Tawana Hotazel
Mining

Tawana Hotazel Mining (Pty) Ltd
PO Box 48477
Roosevelt Park
South Africa

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ACRONYMS

ABA	Acid-base Accounting
ARD	Acid Rock Drainage
AP	Acid Potential (acid generating potential)
ASTM	American Society for Testing and Materials
EHS	Environmental Health and Safety
GARD	Global Acid Rock Drainage
IFC	International Finance Corporation
INAP	International Network for Acid Prevention
MEND	Mine Environment Neutral Drainage
MPC	Maximum Permissible Concentrations
NAG	Net Acid Generation
NP	Neutralising Potential
NNP	Net Neutralising Potential
NPR	Neutralising Potential Ratio
PAG	Potentially acid generating
SANAS	South African National Accreditation System
THM	Tawana Hotazel Mine
XRD	X-Ray Diffraction
WB	World Bank

1. INTRODUCTION

1.1 Background

Tawana Hotazel Mining (Pty) Ltd seeks to develop an opencast mine targeting primarily manganese ore in the Northern Cape province of South Africa.

The area under application for the proposed Tawana Hotazel Mine (THM) covers portions of the farms Hotazel 280 and York 279 within the Joe Morolong Local Municipality in the Northern Cape Province and is located approximately 1 km south-east of the town of Hotazel (Figure 1). The THM largely incorporates the historical Hotazel Manganese Mine (HMM), including the flooded residual opencast void, surface dumps of low-grade material and the mothballed processing plant and rail loadout facility. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore.

The target minerals applied for in the Mining Right include iron and iron-bearing minerals including hematite, goethite, specularite and limonite and manganese and manganese bearing minerals. Opencast mining methods will be utilised. Proposed surface infrastructure includes the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure.

1.2 Legislative Background

Mine residue material (residue stockpiles and residue deposits) is defined in the Mineral and Petroleum Resources Development Act, No. 28 of 2002 (MPRDA) as *any debris, discard, tailings, slimes, screening, slurry, waste rock, foundry sand, beneficiation plant waste, ash or any other product derived from or incidental to a mining operation and which is stockpiled, stored or accumulated for potential re-use, or which is disposed of by the holder of a right*.

According to Schedule 3 to the National Environmental Management: Waste Act, No. 59 of 2008 (NEMWA) mine residue material is classified as a hazardous waste. As such, Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits were published in GNR 632 of 2015 in terms of Section 69(1)(iA) of NEMWA. These regulations were amended in September 2018 by GN990, before which mining residue was classified and disposed of in line with the Waste Classification and Management Regulations (GNR 634 of 2013) and the National Norms and Standards (GNR 635 and GNR 636 of 2013).

The handling and disposal of mine residue material is considered a water use in terms of Section 21G of the National Water Act, No. 36 of 1998 (NWA) "disposing of waste in a manner which may detrimentally impact on a water resource". Regulations on the Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources were published in GN704 of 1999 in terms of Section 26 of the NWA.

The proposed backfilling of mine residue material at THM (the overburden material and waste from the crushing and screening process) into the opencast pit void requires that exemption from the provisions of GN704 prohibiting the *placement or disposal of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation* is sought.

Finally, GN704 (read with Section 21G of the NWA) places onus on the person in control of a mine or activity to manage contaminated water arising (such as from seepage from mining outcrops, workings or as a result of runoff from residue material or ore stockpiles) in such a way that it does not result in the pollution of clean water or the environment.

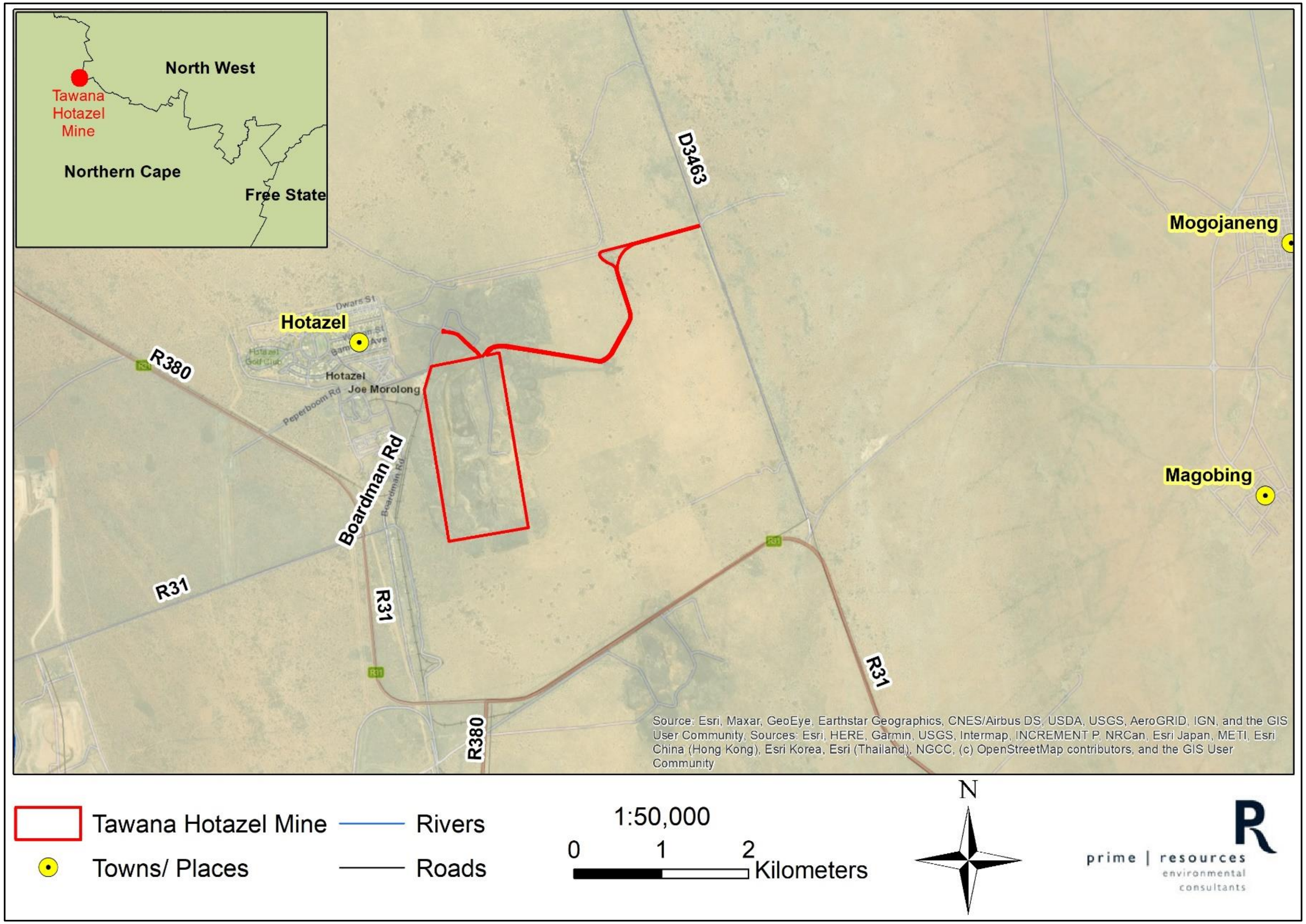


Figure 1: THM location

1.3 Study Objectives

The need to undertake a geochemical assessment for the THM was identified during the preliminary phases of the project in order to inform the strategy regarding residue handling and disposal on-site-, integrated waste and water management, as well as to provide inputs for the hydrogeological mass transport model.

The objectives of this geochemical study are to:

- Identify potential pollutants (e.g. anions, metals and metalloids) associated with the mine residue material (i.e. waste rock / overburden) and ore material; to assess the metal-leaching and acid-generating and/or neutralising potential of these materials;
- Characterise the liberation and mobilisation of identified pollutants according to criteria presented in the Waste Classification and Management Regulations and associated National Norms and Standards (GNR 634 - 636 of 2013) read in the context of the GNR 632 Regulations regarding residue planning and management;
- Following a risk-based approach, provide recommendations for the management of residue materials arising at the THM for consideration in the design of any potential barrier requirements (as per local and international standards), mitigation measures, monitoring requirements and considerations for closure and rehabilitation;
- Characterize impounded water in the historic mine void in order to inform options for the management thereof.

The deliverable of this work is a report addressing the outcomes of the various objectives discussed above (this document).

1.4 Study Metholodogy

The scope of this assessment was conducted in alignment with the following guidance documents:

- NEMWA and associated regulations GNR 632 of 2015 (as amended in 2018)-; and the Waste Classification and Management Regulations and associated Norms and Standards (GNR 634 – 636 of 2013);
- Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries (European Commission, 2018);
- Global Acid Rock Drainage (GARD) Guide (INAP, 2012)
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND report (Price, 2009)
- Technical Document: Acid Mine Drainage Prediction (US EPA, 1994)
- International Finance Corporation- World Bank Series (IFC-WB) Environmental, Health and Safety (EHS) Guidelines for Mining

The simplified methodology for the assessment of the waste rock and ore was as follows:

- **Review** of relevant and available geological / chemical information; review of analyses undertaken to-date; verification of environmental legislative and best practice requirements;
- **Sampling:** Lithological units were identified through a review of the Mining Work Programme to be submitted with the Mining Right Application and in consultation with the project geologist. Rock samples which were to be collected on-site were discussed with the appointed geohydrologist and additional samples where necessary were included into the sample selection. Sampling was then undertaken by the geohydrology team (refer to Section 3 for further information).
- **Analytical test work:** Geochemical analyses were conducted by Waterlab (Pty) Ltd. Analyses of the rock samples included acid-regia digestion and analyses by inductively coupled plasma mass spectrometry (ICP-MS) and optical emission spectrometry (ICP-OES) for determination of total elemental composition; Synthetic Precipitation Leaching Procedure (SPLP) at 1:20 solid to liquid ratio; Acid-Base Accounting (ABA) and sulphur speciation. Further analyses of the two composite waste samples included 1:4 distilled water leach tests and x-ray diffraction for mineralogical determination (refer to Section 4 for analytical test work and Section 5 for geochemical results).
- **Characterisation and waste classification** according to local standards (refer to Sections 5 and 5.4.2). Results were also compared to international standards where applicable.
- **Geochemical summary and recommendations** for appropriate management and mitigation techniques and barrier requirements for the residue impoundments were made (refer to Section 7).

Geochemical modelling was undertaken in order to understand the suite of solid evaporite / efflorescent minerals and evolving brine water chemistry that could potentially result during the mechanical evaporation of water impounded in the historical pit void “pit water” (should such management option be elected). The simplified methodology for the geochemical modelling included:

- **Data review** of the available pit water quality (refer to Section 6.1);
- **Speciation-solubility modelling** of the solution undertaken with Geochemist’s Workbench SpecE8 software;
- **Evaporation modelling** of 1000 kg of solution undertaken with Geochemist’s Workbench React software;
- **Discussion and Recommendations** of the outcomes of the modelling and their implications for water management on site.

1.5 Qualifications

Prime Resources (Pty) Ltd (Prime Resources) is a specialist environmental consulting firm providing environmental, social, and related services, which was established in 2003. Prime Resources was founded by Peter Theron (PrEng, SAIMM), the Managing Director and Principal Environmental- and Civil Engineer of the firm. Peter has a GDE Environmental Engineering from the University of Witwatersrand and over 30 years’ experience in the field of environmental science and engineering.

Dr Bronwyn Grover is a Senior Environmental Geochemist and SACANSP registered scientist (Environmental Science, 116334). She has a PhD in Environmental Analytical Chemistry from the University of the Witwatersrand and five years' experience in the field of geochemistry and environmental science. Her recent projects includes the characterising and assessing the impacts of mine residue stockpiles on surface and ground water systems, water monitoring, contaminated land assessments, soil and land capability studies.

Jonathan van de Wouw (BSc Hons) is a Principal Environmental Consultant and Registered EAP (EAPASA Reg No 2019/909) with thirteen years' experience managing projects in the mining and industrial sectors, including financial liability assessments associated with mine closure and rehabilitation, mine waste and water management planning, environmental impact assessments and management planning and environmental auditing. He also has a detailed knowledge of environmental law and precedents, both locally and internationally.

2. PROJECT CHARACTERISATION

2.1 Climate

The Northern Cape is generally considered to be hot and dry. Maximum summer temperatures often exceed 40°C. During winter, the average daytime temperatures are mild and night time temperatures may drop below 0°C. The town of Hotazel is classed as a cold semi-arid area (THM Scoping Report, 2021).

The project area is located within the summer rainfall region of South Africa, in which more than 80 % of the annual rainfall occurs from October to April. The winter months are dry even through the relative humidity is greater during the winter period than other seasons. Dust can be generated by strong winds that accompany storms. This dust generally occurs in areas with dry soils and sparse vegetation.

2.2 Geology

The project area is located on the relatively young Kalahari Group (Figure 2). The Karoo Supergroup, Olifantshoek Supergroup and Postmasburg Group of the Griqualand West Basin sequence of the Transvaal Supergroup underly the larger regional area.

The base of the sequence in the area is formed by the andesite lavas of the Ongeluk Formation of the Postmasburg Group. The Hotazel Formation (Postmasburg Group) overlies the lava and consists of 40 – 100 m thick jaspillites (banded ironstone) and inferred volcanic-exhalative manganese deposits. The Kalahari Manganese Field is situated in the Hotazel Formation, located within the Kuruman district. The THM area is in the northern portion of the Kalahari Manganese Field.

The Hotazel formation is overlain by a sequence of shales and quartzites of the Mapedi Formation (Olifantshoek Supergroup). Glacial sediments of the Dwyka Formation (Karoo Supergroup) occur in the regional area occupying the NE – SW trending glacial valleys. The Mapedi Formation is overlain by the recent Kalahari Group consisting of a series of aeolian sands, clays, and gravels.

According to the Mining Work Programme for THM, exploration drilling at the project intersected, from top to bottom, the Kalahari Group, Hotazel and Ongeluk Formations. The Kalahari Group is up to 23m thick and consists of a sequence of sand, calcrete, red clay and gravel units. The Hotazel Formation consists of a banded iron formation unit interlayered with manganese layers. All three manganese units (Upper Body, Middle Body and Lower Body) are present. The Hotazel Formation overlies a pillow lava basement of the Ongeluk Formation. The THM area is unique in that both ore types of the Kalahari Manganese field appear to be present (i.e., a higher grade oxide ore and a lower grade carbonaceous ore).

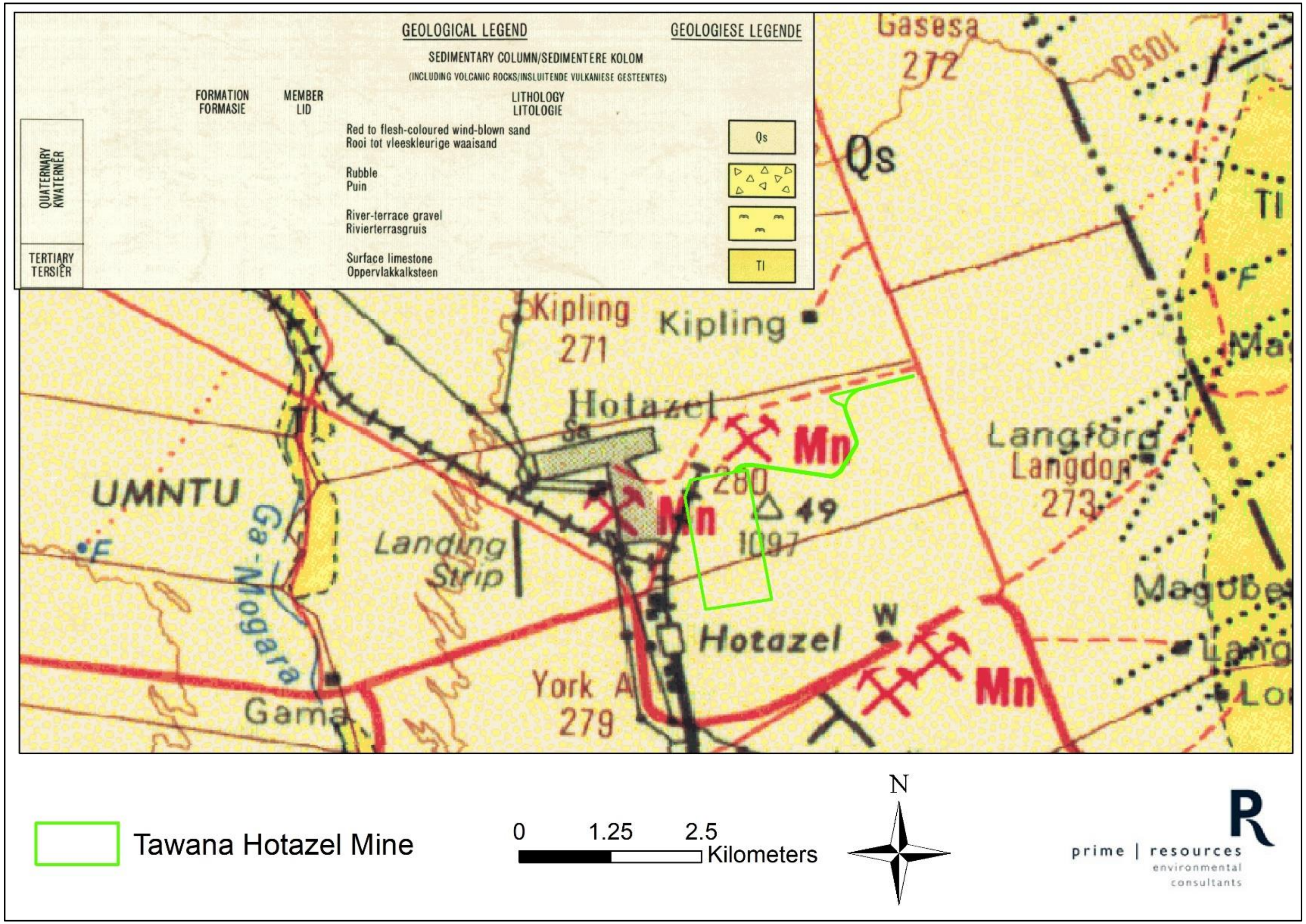


Figure 2: Surface geology of the study area

2.3 Water Resources

Information regarding water resources has been adapted from the Scoping Report for the THM project compiled by Prime Resources (2021). In terms of surface water resources, THM is located within the newly revised Vaal Water Management Area within Quaternary Catchment D41K, within the Molopo River catchment. The THM area does not support any rivers or streams within the boundaries of the project area. The closest rivers are the Gamagara River (5 km west) and the Kuruman River (10 km north). The Gamagara River confluences with the Kuruman River to the north of THM, which eventually joins the Molopo River further downstream to the west.

In terms of groundwater resources, three aquifer systems occur in the regional area. These aquifers are associated with:

- The primary sandy gravel material
  - The aquifer is formed by vertical infiltration of recharging rainfall through the primary sandy gravel material being retarded by the lower permeability of the underlying competent rock. In the region this aquifer ranges between 3 and 10 m in thickness.
  - Expected to be dry for large portions of the year.
- The fractured rock and leached banded iron formation aquifer
  - Although the lower permeability of the competent rock material will retard vertical infiltration of groundwater, some of the water in the upper aquifer will recharge the lower aquifer through faults and fractures.
  - Groundwater flows and contaminant transport will be along discrete pathways associated with the fractures. These are not high-yielding aquifers.
- The dolomitic aquifers of the Griqualand West Sequence.
  - The dolomitic karst aquifer in the region is well known for its high potential.
  - Based on the general constant high competence and absence of indications of karstic dolomite, the likelihood of intercepting karstic dolomite at the THM is considered to be very low.

The aquifers present in the area are classified as minor aquifers. The aquifers are of high importance to the local landowners outside of Hotazel town as it is their only source of water for domestic, gardening, and agricultural purposes.

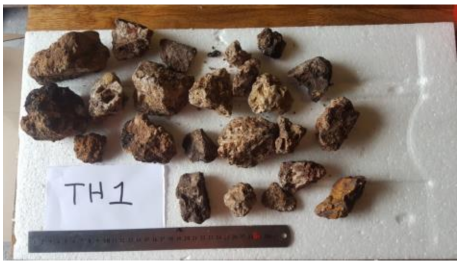
3. SAMPLING

Lithological units were identified through a review of data presented in the Mining Work Programme and in discussion with the project geologist. Rock samples to be collected on-site were discussed with the appointed geohydrologist and additional samples were included into the sample selection where necessary. Sampling was undertaken by the geohydrology team during the groundwater hydrocensus fieldwork. Each sample was comprised of 3 to 5 sub-samples representing the lithology identified in the review. Table 1 summarises the samples that were collected on-site (not all lithological units identified in the review process were available for sampling).

The samples collected are considered to be representative of the waste rock (TH 1, 2, 7) that will be excavated, stockpiled and backfilled into the opencast void (residual stockpiles from historic mining activities are also represented); and ore material (TH 5 and 6) that will be crushed, screened and stockpiled for sale. Samples are also representative of fine material that could be dispersed by wind from stockpiles (TH 8).

Samples of the Ongeluk lava and dyke intrusions were not available for sampling as it is understood that, when encountered, this material was sold to aggregate producers. The Ongeluk lava forms the base of the geological series and would not be excavated in significant quantities, therefore it was not a significant portion of waste rock at the historical workings and will contribute only a low percentage of total waste rock at the operations in the future. The dyke intrusion was intercepted to the north of the historical pit and is considered unlikely to contribute significantly to waste rock volume in the future.

Table 1: Lithologies identified in review and samples collected on site, February 2021

SAMPLE NAME	IMAGE	DESCRIPTION
TH 1		Calcrete composite sample (waste rock)
TH 2		Banded ironstone composite sample (waste rock)
TH 3	No sample	Ongeluk lavas. Basal rock. No stockpiles present on-site (excavated material used to

SAMPLE NAME	IMAGE	DESCRIPTION
		be provided to aggregate company). Drilling usually stops when the lava is intersected.
TH 4	No sample	Dyke. The dyke intrusion is only intercepted north of the pit. No stockpiles present on-site (excavated material used to be provided to aggregate company).
TH 5		High grade Mn ore. Sampled at the old plant.
TH 6		Low grade Mn ore. Sampled from historic waste rock.
TH 7		Composite sample of surface waste rock. BIF, calcrete and quartzite.
TH 8		Composite sample of fine material. Appears to have been screened or windblown. Occurs on the roads on the site. Comprised of BIF and manganese.

4. ANALYTICAL TESTWORK

As required by the IFC-WB EHS Guidelines, mining operations should prepare and implement ore and waste geochemical characterization methods for proper routing of potentially acid generating (PAG) and metal leaching materials and waste management programs.

Samples were analysed by Waterlab (Pty) Ltd (SANAS accredited, T0391) in Pretoria, South Africa. Analyses were undertaken in accordance with the relevant requirements of the NEMWA Waste Classification and Management Regulations.

Geochemical analyses of all samples included:

- Acid Digestion (HNO_3 and HF) and total elemental analyses by ICP-MS.
- Acid-Base Accounting (ABA) including total sulphur analyses and neutralisation potential. Following review of the preliminary data received from the lab, it was concluded that it was not necessary to undertake further net-acid generation testing due to low sulphide abundances and significant neutralisation potential.
- Synthetic Precipitation Leachate Procedure (SPLP) for determination of leachable metals at a ratio of 1:20. The standard waste classification procedure utilises reagent water. The SPLP procedure utilises a mildly acidic solution to better represent rainwater interaction with the material. The SPLP leaching solution is anticipated to leach slightly higher concentrations of the soluble metal fraction and is therefore considered a more conservative test than reagent water in assessing the metal leaching potential of the material.

Further geochemical characterisation of the composite samples TH 7 (waste rock) and TH 8 (fines) included:

- Qualitative X-Ray diffraction (XRD) to confirm mineralogy.
- Water soluble fraction leach testing at a ratio of 1:4. This testing was undertaken to identify soluble pollutants arising from the composite waste rock that may have been diluted in the 1:20 leach testing and to provide further information for GN 704 exemption motivation.

The results as received from the laboratory are included as Appendix 1 to this report.

5. RESULTS AND DISCUSSION

5.1 Total Elemental Analyses

Whole rock analyses / elemental composition analyses were undertaken to identify elements (metals and metalloids) which are enriched in the waste rock and to identify elements of potential contamination concern.

The Geochemical Abundance Index (GAI) compares the analysed abundance of an element in a sample with the average abundance of that element in a relevant media (INAP, 2012). In order to indicate whether an element is considered enriched, the analyses of the THM rock samples were compared to average upper crust values derived by Rudnick and Gao (2003) (Table 2).

The GAI is calculated as follows, where C_A is the analysed abundance and C_{RG} is the average upper crust value:

$$\mathrm{GAI} = \log_2\left(\frac{\mathrm{C_A}}{1.5\ \times \mathrm{C_{RG}}}\right)$$

A GAI value of 0 indicates the element is present at a concentration similar to, or less than, average upper crust abundance and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above median abundance. As a general guide, a GAI of 2 is considered slightly enriched and a GAI of 3 or above is considered significant and such an enrichment may warrant further examination (INAP, 2012).

The analytical results indicated that the calcrete waste rock sample (TH 1) is not significantly enriched (GAI< 3, Table 2) in any of the analysed metals and metalloids. The BIF waste rock sample (TH 2) was significantly enriched in manganese and slightly enriched (GAI >2) in iron. The composite waste rock sample (TH 7) collected from the surface waste rock piles was significantly enriched in manganese and slightly enriched in boron. The composite fines sample (TH 8) which has been screened and windblown was significantly enriched in manganese and lead and slightly enriched in boron and gallium.

The high grade Mn ore sample (TH 5) was significantly enriched in manganese and lead and slightly enriched in boron and zinc. The low grade Mn ore sample (TH 6) was significantly enriched in manganese and slightly enriched in boron and calcium.

A duplicate analyses was undertaken on the TH 8 sample for quality control purposes. The analytical results of the duplicate did not indicate any significant deviations from the original analyses (Table 2).

The presence of enrichment does not infer that the element presents an environmental risk. The ease with which the element leaches from the material during weathering and remains in solution during transport indicates the risk which an element presents. The leaching potential of these elements is assessed in Section 5.4. The GAI analysis has indicated in particular that the leach potential of manganese, boron, iron, gallium, lead and zinc be further assessed as these elements are enriched in the material.

The total elemental analytical results were also compared to the GN 331 National Norms and Standards for the Remediation of Contaminated Land and Soil Quality (Table 3). This was undertaken in order to guide the potential land uses for the project following rehabilitation:

- The waste rock samples TH 1, 2 and 7, which represent material likely to backfill the pit, exceed the SSV 2 manganese guidelines for standard residential development (TH 1) and commercial development (TH 2 and TH 5). All other metal analytes were within the SSV guidelines for all land uses, including SSV 1 which is protective of water resources.
- The waste rock samples discussed above were selected for the study in order to represent the waste material that is likely to backfill the pit. The samples do not necessarily represent the cover material which will be present nor the final soil quality of the area. Therefore, the final land use should be re-evaluated as part of ongoing closure planning once more information is known regarding the quality of topsoil cover to be used in rehabilitation in order to verify the appropriate land use in terms of soil screening values.
- The ore samples (TH 5 and TH 6) exceeded the SSV 2 commercial development guideline for manganese. The high grade sample, TH 5, also exceeded SSV 1 (protective of water resources) for zinc and the SSV 2 lead guideline for standard residential development. Wind-blown dust arising from the stockpile area may lead to deterioration of the soil resources surrounding the area. Measures for reducing the potential for contamination arising from the ore stockpiles area are included in Section 8.
- The composite sample of the fines material also had manganese abundance which exceeded the SSV 2 for commercial development as well as a lead abundance which exceeded the SSV 2 guideline for informal residential development. The fines material was noted to occur on the road surfaces within the project area.

The total elemental analytical results are further discussed in Section 5.4 when compared to local standards for waste classification.

Table 2: Elemental abundances of the THM rock samples compared to average upper crust

ELEMENTS	SAMPLE (ppm)							AVERAGE UPPER CRUST (ppm)
	TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)	TH8 (DUPLICATE, FINES)	
Al	2590	1025	1212	584	3414	2218	2231	81500
As	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	4,8
B	<4.00	42	123	141	83	117	107	17
Ba	21	87	15	8	97	697	694	628
Be	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	2,1
Ca	28400	14800	17600	79200	72400	28400	28400	17700
Ce	<4.00	4	<4.00	<4.00	<4.00	<4.00	<4.00	63
Co	<4.00	6	14	14	9	28	29	17,3
Cr	5	<4.00	8	<4.00	6	14	14	92
Cs	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	4,9
Cu	<4.00	<4.00	<4.00	<4.00	<4.00	9	9	28
Fe	22000	284000	76400	41200	126800	123200	132400	39200
Ga	<4.00	10	<4.00	<4.00	9	89	86	17,5
K	1876	<200	326	<200	3632	957	916	23200
La	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	31
Li	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	21
Mg	4800	6800	3200	10400	11600	4400	4800	15000
Mn	1780	58400	600000	395600	290000	423600	418400	632
Na	<400	<400	<400	<400	<400	<400	<400	24300
Ni	<4.00	<4.00	6	<4.00	<4.00	8	7	47
P	19	126	91	116	81	213	102	700
Pb	<4.00	39	307	17	39	214	226	17
Rb	4	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	84
Sc	<4.00	<4.00	5	8	<4.00	<4.00	7	14
Si	112000	67200	4017	16400	64400	32400	33600	308000
Sr	7	27	7	4	40	66	65	320
Th	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	10,5
Ti	588	65	93	86	289	229	281	3800
U	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	2,7
V	24	50	18	4	105	54	54	97
Zn	<4.00	30	434	29	24	90	110	67

The following elements were also analysed and found to be below detection of 4 ppm: Au, Ag, Bi, Cd, Dy, Er, Eu, Gd, Ge, Hf, Hg, Ho, In, Ir, Lu, Mo, Os, Nd, Nb, Pd, Pr, Pt, Rh, Ru, Se, Sb, Sm, Sn, Ta, Tb, Te, Tl, Tm, W, Y, Yb, Zr.

LEGEND

- GAI<1 represents <6 times average upper crust (white)
- GAI=2 represents 6 to 12 times average upper crust (green)
- GAI=3 represents 12 to 24 times average upper crust (yellow)
- GAI=4 represents 24 to 48 times average upper crust (orange)
- GAI=5 represents 48 to 96 times average upper crust (red)
- GAI>6 represents more than 96 times average upper crust (purple)

Table 3: Elemental abundances of the THM rock samples compared to soil screening values

ELEMENTS	SAMPLE (mg/kg) TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)	GN 331 SOIL SCREENING VALUES SSV 1 ALL LAND USES	SSV 2 INFORMAL RESIDENTIAL	SSV 2 STANDARD RESIDENTIAL	SSV 2 COMMERCIAL
As	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	5,8	23	48	150
Cd	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	7,5	15	32	260
Co	<4.00	5,8	14,5	13,6	9,2	28,3	300	300	630	5000
Cr	5,4	<4.00	7,8	<4.00	5,6	14,0	46000	46000	96000	790000
Cu	<4.00	<4.00	<4.00	<4.00	<4.00	8,9	16	1100	2300	19000
Pb	<4.00	39	307	17	39	214	20	110	230	1900
Mn	1780	58400	600000	395600	290000	423600	740	740	1500	12000
Hg	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	0,93	0,93	1	6,5
Ni	<4.00	<4.00	5,8	<4.00	<4.00	8,1	91	620	1200	10000
V	24	50	18	4	105	54	150	150	320	2600
Zn	<4.00	30	434	29	24	90	240	9200	19000	150000

5.2 X-Ray Diffraction

Mineralogical determination was undertaken on the two composite waste rock and fines samples (TH 7 and TH 8 respectively).

The major mineralogy (>10%) of the surface waste rock composite sample (TH 7) was comprised of carbonate minerals (calcite, dolomite), quartz, iron hydroxide (hematite) and manganese oxide (cryptomelane and hausmannite). Minor abundances of manganese bearing silicate minerals were noted. Amorphous mineralogy was not quantified. The mineralogy is consistent with the elevated elemental abundance of manganese noted in Section 5.1 as well as the high acid-neutralising capacity of the sample as noted in Section 5.3.

The major mineralogy (>10%) of the fines composite sample (TH 8) was comprised of manganese silicate minerals (neltnerite and braunite) as well as iron and manganese oxide minerals (hematite and hausmannite respectively). Carbonate minerals within the sample accounted for approximately 10%, consistent with the lower acid neutralising potential observed in Section 5.3.

Minerals that were identified as likely to exert a strong influence on the drainage chemistry of leachate arising from the waste rock were:

- Calcite and dolomite (carbonate, neutralising minerals). These minerals are in high abundance in the composite waste rock sample. The absence of acid generating mineralogy in the samples indicates that the drainage will likely be circum-neutral (as observed in Section 5.4).
- Hematite (oxy-hydroxide iron minerals, known to adsorb metals and metalloid onto their reactive surfaces). Similar adsorption abilities have been noted for manganese oxy-hydroxide minerals.
- Silicate minerals (slower to weather than the more reactive minerals discussed above, impacts long term water chemistry).

Potential drainage chemistry is discussed in further detail Section 5.4.

Table 4: XRD results of mineralogical composition of THM waste rock samples

MINERAL	% ABUNDANCE	
	TH 7 (SURFACE WASTE ROCK)	TH 8 (FINES)
Quartz (SiO_2)	16.4	5.3
Calcite ($CaCO_3$)	26.6	8.3
Dolomite ($CaMg(CO_3)_2$)	18.9	2.3
Cryptomelane (KMn_8O_{16})	10.4	3.5
Neltnerite ($CaMn_6(SiO_4) O_8$)	0.5	19.6
Hausmannite (Mn_3O_4)	3.1	19
Braunite ($Mn^{(II)}Mn^{(III)}{}_6O_8 (SiO_4)$)	9.4	20.3
Hematite (Fe_2O_3)	14.8	21.6

5.3 Acid Generating Potential

Acid Rock Drainage (ARD) occurs when materials with acid generating minerals (typically sulphide minerals) in excess of acid neutralizing minerals (principally carbonates) oxidise (in the presence of oxygen or other oxidising agents) and the oxidation products drain into water bodies.

Samples with less than 0.2% sulphide sulphur are generally regarded as having insufficient oxidisable sulphides to sustain long-term acid generation. The THM samples have very low abundances of sulphur (<0.01%, Table 5). Therefore, the samples **have insufficient sulphide** present, that if oxidised, could sustain long term acid generation.

Acid-Base Accounting (ABA) is a cost-effective method to predict whether a geological waste will be potentially acid generating in the long term. ABA is based on a series of laboratory compositional tests and calculations (refer to GARD, 2012 and Price, 2009 for further information).

ABA consists of the following analyses and calculations, discussed with the findings for the THM samples (Table 5 and further illustrated in Figure 3 and Figure 4):

- Analysis of paste pH
    - The paste pH of the THM samples were alkaline (pH >7). Therefore, the material in its current state is not acid generating.
- Analysis of acid generating sulphur species and calculation of acid potential (AP)- a factor of 31.25 is used to convert %S to kg $CaCO_3$ equivalents/tonne based on the assumption that 1 mole of sulphur produces 2 moles of H^+ (acid) and 1 mole of calcite ($CaCO_3$) neutralizes $2H^+$;
    - In this study total sulphur was determined; due to the low sulphur content it was not necessary to quantify acid producing sulphide and salt sulphur. Total sulphur content was less than 0.01%. Therefore, a maximum sulphur abundance of 0.01% was used in the acid generating calculations. The acid potential of all of the samples was 0.31 kg Ca/t.
- Analysis of neutralizing potential (NP)- determined by acid-base titration using the Modified Sobek method;
    - The calcrete waste rock (TH 1) sample had a high NP (399 kg/t), as expected from its chemical composition (dominated by carbonate mineralogy).
    - The BIF waste rock sample (TH 2) had a lower NP (37 kg/t), due to its lack of carbonate material.
    - The composite waste rock samples (TH 7 and 8) had NP values intermediate of the calcrete and BIF. The high NP value noted in the TH 7 sample is attributed to the significant abundance of carbonate minerals (calcite and dolomite, collectively comprising 45% of the sample, Section 5.2).
    - The NP of the lower grade ore sample (TH 6) was higher than the high grade sample (TH 5). This is consistent with the geological description of the ore samples, in that lower grade ore was more carbonaceous and higher grade ore was more oxide rich.
- Calculation of Net Neutralising Potential (NNP); in which NNP = NP – AP. If NNP < 0, the sample has the potential to generate acid, and if NNP> 0, the sample has the potential to

neutralise acid produced. However, due to uncertainty related to the exposure and reactivity of the carbonate minerals and pyrite, if the NNP is between -20 kg/t and 20 kg/t it is considered uncertain as to whether or not the rock is likely to generate or neutralise acid;

  - All of the samples classify as non-acid forming as the NNP of all samples was greater than 20 kg/t. This is attributed to the very low sulphur content of the samples and the significant neutralising capacity.

- Calculation of Neutralising Potential Ratio – NPR = NP / AP or NP:AP. Samples are considered a significant risk for acid forming if the NPR < 1; possibly risk for acid forming is 1<NPR<2 (if NP is insufficiently reactive or is depleted at a fast rate); low risk if 2<NPR<4 (acid forming if significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP) and very low risk / non-acid forming if NPR > 4 (no further acid generating testing required).
  - The NPR values of all of the samples were greater than 100 (i.e. NPR >4), and therefore the samples present a very low risk in terms of acid generation and are considered non-acid forming.

Table 5: Acid-base accounting of THM samples

ACID BASE ACCOUNTING	TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)
Paste pH	8,1	8,2	7,8	8,4	7,9	8,2
Total Sulphur (%)	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
Acid Potential (AP) (kg/t)	0,313	0,313	0,313	0,313	0,313	0,313
Neutralization Potential (NP) (kg/t)	399	38	69	127	131	52
Nett Neutralization Potential (NNP)	399	37	68	127	130	52
Neutralising Potential Ratio (NPR) (NP : AP)	1277	120	220	407	418	167
Rock Type	Non- acid forming	Non- acid forming	Non- acid forming	Non- acid forming	Non- acid forming	Non- acid forming

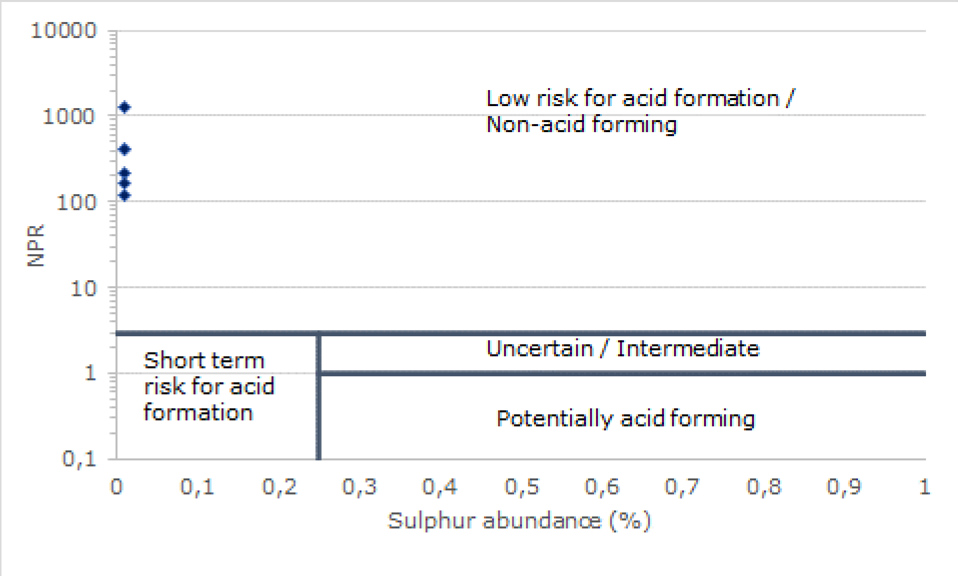


Figure 3: Neutralising Potential Ratio vs sulphur abundance

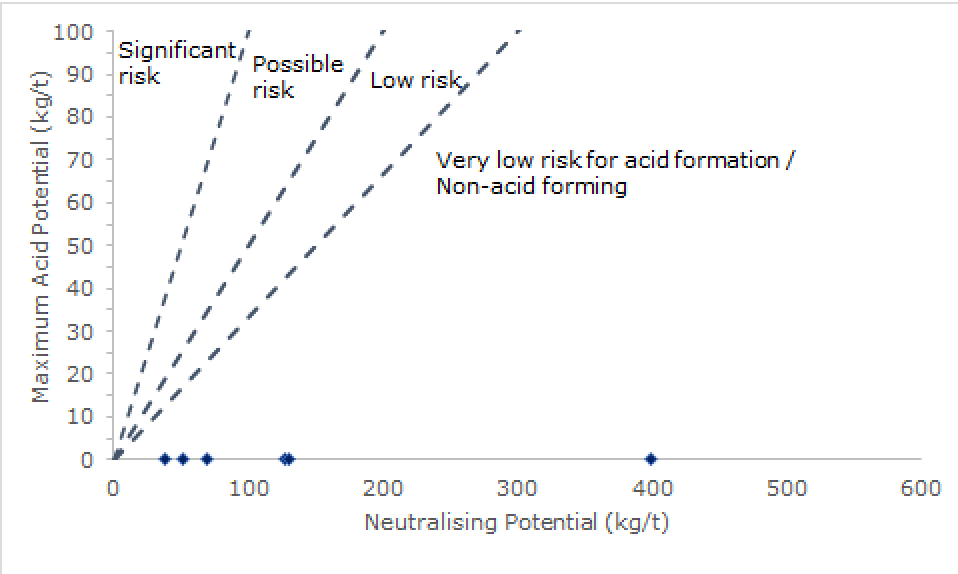


Figure 4: Maximum acid potential vs neutralising potential

5.4 Metal and sulphate leaching potential

The release of metals and metalloids of pollution concern from solid material into solution is controlled by the mineralogical and physical composition of the host rocks and by the pH, temperature, chemical composition and degree of saturation of the leaching solution. The fate of released metals and metalloids within the environment is then dependent on the secondary precipitation of minerals from solution and interaction of the contaminant with the environment (sorption onto reactive mineral surfaces such as clay or oxyhydroxides, uptake by organisms, oxidation/reduction processes, etc).

5.4.1 1:20 leach testing

The potential for leaching of the contaminants of concern from the THM rock samples was assessed by batch leaching experiments. The Synthetic Precipitation Leaching Protocol (SPLP) was utilised. The leaching solution is slightly acidic to simulate rainwater with a 1:20 material to leaching solution ratio. Standard practice for mono-filled waste sites typically utilises a 1:20 reagent water leach for assessment. For this study, synthetic rainwater was used instead of reagent water as the rocks are carbonate based and likely to interact more aggressively with slightly acidic rainwater than neutral pH water. The SPLP test would yield higher leaching concentrations than a reagent water leach, and is therefore considered a more realistic and conservative assessment of contaminant release potential.

The leach test results were compared to the South African General Standards for Discharge (GN 665 of 2013), IFC Effluent Standard for Mining, South African drinking water standards (SANS 241-1:2015), and the ANZECC drinking water for livestock (2000, Australian and New Zealand standard which is under revision).

Leach test results are summarised in Table 6. Only results for which a standard was available for comparison or for which a detectable concentration was leached are included in Table 6; full results are available in Appendix 1. The leach test results for the 1:20 SPLP experiments have shown that copper in the low grade ore sample (TH 6) narrowly exceeded the General Standard for Discharge and manganese in the composite fine sample (TH 8) exceeded the General Standard for Discharge and aesthetic SANS 241 drinking water guideline. No other concentrations of the analysed metal and metalloid contaminants of concern have been released in concentrations which exceed water quality guidelines (Table 6).

The total elemental composition (Section 5.1) had indicated manganese, lead, iron, gallium, boron and zinc were enriched some of the samples. The following discussion relate to the presence of these elements in the leachate as well as other contaminants of concern:

- Low concentrations of manganese were liberated from the high- and low-grade ore samples as well as from the BIF sample (TH 2, 5 and 6), these concentrations were within guideline values. A higher concentration of Mn was leached from the waste rock fines sample (TH 8), the concentration exceeded the General Discharge standard and aesthetic drinking water standard (though within health guideline);
- Gallium was leached in low concentrations from the low grade ore and fines samples (TH 6 and TH 8), however no guideline values for gallium were sourced. Gallium is anticipated to portray a similar toxicity profile to aluminium;
- A low concentration of copper that narrowly exceeded the General Discharge standard was released from the low grade ore sample, however this concentration is well within drinking water standards for humans and livestock;
- Iron was leached in low concentrations that did not exceed guideline values;
- Lead, boron and zinc were not leached from any of the waste rock and ore samples in detectable concentrations. Other contaminants of concern that were leached in low or below detectable concentrations are listed in Table 6.

The SPLP results indicated that the waste rock (represented by TH 1, 2 and 7) and ore samples present a **low risk** in terms of metal leaching potential. The circum-neutral pH of the solutions resulting from the leach testing as well as the presence of oxyhydroxide iron and manganese minerals (Section 5.2) within the material inhibits the mobilisation of metal contaminants of concern. The fines material (TH 8) presents a higher risk due to manganese leaching at concentrations exceeding drinking water and discharge standards. Additional management measures may be required for this material, refer to Section 8 for recommendations.

The SPLP analytical results are further discussed in Section 5.4.2 when compared to local standards for waste classification and in the geochemical summary in Section 8.

Table 6: SPLP (1:20), short term leach test results of THM rock composite samples

ANALYTE (mg/L)	TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)	IFC EFFLUENT STANDARD FOR MINING	ANZECC LIVESTOCK DRINKING WATER (2000)	GENERAL DISCHARGE STANDARD (GN 665)	SANS 241 DRINKING WATER STANDARD
pH	8,20	7,80	7,40	7,90	7,80	7,40	6-9		5,5 -9,5	5-9,7
EC (mS/m)	7,5	6,1	8,1	5,9	6,8	5,5			150	170
Total Alkalinity ($CaCO_3$)	28,0	28,0	20,0	28,0	24,0	28,0				
Cl	<2	<2	<2	<2	<2	<2				300
SO_4	2	2	5	<2	<2	4		1000		250
NO_3 as N	<0.1	0,7	1,4	<0.1	<0.1	<0.1		90	15	11
NO_2 as N	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				0,9
F	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		2	1	1,5
Al	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100		5		0,3
As	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,10	0,5	0,02	0,01
B	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		5	1	2,4
Ba	0,018	<0.010	<0.010	0,080	<0.010	0,448				1
Ca	8	7	10	7	8	7		1000		150
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,05	0,01	0,005	0,003
Co	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		1		0,5
Cr	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,10	1	0,05 (Cr VI)	0,05
Cu	<0.010	<0.010	<0.010	0,015	<0.010	<0.010	0,3	0,4	0,01	2,0
Fe	0,04	0,05	<0.025	0,04	<0.025	0,06	2		0,3	2,0
Ga	<0.010	<0.010	<0.010	0,01	<0.010	0,07				
Hg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,002	0,002	0,005	0,006
K	0,90	<0.5	<0.5	<0.5	<0.5	<0.5				50
Mg	2	1	1	1	1	1				70
Mn	<0.025	0,089	0,055	0,040	<0.025	0,34			0,1	0,4 / 0,1
Mo	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		0,15		
Na	<1	<1	<1	<1	<1	<1				200
Ni	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,5	1,0		0,07
P	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010			10	
Pb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,2	0,10	0,01	0,01
Sb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010				0,02
Se	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		0,02	0,02	0,04
Si	5,95	3,05	0,98	0,24	3,36	1,69				
Sr	0,09	0,03	<0.010	0,02	0,08	0,62				
U	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		0,2		
V	0,01	<0.010	<0.010	<0.010	<0.010	<0.010				0,2
Zn	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,5	20	0,1	5

Concentrations below detection and no guideline values: Ag, Be, Bi, Ce, Cs, Dy, Er, Eu, Gd, Ge, Hf, Ho, In, La, Li, Lu, Nb, Nd, Pd, Pr, Pt, Rb, Rh, Ru, Sc, Sn, Sm, Ta, Tb, Te, Th, Ti Tl, Tm, W, Y, Yb, Zr

Values in **red** exceed a guideline value

5.4.2 1:4 leach testing

The SPLP leach testing discussed in the previous section utilises a 1:20 rock to solution leaching ratio (as per standard practice). Although 1:20 is the standard leaching ratio, the actual leaching ratio experienced in many site conditions would have a higher rock to water ratio i.e. more rock interacting with less water, for example water slowly percolating through material stockpiles or rising water levels in backfilled waste. Therefore, additional testing was prescribed for the two composite waste rock and fines samples (TH 7 and TH 8) in order to identify the soluble pollutant fraction that may have been diluted beyond detection limits in the 1:20 tests.

The 1:4 leach test results were compared to the South African General Standards for Discharge (GN 665 of 2013), IFC Effluent Standard for Mining, South African drinking water standards (SANS 241-1:2015), and the ANZECC drinking water for livestock (2000, Australian and New Zealand standard which is under revision).

Leach test results are summarised in Table 7. Boron exceeded the General Discharge Standard of 1 mg/L in the surface waste rock composite (TH 7). Boron was not leached in detectable concentration in the 1:20 SPLP leach test, and was therefore diluted due to the high leaching ratio. The potential for boron leaching from the waste rock in concentrations exceeding guidelines is therefore dependent on the site-specific rock to water interaction ratio.

Manganese exceeded the General Discharge Standard and aesthetic drinking water standard in the fines composite (TH 8). The concentration of manganese observed in the 1:4 leach test and the 1:20 SPLP test are not markedly different. Given the high abundances of manganese oxide minerals noted in the mineralogy (Section 5.2), the concentration of manganese in the solution is not governed by the amount of manganese-bearing mineral present or the water to rock leaching ratio but is more likely to be metered by mineral solubility controls. This assumption was further tested by geochemical modelling which indicated that manganese oxide minerals were saturated to slightly supersaturated in both the 1:4 and SPLP leach tests for TH 8. Therefore, provided that pH remains circum-neutral and the leaching solution has a similar low electrical conductivity, the concentration of manganese released from this sample is unlikely to increase significantly.

Table 7: 1:4 distilled water, short term leach test results of THM rock composite samples

ANALYTE (mg/L)	TH 7 (SURFACE WASTE ROCK)	TH 8 (FINES)	IFC EFFLUENT STANDARD FOR MINING	ANZECC LIVESTOCK DRINKING WATER (2000)	GENERAL DISCHARGE STANDARD (GN 665)	SANS 241 DRINKING WATER STANDARD
pH	7,80	6,80	6-9		5,5 -9,5	5-9,7
EC (mS/m)	11,2	8,3			150	170
Total Alkalinity ($CaCO_3$)	36,0	24,0				
Cl	3,0	<2				300
SO_4	7	12		1000		250
NO_3 as N	0,7	0,1		90	15	11
NO_2 as N	<0,05	<0,05				0,9
F	<0,05	<0,05		2	1	1,5
Ag	<0,010	<0,010				
Al	<0,100	<0,100		5		0,3
As	<0,010	<0,010	0,10	0,5	0,02	0,01
B	1,35	0,530		5	1	2,4
Ba	<0,010	0,193				1
Ca	14	11		1000		150
Cd	<0,010	<0,010	0,05	0,01	0,005	0,003
Co	<0,010	<0,010		1		0,5
Cr	<0,010	<0,010	0,10	1	0,05 (Cr VI)	0,05
Cu	<0,010	<0,010	0,3	0,4	0,01	2,0
Fe	<0,025	0,056	2		0,3	2,0
Ga	<0,010	0,036				
Hg	<0,010	<0,010	0,002	0,002	0,005	0,006
K	0,6	<0,5				50
Mg	4	3				70
Mn	<0,025	0,288			0,1	0,4 / 0,1
Mo	<0,010	<0,010		0,15		
Na	1	<1				200
Ni	<0,010	<0,010	0,5	1,0		0,07
P	<0,010	<0,010			10	
Pb	<0,010	<0,010	0,2	0,10	0,01	0,01
Sb	<0,010	<0,010				0,02
Se	<0,010	<0,010		0,02	0,02	0,04
Si	7,3	5,1				
Sr	0,112	0,618				
U	<0,010	<0,010		0,2		
V	<0,010	<0,010				0,2
Zn	<0,010	<0,010	0,5	20	0,1	5

Concentrations below detection and no guideline values: Be, Bi, Ce, Cs, Dy, Er, Eu, Gd, Ge, Hf, Ho, In, La, Li, Lu, Nb, Nd, Pd, Pt, Pr, Pt, Rb, Rh, Ru, Sc, Sm, Sn, Ta, Tb, Te, Th, Ti, Tl, Tm, W, Y, Yb, Zr

6. EVAPORATION OF PIT WATER

Geochemical modelling was undertaken in order to understand the suite of solid evaporite / efflorescent minerals that could potentially result during the mechanical evaporation of water impounded in the historical pit void "pit water" (should such management option be elected) as well as the changing composition of the brine that forms during the process.

6.1 Pit Water Quality

Analysis of the pit water chemistry is discussed in the Tawana Hotazel Mine Groundwater Study by Future Flow GPMS cc (June 2021, Table 8).

Table 8: Pit water quality (Future Flow GPMS cc; June 2021)

ANALYSIS	UNITS	SANS 241:2015 GUIDELINE	HP (PIT WATER SAMPLE)
pH		≥5 - ≤9.7	7.84
Electrical Conductivity (EC)	mS/m	≤170	456
Total Dissolved Solids (TDS)	mg/L	≤1 200	4144
Total Alkalinity	mg/L $CaCO_3$	None	150
Total Hardness	mg/L $CaCO_3$	None	2080.8
Chloride (Cl)	mg/L	≤300	774.9
Sulphate (SO_4)	mg/L	≤500 (health)	199
Nitrate (NO_3)	mg/L	≤50	992.8
Nitrite (NO_2)	mg/L	≤3	1.2
Ammonium (NH_4)	mg/L	None	<0.03
Phosphate (PO_4)	mg/L	None	0.12
Fluoride (F)	mg/L	≤1.5	<0.3
Bromide	mg/L	None	6.95
Calcium (Ca)	mg/L	None	384.6
Magnesium (Mg)	mg/L	None	266.5
Sodium (Na)	mg/L	≤200	239.3
Potassium (K)	mg/L	None	5.4
Aluminium (Al)	mg/L	≤0.3	<0.02
Arsenic	mg/L	≤0.01	<0.0025
Cadmium (Cd)	mg/L	≤0.003	<0.0005
Chromium (Cr)	mg/L	≤0.05	0.002
Cobalt (Co)	mg/L	None	<0.002
Copper (Cu)	mg/L	≤2	<0.007
Iron (Fe)	mg/L	≤2 (health)	0.08
Lead (Pb)	mg/L	≤0.01	<0.005
Manganese (Mn)	mg/L	≤0.4 (health)	0.007
Nickel (Ni)	mg/L	≤0.07	<0.002
Selenium	mg/L	≤0.04	<0.003
Vanadium	mg/L	None	0.0082
Zinc (Zn)	mg/L	≤5	0.007

(green) Exceeds SANS241:2015 drinking water quality guideline

N/A = Not analysed

N/G = No SANS241:2015 guideline value

6.2 Speciation Solubility Modelling

Geochemist's Workbench Professional was used to compile a speciation solubility model of the pit water discussed in Section 6.1.

The following considerations and results are noted:

- The Thermot.dat and Wateqf.data databases were utilized for speciation-solubility modelling;
- The nitrate-nitrite couple was used to define the Oxidation-Reduction Potential (Eh) of the initial system (Eh calculated to be 0.43 V);
- The model indicated that the charge balance of the system was 7.1%, this shows that there may be analytes missing from the water analyses or that an analyte concentration was overestimated. Typically, a value of <5% is considered acceptable. The calculated total dissolved solids (TDS) was 3237 mg/L which is lower than the measured value of 4144 mg/L.
- The water type was determined to be Mg/Ca-Cl, as indicated in the Piper diagram (Figure 5).
- Saturation indices (SI) are calculated to identify which minerals the water system may be in equilibrium with (i.e. which minerals are dissolving and precipitating at the same rate), these minerals typically have an SI of 0. An SI>1 indicates that the solution is supersaturated with that mineral. This could indicate that the system may precipitate out that mineral, however often there are barriers to the precipitation of a particular mineral (such as kinetic restrictions or high activation energy required for precipitation). Minerals that are supersaturated in the system include vanadium oxide, dolomite, calcite and magnesite. These minerals may be dissolving into solution but not precipitating out of solution due to barriers. Sometimes these minerals may require much higher levels of saturation before precipitation can commence or, as the case with dolomite, inorganic precipitation is not known to occur at atmospheric conditions. Minerals that are close to saturation include siderite, gypsum and monohydrocalcite.

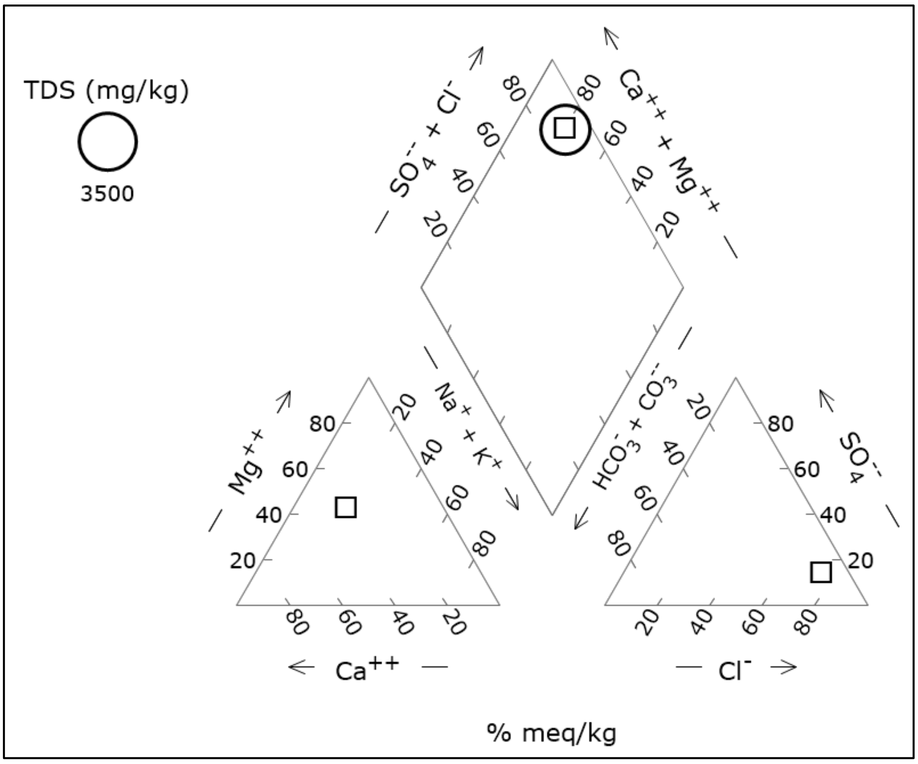


Figure 5: Piper diagram indicating pit water composition

6.3 Evaporation Modelling

Geochemical modelling of the evaporation of the pit water was undertaken in order to understand the changing composition of the brine water resulting from the evaporation as well as the suite of efflorescent minerals that could be anticipated during the evaporation process. The following considerations were compiled into the Geochemist's Workbench REACT model:

- The model was run with various thermodynamic databases which each have their own shortcomings. For example, modelling of brine solutions is generally better suited to the Harvey-Moeller-Weire activity model which accounts for the ionic interactions of highly concentrated solutions, however the range of minerals for this database is small (51 minerals) and specifically suited to saltwater scenarios (thermodynamic data is only available for 9 common elements). The Thermo database uses the Debye-Huckel activity model and is a very large database (46 elements, 624 minerals) which incorporates the metal ions of contamination concern, however its applicability to concentrated solutions is not ideal. A reasonable compromise is the WATEQ4F database (35 elements and 310 minerals) which incorporates a modified Debye-Huckel activity model (Truesdell-Jones). Though its applicability in highly concentrated solutions may also waiver, it is also acknowledged that complete evaporation is seldomly observed in natural settings.
- The evaporation of 1000 kg of water down to 4 kg of water was modelled under atmospheric conditions. Oxygen and carbon dioxide were included in the basis set and their abundance was fixed to atmospheric levels.
- Minerals which are unlikely to precipitate in atmospheric conditions were suppressed.

The following results regarding the geochemical modelling using of evaporation of pit water are noted:

- The pH of the solution is not expected to become acidic during evaporation (Figure 6).
- Figure 7 and Figure 8 shows the anticipated mineral suite to develop during evaporation of 1000 kg of water using the WATEQ4F and H-M-W databases respectively. Gypsum ($CaSO_4 \cdot 2H_2O$) becomes supersaturated and precipitates once 90% of the liquid has evaporated. The equilibration of atmospheric oxygen with the pit water leads to the precipitation of iron and manganese oxyhydroxides, represented in the model by ferrihydrite ($Fe(OH)_3$) and nsutite (MnO_2, other manganese oxide derivatives yield similar curves) (other bivalent metals such as chromium, vanadium, zinc would be incorporated into these minerals). Halite (NaCl) is nearly saturated in the final solution and may be expected to form towards the final stages of evaporation as well as other chloride-bearing minerals such as carnallite (potassium magnesium chloride mineral, Figure 8) or similar.
- Less than 1 kg of efflorescent minerals are anticipated to form with most of the chemical constituents remaining in solution. This is due to the high solubility of nitrate and chloride minerals.
- The calculated composition of the solutions resulting from the evaporation process are summarized in Table 6. The calculated TDS of the resulting brine increases to 5 300 mg/L by 40% evaporation and to 15 138 mg/L by 80% evaporation.

6.4 Evaporation Modelling Discussion

The modelling of the evaporation of the pit water indicated that:

- For most of the evaporative process, only small amounts of efflorescent minerals are likely to precipitate out of solution. This is due to the high concentration of chloride and nitrate anions present in the solution and the high solubility of the salts of these anions. Solid minerals are anticipated to include gypsum (and similar derivatives), possibly carbonate minerals, and small amounts of iron-manganese oxyhydroxides. Towards the very late stages of evaporation, chloride salts such as halite (NaCl) may precipitate from solution.
- A brine liquid would develop with evaporation, the calculated composition of this solution was modelled (Table 9). The water quality of the brine is affected by the concentration of some analytes by evaporation and the removal of other analytes during the precipitation of efflorescent minerals. The geochemical model is based only on inorganic properties. Microbial influence may significantly alter the composition of the resulting fluid. Microbial or biological influence may be significant for the nitrate content.

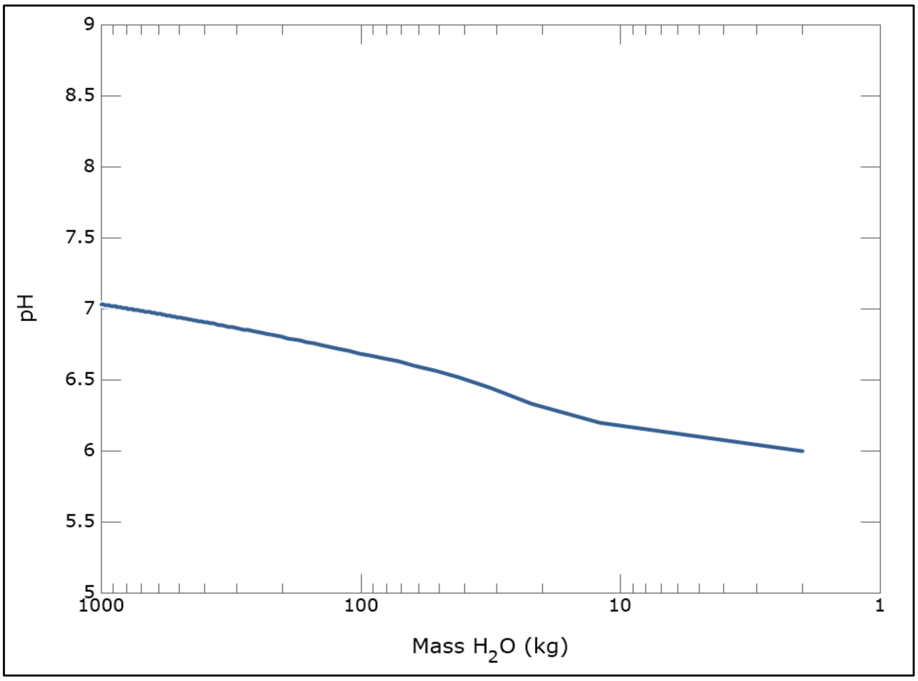


Figure 6: pH of solution during evaporation (Geochemist's Workbench, WATEQ4f)

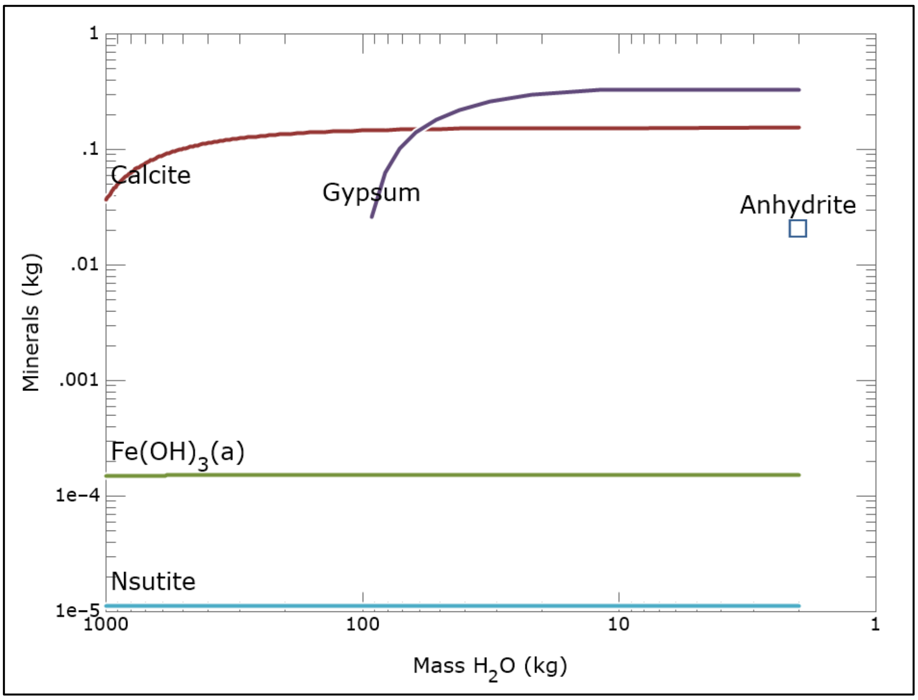


Figure 7: Minerals precipitated from evaporation of 1000 kg of pit water (Geochemist's Workbench, WATEQ4f)

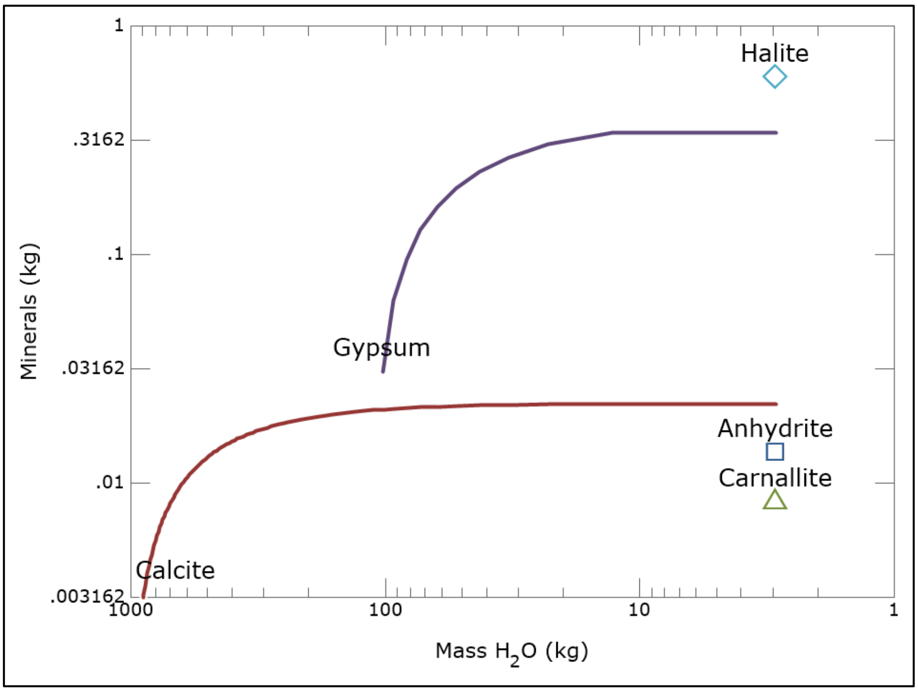


Figure 8: Minerals precipitated from evaporation of 1000 kg of pit water (Geochemist's Workbench, H-M-W database)

Table 9: Calculated composition of solution during evaporation (Geochemist's Workbench, WATEQ4f)

Percentage evaporated	Mass of solution (kg)	pH	Electrical conductivity (mS/m)	Concentration in solution (mg/kg)											
				Br^-	Ca^{2+}	Cl^-	Fe^{2+}	K^+	Mg^{2+}	Mn^{2+}	NO_2^-	NO_3^-	Na^+	SO_4^{2-}	Zn^{2+}
0%	1000	7,0	516	6,91	371	1010	0,002	5,41	267	0,000	1,2	995	239	199	0,01
20%	800	7,0	628	8,63	450	1260	0,002	6,75	334	0,000	1,5	1240	299	249	0,01
40%	600	7,0	810	11,5	581	1670	0,002	8,99	444	0,000	2	1650	398	331	0,01
60%	401	6,9	1160	17,1	844	2500	0,003	13,4	664	0,000	2,98	2470	594	495	0,02
80%	202	6,8	2129	33,9	1620	4940	0,003	26,5	1310	0,000	5,89	4870	1170	977	0,03
91%	92	6,7	4207	73,1	3390	10600	0,004	57,2	2830	0,000	12,7	10500	2530	1950	0,07

7. WASTE CLASSIFICATION

The geochemical characteristics of the THM samples were further analysed per the standard assessment methodology presented in the NEMWA Waste Classification and Management Regulations (GN634 of 2013) and associated Norms and Standards (GN635 and GN636 of 2013). Evaluation in terms of these Regulations is undertaken in order to inform measures for the containment and management of the various mine residues on-site following the risk-based approach presented in the GN632 Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits. The requirements in terms of disposal barrier design in terms of the Norms and Standards for Waste Disposal to Landfill (GN636 of 2013) are therefore not wholly prescriptive to the various mine residue streams evaluated herein .

In terms of the Waste Classification and Management Regulations, if all total elemental abundances are below Total Contaminant Threshold (TCT) 0 and Leachable Concentration Threshold (LCT) 0, then the waste stream is classified as Type 4 (depending on leachable concentrations) and may be disposed of to a facility with a single clay liner (which meets certain requirements). Waste streams are classified based on the extent to which the total abundances exceed the TCT 0, TCT 1 and TCT 2 guidelines, considered with the extent to which the leachable fractions exceed the LCT 0, LCT 1, LCT 2 and LCT 3 guidelines. The "type" of waste disposal facility (i.e. the containment barrier design) is then determined by the resulting classification.

Comparison of the total elemental analyses (Section 5.1) with the TCT guidelines indicates the following (Table 10):

- Barium exceeds TCT 0 in 3 samples (TH 2, 7 and 8);
- Manganese is highly enriched in the ore samples, composite waste rock sample and fines sample and exceeds TCT 2 (TH 5, 6, 7 and 8). Manganese is less enriched in the 'cleaner' waste rock end members; calcrete and BIF (TH 1 and TH 2 respectively) and exceeds TCT 0 and TCT 1 respectively;
- Lead abundances exceed TCT 0 in 4 samples (TH 2, 5, 7 and 8);
- Zinc exceeds TCT 0 in the high grade ore sample (TH 5);
- All other total abundances were within the TCT 0 guideline, where specified.

As discussed in the leach testing results (Section 5.4.1), the mobility of these potential contaminants was found to be low, likely due to the neutral pH of the solutions and presence of metal adsorption surfaces (iron and manganese oxyhydroxides) within the material itself. Therefore, the analysed concentrations of these contaminants in solution were low. Correspondingly, the 1:20 leach test results show that no analyte exceeded LCT 0 (Table 11).

As per Section 7(6) of GNR 635: *wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT 0 limits are considered to be Type 3 waste, irrespective of the total concentration of elements or chemical substances in the waste, provided that all chemical substance concentration levels are below the* *total concentration limits for organics and pesticides (total organic carbon of the THM samples is below 3%); the inherent physical and chemical character of the waste is stable and will not change over time (the samples are non-acid producing and non-putrescible); and the waste is disposed of to landfill without any other waste (co-disposal of waste is not planned).*

Therefore, the **THM waste rock, ore and fines samples would classify as Type 3 waste**. Although a Class C containment barrier system (composite clay and HDPE liner) would be prescribed in terms of the Waste Classification and Management Regulations, an alternative containment barrier system is recommended according to the risk-based approach for mine residue stockpiles and deposits per GN632 (refer to Section 8).

Table 10: Comparison of elemental abundances to Total Concentration Thresholds (TCT)

TOTAL ABUNDANCE (ppm)	TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)	GNR 635 of 2013 TCT0	GNR 635 of 2013 TCT1	GNR 635 of 2013 TCT2
As	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	6	500	2000
B	<4.00	42	123	141	83	117	150	15000	60000
Ba	21	87	15	8	97	697	63	6250	25000
Cd	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	8	260	1040
Co	<4.00	5,8	14,5	13,6	9,2	28,3	50	5000	20000
Cr	5,4	<4.00	7,8	<4.00	5,6	14	46000	800000	N/A
Cu	<4.00	<4.00	<4.00	<4.00	<4.00	8,9	16	19500	78000
Hg	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	0,93	160	640
Mn	1780	58400	600000	395600	290000	423600	1000	25000	100000
Mo	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	40	1000	4000
Ni	<4.00	<4.00	5,8	<4.00	<4.00	8,1	91	10600	42400
Pb	<4.00	39	307	17	39	214	20	1900	7600
Sb	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	10	75	300
Se	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	10	50	200
V	24	50	18	4	105	54	150	2680	10720
Zn	<4.00	30	434	29	24	90	240	160000	640000

Table 11: Comparison of leach testing results with Leachable Concentration Thresholds (LCT)

LEACHABLE CONCENTRATION (mg/L)	TH1 (CALCRETE)	TH2 (BIF)	TH5 (HIGH GRADE ORE)	TH6 (LOW GRADE ORE)	TH7 (SURFACE WASTE ROCK)	TH8 (FINES)	GNR 635 of 2013			
							LCT0	LCT1	LCT2	LCT3
Cl	<2	<2	<2	<2	<2	<2	300	15000	30000	120000
SO4	2	2	5	<2	<2	4	250	12500	25000	100000
NO3 as N	<0.1	0,7	1,4	<0.1	<0.1	<0.1	11	550	1100	4400
F	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1,5	75	150	600
As	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,01	0,5	1,0	4,0
B	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,5	25	50	200
Ba	0,018	<0.010	<0.010	0,080	<0.010	0,448	0,7	35	70	280
Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,003	0,15	0,3	1,2
Co	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,5	25	50	200
Cr	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,1	5	10	40
Cu	<0.010	<0.010	<0.010	0,015	<0.010	<0.010	2	100	200	800
Hg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,006	0,3	0,6	2,4
Mn	<0.025	0,089	0,055	0,040	<0.025	0,34	0,5	25	50	200
Mo	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,07	3,5	7	28
Ni	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,1	3,5	7	28
Pb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,01	0,5	1	4
Sb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,02	1,0	2	8
Se	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0,01	0,5	1	4
V	0,01	<0.010	<0.010	<0.010	<0.010	<0.010	0,2	10	20	80
Zn	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	5	250	500	2000

8. GEOCHEMICAL SUMMARY AND RECOMMENDATIONS

8.1 Waste rock

Three samples of waste rock were analysed. The samples represented the major lithologies of the waste rock (calcrete, TH 1 and BIF, TH 2) and a composite sample representing the residual surface waste rock stockpiles currently present at the site (TH 7). The samples collected are considered to be representative of the waste rock that will be excavated, stockpiled and backfilled into the opencast void (residual stockpiles from historic mining activities are also represented). All of the waste rock samples were found to be non-acid generating, due to low sulphur abundances and significant neutralisation potential.

The calcrete sample was not significantly enriched in any of the analysed metals and metalloids. The BIF sample was enriched in iron and manganese. The composite surface waste rock sample was also enriched in manganese and exhibited a high iron content (owing to the presence of iron and manganese oxide minerals) as well as being slightly enriched in boron.

Leach testing (1:20 ratio) of all waste rock samples indicated that anions, metals and metalloids within the material were not highly soluble and mobile. Higher solid-water leach testing (1:4) of the composite surface waste rock sample indicated that boron may be mobilised from the sample, the concentration of boron present in the runoff on site will be dependent on the rock to water leaching ratio. Runoff from this material is anticipated to be of circum-neutral to alkaline pH with low concentrations of dissolved solids.

The samples that were collected have been exposed to atmospheric conditions and therefore may be depleted of their original highly-soluble fraction. The runoff during the first exposures of fresh waste rock to rainfall is expected to have circum-neutral pH and elevated TDS due to the presence of soluble minerals. Thereafter, the runoff and seepage to be expected from the THM waste rock is largely considered to be of acceptable quality relative to prescribed local and international guidelines (represented by TH 1, 2, 7).

High nitrate concentrations have been reported in the water quality monitoring exercises in the region. The leach testing found that a low concentration of nitrate was liberated from the BIF sample with the other waste rock samples releasing no measurable nitrate. Therefore, from the geochemical analyses undertaken for this study, the waste rock material is unlikely to contribute directly to the high nitrate concentrations observed in the region.

This material is considered to present a **low risk** in terms of acid generation and metal leaching potential.

Recommendations for measures for the management of waste rock at THM include:

- Freshly exposed waste rock stockpiles on surface (if present) should have water management measures to ensure that unrestricted discharge to the environment does not take place. This recommendation is provided as freshly exposed waste rock may initially leach higher concentrations of soluble metals than that anticipated in the long term.
- In the long term, backfilling of waste rock into the opencast pit void is recommended. The proposed backfilling of the waste rock into the opencast pit requires that exemption from the provisions of Regulation 4 of GN 704 of 1999 *Regulations on use of Water for Mining and Related Activities Aimed at the Protection of Water Resources* is sought. The following motivates for this exemption:
    - Backfilling is considered an acceptable long term storage solution for the waste rock due to the low geochemical risk the waste rock presents. The waste rock is non-acid generating and very low concentrations of soluble anions, metals and metalloids are anticipated to arise in the long-term in neutral pH conditions.
    - Provision of a stable repository for waste rock – long-term slope stability of large waste rock dumps is not of concern when the material is backfilled. Stability aspects such as subsidence may, however, be of concern and the area is to be managed appropriately in terms of the mine closure and rehabilitation plan;
    - Reduction of exposed surface area – waste rock material stockpiled on surface has a greater surface area for rainwater interaction, leading to higher runoff volumes and a greater impact on surface water resources. Backfilling limits exposure of the slopes of both the pit and overburden stockpiles to atmospheric weathering and oxidation. Where residue material has been backfilled, only the upper surface is exposed to atmospheric conditions in the long term;
    - Avoidance of pit lakes –the backfilling of a pit eliminates the creation of a pit lake which in itself carries environmental and safety concerns, and therefore promotes a free-draining surface in the long-term;
    - Restoration of impacted land to beneficial use – areas that would host waster rock dumps can be rehabilitated to an acceptable end-use.
- It is recommended that the backfilled waste rock should be compacted to restrict rainwater infiltration and the resulting landform shaped to promote rainwater runoff.

8.2 Fines

Residual fine windblown or screened material was present on-site at the time of sampling, having arisen from the previous mining activities undertaken. The presence of this material on the roads was noted. The fines sample was comprised of manganese bearing silicate minerals as well as iron and manganese oxide minerals.

The composite fines sample (TH 8) was found to be non-acid generating, due to low sulphur abundance and significant neutralisation potential.

The sample was significantly enriched in manganese and lead and slightly enriched in boron and gallium.

In the leach testing, only manganese was liberated from the fines sample in a concentration exceeding local discharge standards and drinking water standards. The manganese abundance in this sample was not higher than the ore samples, however a higher fraction of this manganese was liberated in the leachate. The higher fraction of soluble manganese released from this sample may be attributed to the fines sample being finer grained than the other samples and therefore having a higher reactive surface area available for leaching. The higher leaching ratio of 1:4 for this sample did not yield a manganese concentration higher than the 1:20 leach test, therefore indicating the manganese concentration is controlled by mineral solubility.

The mobility of manganese from the fines sample indicates that areas that will handle fine material may require water management measures in place to ensure that sediment laden runoff does not enter the environment. The fines material is anticipated to have arisen from ore stockpile areas, therefore recommended measures for ore management and handling areas described in Section 8.3 below bear relevance.

8.3 High- and low-grade ore

Two composite samples of ore material, representing high grade (TH 5) and low grade (TH 6) were analysed.

The ore samples were found to be non-acid generating, due to low sulphur abundances and significant neutralisation potential.

The ore samples were significantly enriched in manganese. The high grade sample was also enriched in lead and slightly enriched in boron and zinc. The low grade sample was slightly enriched in boron and calcium.

Leach testing (1:20 ratio) of the ore samples indicated that the manganese content was not readily soluble, likely owing to the circum-neutral pH of the resulting leachate. The anions, metals and metalloids within the high-grade material were not highly soluble and mobile. Copper was leached from the low-grade sample in a concentration slightly exceeding local discharge standards, however within drinking water and international standards. A low concentration of nitrate was released from the high grade ore (1.4 mg/l).

Runoff from stockpiles of ore material is anticipated to be of circum-neutral to alkaline pH with low concentrations of dissolved solids.

The samples that were collected have been exposed to atmospheric conditions and therefore may be depleted of their highly soluble fraction. The runoff during the first exposures of fresh ore material to rainfall is expected to have circum-neutral pH and elevated TDS due to the presence of soluble minerals. Thereafter, the runoff and seepage to be expected from the THM ore samples is largely considered to be of acceptable quality relative to prescribed local and international guidelines (represented by TH 5 and 6).

This material is considered to present a **low risk** in terms of acid generation and metal leaching potential. The sediment load of **fine material** liberated from ore stockpiles **may pose a higher risk** as noted in Section 8.2.

Recommendations for measures for the management of ore material at THM include:

- Freshly exposed ore stockpiles on surface should have water management measures to ensure that unrestricted discharge to the environment does not take place.
- The material is classed as a Type 3 waste which, according the local guidelines, would require a Class C liner. It is motivated that a Class C liner is not a practical barrier for ore stockpiles as the areas are extensively worked with machinery and would result in damages to such a liner system. It is recommended that a compacted base or concrete base be considered as alternative barriers at the ore stockpiles. No stockpiles of ore material will remain on the site post-closure and rehabilitation.
- Although the larger fractions of THM ore material do not pose long-term metal leaching risk, fine material that is wind-blown or washed away does present a higher risk. Management measures to control windblown fines material should therefore be put in place (as advised by air quality specialists). Water management measures to prevent unrestricted discharge of water arising from the stockpile area should be in place with silt traps as necessary to control the amount of fine material entering water facilities.

8.4 Evaporation of pit water

Geochemical modelling was undertaken in order to understand the suite of solid evaporite / efflorescent minerals that could potentially result during the mechanical evaporation of water impounded in the historical pit void "pit water" (should such management option be elected) as well as the changing composition of the brine that forms during the process.

- The pit water has concentrations of chloride, nitrate and sodium which exceed drinking water quality guidelines as well as high concentrations of calcium and magnesium.
- Evaporation modelling indicated that most of the constituents within the solution will remain in solution during the evaporation process and not precipitate out until the very late stages of evaporation. This results in the formation of a brine solution with high total dissolved solids.
- Efflorescent minerals anticipated to form in low abundance during the evaporation of the solution includes gypsum, possibly carbonate minerals, and small amounts of iron-manganese oxyhydroxides. Towards the very late stages of evaporation, chloride salts such as halite (NaCl) may precipitate from solution.
- Should the management of the pit water incorporate mechanical evaporation methodology, the evolving water quality of the brine solution can be inferred from the modelled results presented in Section 6.

9. CONCLUSION

A geochemical assessment of the waste rock and ore material of the Tawana Hotazel Mine was undertaken by Prime Resources. Composite samples representative of the various types of rock material arising at the project were assessed and analysed at an accredited laboratory. It was found that the waste rock and ore material were non-acid forming and presented a very low risk in terms of acid generation. The waste rock presented a low geochemical risk in terms of metal leaching and can be considered for backfilling into the opencast pit. The samples of high and low grade ore also present a low risk in terms of metal leaching, with the exception of low concentrations of copper which slightly exceed general discharge standards. The fine fraction of material arising from ore stockpiles was found to leach manganese in concentrations which could exceed guidelines. Recommendations for the management of these materials at THM have been provided.

Geochemical modelling of the evaporation of the pit water was undertaken in order to assess the suite of minerals likely to precipitate during a mechanical evaporation process as well as to predict the evolving water quality of the brine solution remaining. It was found that most of the chemical constituents remain in solution until the late stages of the evaporative process resulting in a brine solution with high total dissolved solids.

Report compiled by:

Dr Bronwyn Grover
Senior Environmental Geochemist
Prime Resources (Pty) Ltd

Report reviewed by:

Jonathan van de Wous
Principal Environmental Scientist
Prime Resources (Pty) Ltd

10. REFERENCES

- European Commission. (2018). Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries in accordance with Directive 2006/21/EC
- GARD Guide. (2012). Global Acid Rock Drainage Guide. The International Network for Acid Prevention. Available at: www. gardquide. com.
- International Finance Corporation- World Bank (2007). Environmental, Health and Safety (EHS) Guidelines for Mining and Coal Processing.
- Price, W. A. (2009). Prediction manual for drainage chemistry from sulphidic geologic materials. MEND report, 1(1), 579.
- Rudnick, R. L., & Gao, S. (2003). Composition of the continental crust. The crust, 3, 1-64.
- US EPA (1994) Technical Document: Acid Mine Drainage Prediction

APPENDIX 1

Laboratory Results

WATERLAB

WATERLAB (PTY) LTD

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received:	**2021/02/26**		**Date completed:**	**2021/03/23**
Project number:	**1000**	**Report number: 98421**	**Order number:**	**Quote (Q-P979-2597)**

Client name:	**Prime Resources Environmental Consultants**	**Contact person:**	**Dr Bronwyn Grover**
Address:	**P.O Box 2316, Parklands, 2121**	**Email:**	**Bronwyn@resources.co.za**
Telephone:	**011 447 4888**	**Email:**	**jonathan@resources.co.za**
		Cell:	**082 851 7433**

Analyses	**TH1**		**TH2**		**TH5**	
Sample Number	**120309**		**120310**		**120311**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**SPLP**		**SPLP**		**SPLP**	
Dry Mass Used (g)	**50**		**50**		**50**	
Volume Used (mℓ)	**1000**		**1000**		**1000**	
pH Value at 25˚C	8,2		7,8		7,4	
Electrical Conductivity in mS/m at 25˚C	7,5		6,1		8,1	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Alkalinity as CaCO3	28	560	28	560	20	400
Chloride as Cl	<2	<40	<2	<40	<2	<40
Sulphate as SO4	2	40	2	40	5	100
Nitrate as N	<0.1	<2.0	0,7	14	1,4	28
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0
ICP-MS Scan	See ICP SPLP tab					
Acid Base Accounting	See attached report 98421 ABA					

Analyses	**TH6**		**TH7**		**TH8**	
Sample Number	**120312**		**120313**		**120314**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**SPLP**		**SPLP**		**SPLP**	
Dry Mass Used (g)	**50**		**50**		**50**	
Volume Used (mℓ)	**1000**		**1000**		**1000**	
pH Value at 25˚C	7,9		7,8		7,4	
Electrical Conductivity in mS/m at 25˚C	5,9		6,8		5,5	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Alkalinity as CaCO3	28	560	24	480	28	560
Chloride as Cl	<2	<40	<2	<40	<2	<40
Sulphate as SO4	<2	<40	<2	<40	4	80
Nitrate as N	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0
ICP-MS Scan	See ICP SPLP tab					
Acid Base Accounting	See attached report 98421 ABA					

[o] = Outsourced

S. Laubscher____________________

Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-MS SCAN ANALYSIS

Date received:	2021/02/26	Date Completed:	2021/03/23
Project number:	1000	Report number:	98421

Client name:	Prime Resources Environmental Consultants	Contact person:	Dr Bronwyn Grover
Address:	PO Box 2316, Parklands, 2121	Email:	Bronwyn@resources.co.za
		Email:	jonathan@resources.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
SPLP	50	1000	20

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.100	<2.00	<0.010	<0.200

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	0,018	0,360
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	0,080	1,60
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	0,448	8,96

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<1	<20
TH1	120309	<0.010	<0.200	<0.010	<0.200	8	160
TH2	120310	<0.010	<0.200	<0.010	<0.200	7	140
TH5	120311	<0.010	<0.200	<0.010	<0.200	10	200
TH6	120312	<0.010	<0.200	<0.010	<0.200	7	140
TH7	120313	<0.010	<0.200	<0.010	<0.200	8	160
TH8	120314	<0.010	<0.200	<0.010	<0.200	7	140

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	0,015	0,300
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.010	<0.200	<0.010	<0.200
TH1	120309	0,036	0,720	<0.010	<0.200	<0.010	<0.200
TH2	120310	0,053	1,06	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.025	<0.500	<0.010	<0.200	<0.010	<0.200
TH6	120312	0,042	0,840	0,013	0,260	<0.010	<0.200
TH7	120313	<0.025	<0.500	<0.010	<0.200	<0.010	<0.200
TH8	120314	0,058	1,16	0,071	1,42	<0.010	<0.200

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<10.0	<0.010	<0.200	<0.010	<0.200
TH1	120309	0,9	18,0	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.5	<10.0	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.5	<10.0	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.5	<10.0	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.5	<10.0	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.5	<10.0	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<1	<20	<0.025	<0.500
TH1	120309	<0.010	<0.200	2	40	<0.025	<0.500
TH2	120310	<0.010	<0.200	1	20	0,089	1,78
TH5	120311	<0.010	<0.200	1	20	0,055	1,10
TH6	120312	<0.010	<0.200	1	20	0,040	0,800
TH7	120313	<0.010	<0.200	1	20	<0.025	<0.500
TH8	120314	<0.010	<0.200	1	20	0,343	6,86

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<1	<20	<0.010	<0.200
TH1	120309	<0.010	<0.200	<1	<20	<0.010	<0.200
TH2	120310	<0.010	<0.200	<1	<20	<0.010	<0.200
TH5	120311	<0.010	<0.200	<1	<20	<0.010	<0.200
TH6	120312	<0.010	<0.200	<1	<20	<0.010	<0.200
TH7	120313	<0.010	<0.200	<1	<20	<0.010	<0.200
TH8	120314	<0.010	<0.200	<1	<20	<0.010	<0.200

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.2	<4.0
TH1	120309	<0.010	<0.200	<0.010	<0.200	5,9	119
TH2	120310	<0.010	<0.200	<0.010	<0.200	3,0	61
TH5	120311	<0.010	<0.200	<0.010	<0.200	1,0	19,6
TH6	120312	<0.010	<0.200	<0.010	<0.200	0,2	4,8
TH7	120313	<0.010	<0.200	<0.010	<0.200	3,4	67
TH8	120314	<0.010	<0.200	<0.010	<0.200	1,7	34

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	0,090	1,80
TH2	120310	<0.010	<0.200	<0.010	<0.200	0,027	0,540
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	0,021	0,420
TH7	120313	<0.010	<0.200	<0.010	<0.200	0,077	1,54
TH8	120314	<0.010	<0.200	<0.010	<0.200	0,617	12

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	0,014	0,280
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.010	<0.200
TH1	120309	<0.010	<0.200	<0.010	<0.200
TH2	120310	<0.010	<0.200	<0.010	<0.200
TH5	120311	<0.010	<0.200	<0.010	<0.200
TH6	120312	<0.010	<0.200	<0.010	<0.200
TH7	120313	<0.010	<0.200	<0.010	<0.200
TH8	120314	<0.010	<0.200	<0.010	<0.200

WATERLAB

WATERLAB (PTY) LTD

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TOTALS

Date received:	**2021/02/26**	**Date completed:**	**2021/03/23**
Project number:	**1000**	**Report number: 98421**	
		Order number:	**Quote (Q-P979-2597)**

Client name:	**Prime Resources Environmental Consultants**	**Contact person:**	**Dr Bronwyn Grover**
Address:	**P.O Box 2316, Parklands, 2121**	**Email:**	**Bronwyn@resources.co.za**
Telephone:	**011 447 4888**	**Email:**	**jonathan@resources.co.za**
		Cell:	**082 851 7433**

Analyses						
	TH1		TH2		TH5	
Sample Number	120309		120310		120311	
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0,25		0,25		0,25	
Volume Used (mℓ)	100		100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
ICP-MS Scan	See ICP Digestion tab					

Analyses						
	TH6		TH7		TH8	
Sample Number	120312		120313		120314	
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0,25		0,25		0,25	
Volume Used (mℓ)	100		100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
ICP-MS Scan	See ICP Digestion tab					

[o] = Outsourced

S. Laubscher____________________
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS SCAN ANALYSIS

Date received:	2021/02/26	**Date Completed:**	2021/03/23
Project number:	1000	**Report number:**	98421

Client name:	Prime Resources Environmental Consultants	**Contact person:**	Dr Bronwyn Grover
Address:	PO Box 2316, Parklands, 2121	**Email:**	Bronwyn@resources.co.za
		Email:	jonathan@resources.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
HNO3 : HF	0,25	100	400

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.100	<40	<0.010	<4.00
TH1	120309	<0.010	<4.00	6,48	2590	<0.010	<4.00
TH2	120310	<0.010	<4.00	2,56	1025	<0.010	<4.00
TH5	120311	<0.010	<4.00	3,03	1212	<0.010	<4.00
TH6	120312	<0.010	<4.00	1,46	584	<0.010	<4.00
TH7	120313	<0.010	<4.00	8,54	3414	<0.010	<4.00
TH8	120314	<0.010	<4.00	5,54	2218	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	5,58	2231	<0.010	<4.00

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	0,053	21
TH2	120310	<0.010	<4.00	0,104	42	0,216	87
TH5	120311	<0.010	<4.00	0,307	123	0,037	15
TH6	120312	<0.010	<4.00	0,352	141	0,021	8,48
TH7	120313	<0.010	<4.00	0,207	83	0,242	97
TH8	120314	<0.010	<4.00	0,292	117	1,74	697
TH8	120314 D	<0.010	<4.00	0,267	107	1,74	694

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<1	<400
TH1	120309	<0.010	<4.00	<0.010	<4.00	71	28400
TH2	120310	<0.010	<4.00	<0.010	<4.00	37	14800
TH5	120311	<0.010	<4.00	<0.010	<4.00	44	17600
TH6	120312	<0.010	<4.00	<0.010	<4.00	198	79200
TH7	120313	<0.010	<4.00	<0.010	<4.00	181	72400
TH8	120314	<0.010	<4.00	<0.010	<4.00	71	28400
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	71	28400

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	0,011	4,38	0,014	5,76
TH5	120311	<0.010	<4.00	<0.010	<4.00	0,036	14
TH6	120312	<0.010	<4.00	<0.010	<4.00	0,034	14
TH7	120313	<0.010	<4.00	<0.010	<4.00	0,023	9,17
TH8	120314	<0.010	<4.00	<0.010	<4.00	0,071	28
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	0,073	29

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	0,013	5,37	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	0,020	7,84	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	0,014	5,63	<0.010	<4.00	<0.010	<4.00
TH8	120314	0,035	14	<0.010	<4.00	0,022	8,94
TH8	120314 D	0,036	14	<0.010	<4.00	0,023	9,04

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<10	<0.010	<4.00	<0.010	<4.00
TH1	120309	55	22000	<0.010	<4.00	<0.010	<4.00
TH2	120310	710	284000	0,025	10	<0.010	<4.00
TH5	120311	191	76400	<0.010	<4.00	<0.010	<4.00
TH6	120312	103	41200	<0.010	<4.00	<0.010	<4.00
TH7	120313	317	126800	0,022	8,80	<0.010	<4.00
TH8	120314	308	123200	0,222	89	<0.010	<4.00
TH8	120314 D	331	132400	0,215	86	<0.010	<4.00

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<200	<0.010	<4.00	<0.010	<4.00
TH1	120309	4,7	1876	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.5	<200	<0.010	<4.00	<0.010	<4.00
TH5	120311	0,8	326	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.5	<200	<0.010	<4.00	<0.010	<4.00
TH7	120313	9,1	3632	<0.010	<4.00	<0.010	<4.00
TH8	120314	2,4	957	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	2,3	916	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<1	<400	<0.025	<10
TH1	120309	<0.010	<4.00	12	4800	4,45	1780
TH2	120310	<0.010	<4.00	17	6800	146	58400
TH5	120311	<0.010	<4.00	8	3200	1500	600000
TH6	120312	<0.010	<4.00	26	10400	989	395600
TH7	120313	<0.010	<4.00	29	11600	725	290000
TH8	120314	<0.010	<4.00	11	4400	1059	423600
TH8	120314 D	<0.010	<4.00	12	4800	1046	418400

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<1	<400	<0.010	<4.00
TH1	120309	<0.010	<4.00	<1	<400	<0.010	<4.00
TH2	120310	<0.010	<4.00	<1	<400	<0.010	<4.00
TH5	120311	<0.010	<4.00	<1	<400	<0.010	<4.00
TH6	120312	<0.010	<4.00	<1	<400	<0.010	<4.00
TH7	120313	<0.010	<4.00	<1	<400	<0.010	<4.00
TH8	120314	<0.010	<4.00	<1	<400	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<1	<400	<0.010	<4.00

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	0,014	5,77	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	0,020	8,07	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	0,018	7,22	<0.010	<4.00

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	0,046	19	<0.010	<4.00	<0.010	<4.00
TH2	120310	0,315	126	0,098	39	<0.010	<4.00
TH5	120311	0,227	91	0,768	307	<0.010	<4.00
TH6	120312	0,290	116	0,041	17	<0.010	<4.00
TH7	120313	0,204	81	0,097	39	<0.010	<4.00
TH8	120314	0,532	213	0,536	214	<0.010	<4.00
TH8	120314 D	0,255	102	0,565	226	<0.010	<4.00

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	0,010	4,00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.2	<80
TH1	120309	<0.010	<4.00	<0.010	<4.00	280	112000
TH2	120310	<0.010	<4.00	<0.010	<4.00	168	67200
TH5	120311	0,013	5,05	<0.010	<4.00	10,0	4017
TH6	120312	0,020	8,18	<0.010	<4.00	41	16400
TH7	120313	<0.010	<4.00	<0.010	<4.00	161	64400
TH8	120314	<0.010	<4.00	<0.010	<4.00	81	32400
TH8	120314 D	0,018	7,18	<0.010	<4.00	84	33600

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	0,017	6,96
TH2	120310	<0.010	<4.00	<0.010	<4.00	0,067	27
TH5	120311	<0.010	<4.00	<0.010	<4.00	0,018	7,12
TH6	120312	<0.010	<4.00	<0.010	<4.00	0,011	4,49
TH7	120313	<0.010	<4.00	<0.010	<4.00	0,101	40
TH8	120314	<0.010	<4.00	<0.010	<4.00	0,164	66
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	0,161	65

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	1,47	588	<0.010	<4.00
TH2	120310	<0.010	<4.00	0,163	65	<0.010	<4.00
TH5	120311	<0.010	<4.00	0,232	93	<0.010	<4.00
TH6	120312	<0.010	<4.00	0,215	86	<0.010	<4.00
TH7	120313	<0.010	<4.00	0,722	289	<0.010	<4.00
TH8	120314	<0.010	<4.00	0,574	229	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	0,702	281	<0.010	<4.00

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	0,061	24
TH2	120310	<0.010	<4.00	<0.010	<4.00	0,126	50
TH5	120311	<0.010	<4.00	<0.010	<4.00	0,045	18
TH6	120312	<0.010	<4.00	<0.010	<4.00	0,010	4,10
TH7	120313	<0.010	<4.00	<0.010	<4.00	0,263	105
TH8	120314	<0.010	<4.00	<0.010	<4.00	0,136	54
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	0,136	54

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH2	120310	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH5	120311	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH6	120312	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH7	120313	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00
TH8	120314 D	<0.010	<4.00	<0.010	<4.00	<0.010	<4.00

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<4.00	<0.010	<4.00
TH1	120309	<0.010	<4.00	<0.010	<4.00
TH2	120310	0,076	30	<0.010	<4.00
TH5	120311	1,09	434	<0.010	<4.00
TH6	120312	0,073	29	<0.010	<4.00
TH7	120313	0,060	24	<0.010	<4.00
TH8	120314	0,226	90	<0.010	<4.00
TH8	120314 D	0,274	110	<0.010	<4.00

WATERLAB (PTY) LTD

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received:	**2021/06/04**		**Date completed:**	**2021/06/21**
Project number:	**1000**	**Report number: 101013**	**Order number:**	**Quote (Q-P979-4258)**

Client name:	**Prime Resources Environmental Consultants**	**Contact person:**	**Dr Bronwyn Grover**
Address:	**P.O Box 2316, Parklands, 2121**	**Email:**	**bronwyn@resources.co.za**
Telephone:	**011 447 4888**	**Email:**	**prime@resources.co.za**
		Cell:	**082 851 7433**

Analyses				
	TH 7		**TH 8**	
Sample Number	**129984**		**129985**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**Distilled Water**		**Distilled Water**	
Dry Mass Used (g)	**250**		**250**	
Volume Used (mℓ)	**1000**		**1000**	
pH Value at 25˚C	7,8		6,8	
Electrical Conductivity in mS/m at 25˚C	11,2		8,3	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Alkalinity as CaCO3	36	144	24	96
Chloride as Cl	3	12	<2	<8
Sulphate as SO4	7	28	12	48
Nitrate as N	0,7	2,8	0,1	0,4
Nitrite as N	<0.05	<0.20	<0.05	<0.20
Fluoride as F [s]	<0.05	<0.20	<0.05	<0.20
ICP-MS Scan	See ICP DW tab			
X-ray Diffraction [o]	See attached report 101013 XRD			

[o] = Outsourced

[s] = Sub-contracted as our Flouride meter malfunctioned.

S. Laubscher

Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS SCAN ANALYSIS

Date received:	**2021/06/04**	**Date Completed:**	**2021/06/21**
Project number:	**1000**	**Report number:**	**101013**

Client name:	**Prime Resources Environmental Consultants**	**Contact person:**	**Dr Bronwyn Grover**
Address:	**PO Box 2316, Parklands, 2121**	**Email:**	**Bronwyn@resources.co.za**
Telephone:	**011 447 4888**	**Email:**	**prime@resources.co.za**

Extract	Sample Mass (g)	Volume (ml)	Factor
Distilled Water	250	1000	4

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.100	<0.400	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.100	<0.400	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.100	<0.400	<0.010	<0.040

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	1,35	5,40	<0.010	<0.040
TH 8	129985	<0.010	<0.040	0,530	2,12	0,193	0,774

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<1	<4
TH 7	129984	<0.010	<0.040	<0.010	<0.040	14	56
TH 8	129985	<0.010	<0.040	<0.010	<0.040	11	44

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.100	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.025	<0.100	<0.010	<0.040	<0.010	<0.040
TH 8	129985	0,056	0,222	0,036	0,145	<0.010	<0.040

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<2.0	<0.010	<0.040	<0.010	<0.040
TH 7	129984	0,6	2,4	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.5	<2.0	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<1	<4	<0.025	<0.100
TH 7	129984	<0.010	<0.040	4	16	<0.025	<0.100
TH 8	129985	<0.010	<0.040	3	12	0,288	1,15

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<1	<4	<0.010	<0.040
TH 7	129984	<0.010	<0.040	1	4	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<1	<4	<0.010	<0.040

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.2	<0.8
TH 7	129984	<0.010	<0.040	<0.010	<0.040	7,3	29
TH 8	129985	<0.010	<0.040	<0.010	<0.040	5,1	20

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	0,112	0,448
TH 8	129985	<0.010	<0.040	<0.010	<0.040	0,618	2,47

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040	<0.010	<0.040

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.040	<0.010	<0.040
TH 7	129984	<0.010	<0.040	<0.010	<0.040
TH 8	129985	<0.010	<0.040	<0.010	<0.040

WATERLAB

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2021-02-26
Project number: 1000
Report number: 98421
Date completed: 2021-03-23
Order number: Quote (Q-P979-2597)

Client name: Prime Resources Environmental Consultants
Address: PO Box 2316, Parklands, 2121
Telephone: 011 447 4888
Fax: ---

Contact person: Dr Bronwyn Grover
Email: Bronwyn@resources.co.za
Email: jonathan@resources.co.za
Cell: 082 851 7433

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification			
	TH1	**TH2**	**TH5**	**TH6**
Sample Number	**120309**	**120310**	**120311**	**120312**
Paste pH	8.1	8.2	7.8	8.4
Total Sulphur (%) (LECO)	<0.01	<0.01	<0.01	<0.01
Acid Potential (AP) (kg/t)	0.313	0.313	0.313	0.313
Neutralization Potential (NP)	399	38	69	127
Nett Neutralization Potential (NNP)	399	37	68	127
Neutralising Potential Ratio (NPR) (NP : AP)	1277	120	220	407
Rock Type	III	III	III	III

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification		
	TH7	**TH8**	**TH8**
Sample Number	**120313**	**120314**	**120314 D**
Paste pH	7.9	8.2	8.2
Total Sulphur (%) (LECO)	<0.01	<0.01	<0.01
Acid Potential (AP) (kg/t)	0.313	0.313	0.313
Neutralization Potential (NP)	131	52	51
Nett Neutralization Potential (NNP)	130	52	51
Neutralising Potential Ratio (NPR) (NP : AP)	418	167	165
Rock Type	III	III	III

*** Negative NP values are obtained when the volume of NaOH (0.1N) titrated (pH: 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 – 2.5 Any negative NP values are corrected to 0.00.**

Please refer to Appendix **(p.2)** for a Terminology of terms and guidelines for rock classification

S. Laubscher__________________
Assistant Geochemistry Project Manager

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
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Fax: ---

Contact person: Dr Bronwyn Grover
Email: Bronwyn@resources.co.za
Email: jonathan@resources.co.za
Cell: 082 851 7433

APPENDIX: TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
  Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms:* Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
  Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms:* Nett Acid Production Potential (NAPP)
  Calculation: NNP = NP – AP ; NAPP = ANC – MPA
- Neutralising Potential Ratio (NPR)
  Calculation: NPR = NP : AP

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If NNP (NP – AP) < 0, the sample has the potential to generate acid
If NNP (NP – AP) > 0, the sample has the potential to neutralise acid produced

Any sample with NNP < 20 is potentiall acid-generating, and any sample with NNP > -20 might not generate acid (Usher *et al*., 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

S. Laubscher__________________
Assistant Geochemistry Project Manager

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

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Telephone: 011 447 4888
Fax: ---

Contact person: Dr Bronwyn Grover
Email: Bronwyn@resources.co.za
Email: jonathan@resources.co.za
Cell: 082 851 7433

CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al*., 1997; Usher *et al*., 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	**< 1:1**	Likely AMD generating
Possibly	**1:1 – 2:1**	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	**2:1 – 4:1**	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	**>4:1**	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
3) NPR ratios of 3:1 to 1:1 are consider inconclusive.
4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al*., 2003)

S. Laubscher__________________
Assistant Geochemistry Project Manager

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
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Telephone: 011 447 4888
Fax: ---
Contact person: Dr Bronwyn Grover
Email: Bronwyn@resources.co.za
Email: jonathan@resources.co.za
Cell: 082 851 7433

REFERENCES

LAWRENCE, R.W & WANG, Y. 1997. **Determination of Neutralization Potential in the Prediction of Acid Rock Drainage**. Proc. 4th International Conference on Acid Rock Drainage. Vancouver. BC. pp. 449 – 464.

PRICE, W.A., MORIN, K. & HUTT, N. 1997. **Guidelines for the prediction of Acid Rock Drainage and Metal leaching for mines in British Columbia**: Part 11. Recommended procedures for static and kinetic testing. In: Proceedings of the Fourth International Conference on Acid Rock Drainage. Vol 1. May 31 – June 6. Vancouver, BC., pp. 15 – 30.

SOBEK, A.A., SCHULLER, W.A., FREEMAN, J.R. & SMITH, R.M. 1978. **Field and laboratory methods applicable to overburdens and minesoils**. EPA-600/2-78-054. USEPA. Cincinnati. Ohio.

SOREGAROLI, B.A. & LAWRENCE, R.W. 1998. Update on waste Characterisation Studies. Proc. Mine Design, Operations and Closure Conference. Polson, Montana.

USHER, B.H., CRUYWAGEN, L-M., DE NECKER, E. & HODGSON, F.D.I. 2003. **Acid-Base : Accounting, Techniques and Evaluation (ABATE): Recommended Methods for Conducting and Interpreting Analytical Geochemical Assessments at Opencast Collieries in South Africa.** Water Research Commission Report No 1055/2/03. Pretoria.

ENVIRONMENT AUSTRALIA. 1997. **Managing Sulphidic Mine Wastes and Acid Drainage**.

S. Laubscher___________________
Assistant Geochemistry Project Manager

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2021-06-04
Project number: 1000

Report number: 101013

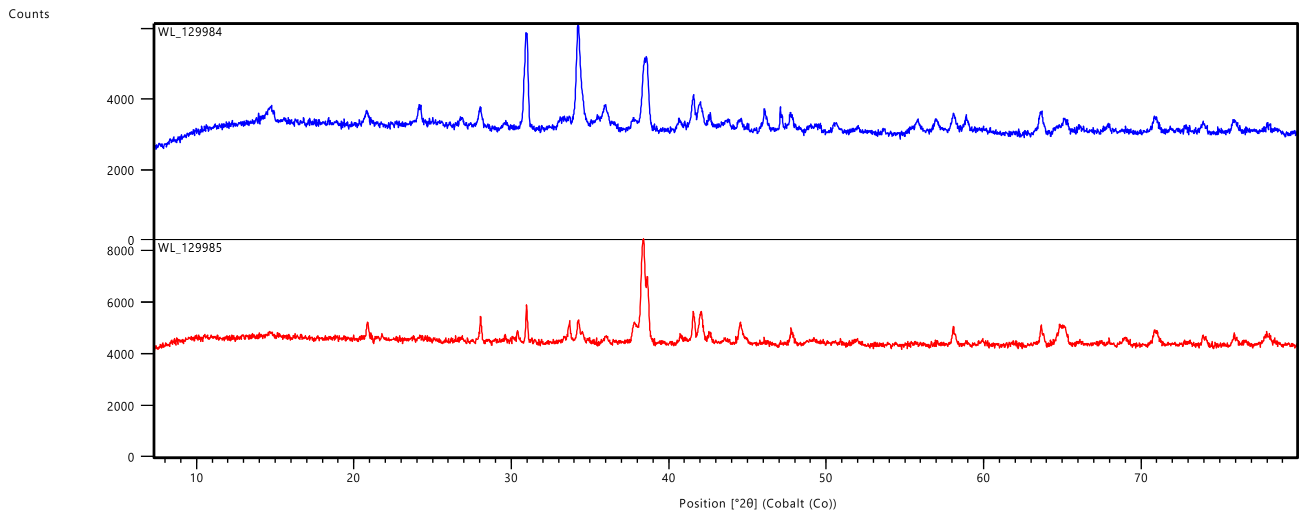
Date completed: 2021-06-21
Order number: Quote (Q-P979-4258)

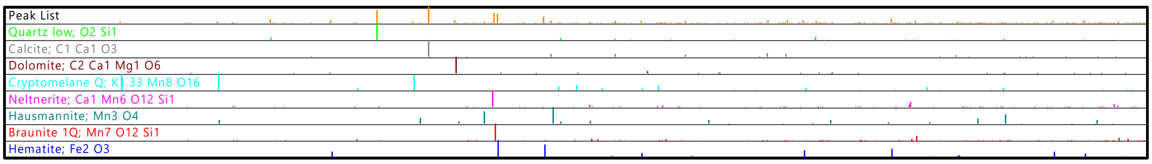
Client name: Prime Resources Environmental Consultants
Address: PO Box 2316, Parklands, 2121
Telephone: 011 447 4888
Fax: ---

Contact person: Dr Bronwyn Grover
Email: bronwyn@resources.co.za
Email: prime@resources.co.za
Cell: 082 851 7433

Composition (%) [o]			
TH 7		**TH 8**	
129984		**129985**	
Mineral	Amount (weight %)	**Mineral**	Amount (weight %)
Quartz	16.4	**Quartz**	5.3
Calcite	26.6	**Calcite**	8.3
Dolomite	18.9	**Dolomite**	2.3
Cryptomelane	10.4	**Cryptomelane**	3.5
Neltnerite	0.5	**Neltnerite**	19.6
Hausmannite	3.1	**Hausmannite**	19
Braunite 1	9.4	**Braunite 1**	20.3
Hematite	14.8	**Hematite**	21.6

[o] = Outsourced





S. Laubscher____________________
Assistant Geochemistry Project manager

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
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Address: PO Box 2316, Parklands, 2121
Telephone: 011 447 4888
Fax: ---
Contact person: Dr Bronwyn Grover
Email: bronwyn@resources.co.za
Email: prime@resources.co.za
Cell: 082 851 7433

Note:

The material was prepared for XRD analysis using a back loading preparation method.
Diffractograms were obtained using a Malvern Panalytical Aeris diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software.
The relative phase amounts (weight %) were estimated using the Rietveld method.

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group.
- Distinction between Braunite 1, Bixbyite, Neltnerite and Braunite 2 is not always clear and errors may occur. The best fitting phases were used in the results.
- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown.
- Traces of additional phases may be present.
- Amorphous phases, if present, were not taken into consideration during quantification.

Ideal Mineral compositions:

Calcite	CaCO3
Quartz	SiO2
Dolomite	Ca Mg (CO3)2
Hausmannite	Mn3O4
Neltnerite	CaMn6 (SiO4) O8
Braunite	Mn Mn6 O8 (SiO4)
Hematite	Fe2O3
Cryptomelane	KMn8O16

S. Laubscher___________________
Assistant Geochemistry Project manager

APPENDIX 21

IMPACT ASSESSMENT REPORT

Prime Resources (Pty) Ltd
The Workshop 70–7th Avenue Parktown North 2193
PO Box 2316 Parklands 2121
T +27 11 447 4888 **F** +27 86 604 2219 **E** prime@resources.co.za
www.resources.co.za

prime | resources
environmental consultants

TAWANA HOTAZEL MINING (PTY) LTD

IMPACT ASSESSMENT FOR THE PROPOSED TAWANA HOTAZEL MINE, NORTHERN CAPE PROVINCE

JANUARY 2022

PREPARED FOR:

Tawana Hotazel Mining

124 Beyers Naude Drive
Roosevelt Park
Johannesburg
2195

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1. INTRODUCTION AND BACKGROUND

This report is to be read in conjunction with the Environmental Impact Assessment Report (EIAR) and the Environmental Management Programme (EMPr), as compiled for the proposed Tawana Hotazel Mine (THM).

1.1. Specialist Studies

Specialist service providers within their respective fields were commissioned to undertake studies to investigate the baseline conditions of the receiving environment as well as to assess the potential impact that the activities and aspects of the proposed THM may have. The following specialist studies were conducted:

Specialist Report	Author
Air Quality, Greenhouse Gas Emissions and Climate Change Impact Assessment	Airshed Planning Professionals (Pty) Ltd
Agricultural Compliance Statement	Digital Soils Africa (Pty) Ltd
Palaeontological Impact Assessment	Professor Marion Bamford
Heritage Impact Assessment	Archaetnos Culture & Cultural Resource Consultants
Noise Impact Assessment	Airshed Planning Professionals (Pty) Ltd
Surface water Impact Assessment	iLanda Technologies (Pty) Ltd
Groundwater Impact Assessment	Future Flow Groundwater and Project Management
Terrestrial Biodiversity Impact Assessment	Field and Form Landscape Science in collaboration with Malachite Ecological Services
Avifaunal Impact Assessment	Feathers Environmental Services
Aquatic Biodiversity Compliance Statement	Ecology International (Pty) Ltd
Blasting and Vibrations Impact Assessment	Blast Management and Consulting
Traffic Impact Assessment	Merchelle's Collective (Pty) Ltd
Geochemical Assessment	Prime Resources (Pty) Ltd

1.2. Impact Rating Methodology

The Prime Resources Impact Assessment Methodology and rationale was used to assess the significance of the potential impacts of the initial layouts on the surrounding biophysical and socio-economic environments.

The objective of the Impact Assessment is to rate the significance of potential impacts of the project prior to and after the implementation of mitigation measures. The methodology encompasses an assessment of the nature, consequence (magnitude, extent, duration) and probability (likelihood) of the identified potential environmental and social impacts of the project. The reversibility of the impact as well as the cumulative impact are also considered. The impact is assessed prior to and after implementation of potential mitigation measures. Where mitigation was recommended these have been included and the significance of the particular impact then determined following mitigation (these values are indicated within square brackets).

The following risk assessment model has been used for determination of the significance of impacts.

Significance = (magnitude + duration + scale) x probability

The maximum potential value for significance of an impact is 100 points. Environmental impacts can therefore be rated as high, medium or low significance on the following basis:

High environmental significance	60 – 100
Medium environmental significance	30 – 59
Low environmental significance	0 – 29

Magnitude (M)	
Minor (2)	Change not measurable; or threshold never exceeded There is no need for people to adapt and will not notice changes to livelihoods and lifestyles
Low (4)	Low disturbance of degraded areas, which have little conservation value. Minor change in species occurrence or variety Minor deterioration (nuisance or minor deterioration) or harm to receptors Change to receiving environment not measurable; or identified threshold never exceeded People are able to adapt and maintain pre-impact livelihoods and lifestyles
Moderate (6)	Moderate/measurable deterioration or harm to receptors Receiving environment moderately sensitive Identified threshold occasionally exceeded People are able to adapt with difficulty (with no resettlement). Pre-impact livelihoods and lifestyles can be maintained with difficulty or with support or intervention. Disturbance of areas that have potential conservation value or are of use as resources Complete change in species occurrence or variety
High (8)	High, measurable deterioration or harm to receptors Receiving environment highly sensitive Identified threshold often exceeded Pre-impact livelihoods and lifestyles cannot be maintained or resettlement is required
Very High / Unknown (10)	Loss of ecosystem function Loss of an irreplaceable natural resource (including cultural and heritage resources) Disturbance of pristine areas that have important conservation value Human health and or safety is compromised Receptors of impact are of conservation importance; or identified threshold (such as SANS limits, Resource Quality Objectives, etc.) consistently exceeded Unknown
Scale (S)	
Footprint (0)	Occurs only within the footprint of the activity
Site (1)	Occurs only within the site of the project
Local (2)	Occurs within approximately 2.5 km of the activity
Regional (3)	A regional scale as determined by administrative boundaries, habitat type/ecosystem or regional loss of a species population.
National (4)	Nationally important or macro-economic consequences
International (5)	Internationally important agreements and resources are affected such as areas protected by international conventions, international waters etc. Unknown
Duration (D)	
Immediate (1)	Completely reversible without management Impact is instantaneous and ceases imminently
Short (2)	Naturally reversible or reversible with minimal management Impact ceases when the activity ceases
Medium (3)	Impact can be reversed with sufficient management Impact ceases when project ends
Long (4)	Impact is potentially irreversible even with management
Permanent (5)	Impact remains after the life of the project The impact will continue indefinitely / ad infinitum Unknown
Probability (P)	
Improbable (1)	Improbable, almost impossible
Unlikely (2)	Low probability, unlikely to occur
Likely (3)	Medium probability, likely to occur
Expected (4)	High probability, expected to occur
Definite (5)	Definite (certain) or unknown

2. DESCRIPTION AND ASSESSMENT OF POTENTIAL IMPACTS

The potential environmental impacts are described per environmental receptor for each phase of the development. Where mitigation was recommended these have been included. This section ends with a qualitative assessment of cumulative impacts, defined as the potential contribution of THM to the overall existing impacts in the surrounding area.

2.1. Air quality

The significant receptors near the THM include the residential areas of Hotazel, Blackrock, Mogojaneng, and Magobing which are made up of individual residences, schools, medical facilities as well as contractors and leisure accommodation. There are also isolated homesteads, contractors and leisure accommodation and mining villages near THM that would also be classified as sensitive receptors. The main sources likely to contribute to baseline PM emissions include mining and processing operations, vehicle entrained dust from local roads, vehicle exhaust and windblown dust from exposed areas. Other sources of PM include farm activities, occasional biomass burning and household fuel burning in the individual residences. The area is dominated by winds from the north-east. The northerly winds are associated with wind speeds of above 6 m/s. According to the US EPA wind speeds exceeding 5 m/s are likely to result in windblown dust emissions.

2.1.1. Construction phase

The sources of atmospheric emissions during the site preparation and construction phase include:

- **Particulate emissions** from stripping of topsoil, excavation of sand, materials handling, bulldozing, erosion of stockpiles due to the wind lifting and dispersing loose material during high wind incidents (>5m/s), entrainment of loose material at unpaved areas because of the movement of mobile equipment in these areas and grading of unpaved roads.
- **Particulate and gaseous emissions** from mobile equipment exhausts, diesel generators exhausts, barge diesel generators used for the void/pit dewatering and evaporators used for the void/pit dewatering.

Direct impacts on **human health may be impaired** as a result of increased pollutant concentrations (inhalable particulate matter (PM_{10}), respirable particulate matter ($PM_{2.5}$), SO_2, NO_x or CO) associated with the construction activities may occur. There may also be a direct impact on amenities from an **increase in nuisance dust fall rates** (PM_{30}) as a result of the construction activities. There may also be a potential direct **impact on vegetation health** and an indirect impact on animal and human health, and amenities from increased dustfall rates (PM_{30}) and pollutant concentrations (SO_2 and NO_x) due to the construction phase activities. It is not anticipated that the various construction activities will result in higher PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO ground level concentrations (GLCs) and dustfall rates than the operational phase activities.

Mitigation and management measures for the potential impacts include the following:

- Use water bowsers on unpaved roads;
- Use water sprays at stockpiles and handling points; and
- Limit construction (including mobile equipment) activities to take place during day-light hours.

2.1.2. Operational phase

The sources of atmospheric emissions during the operational phase include:

- **Particulate emissions** from blasting, excavations, materials handling, crushing and screening, bulldozing as part of stockpile management, erosion of RoM, product, topsoil and sand stockpiles and portions of the waste stockpiles due to the wind lifting and dispersing loose material during high wind incidents (>5m/s), entrainment of loose material along the unpaved in-pit, haul roads and access roads because of vehicles travelling along these roads and grading of unpaved haul roads and access roads.
- **Particulate and gaseous emissions** from vehicles exhausts and diesel generators exhausts.

The main pollutants of concern with regards to human health impacts are PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, Mn and diesel exhaust as diesel particulate matter (DPM). Given the size of the fallout dust particles, dustfall rates could reduce the efficiency of panels at the solar facility as well as being a nuisance to residents as well as contractors and leisure accommodation owners. The source group that was determined to contribute the most to the annual PM_{30}/TSP, PM_{10}, and $PM_{2.5}$ emissions for unmitigated operations is vehicles travelling along unpaved roads.

Direct impacts on **human health may be impaired** as a result of increased pollutant concentrations (PM_{10}, $PM_{2.5}$, SO_2, NO_x or CO) associated with the operational activities may occur. Simulated results (see below) show that the NAAQS are exceeded at multiple AQSRs, thus the simulated operations are likely to be a significant risk to human health at the existing surrounding receptors. There may also be a potential direct impact on **vegetation health** and an indirect impact on animal and human health, and amenities from increased dustfall rates (PM_{30}) and pollutant concentrations (SO_2 and NO_x) due to the operational phase activities.

Inhalable particulate matter (PM_{10})

Without mitigation applied, simulated annual average PM_{10} concentrations exceed the National Ambient Air Quality Standards (NAAQS) of 40 µg/m^3 at multiple Air Quality Sensitive Receptors (AQSRs) (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 1). With the design mitigation measures applied, simulated annual average PM10 concentrations exceed the NAAQS of 40 µg/m^3 but not at any AQSRs (Figure 2).

Without mitigation applied, the 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is exceeded at multiple AQSRs (most residences in Hotazel as well as Hotazel College, Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic) (Figure 3). With design mitigation measures applied, the 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic) (Figure 4).

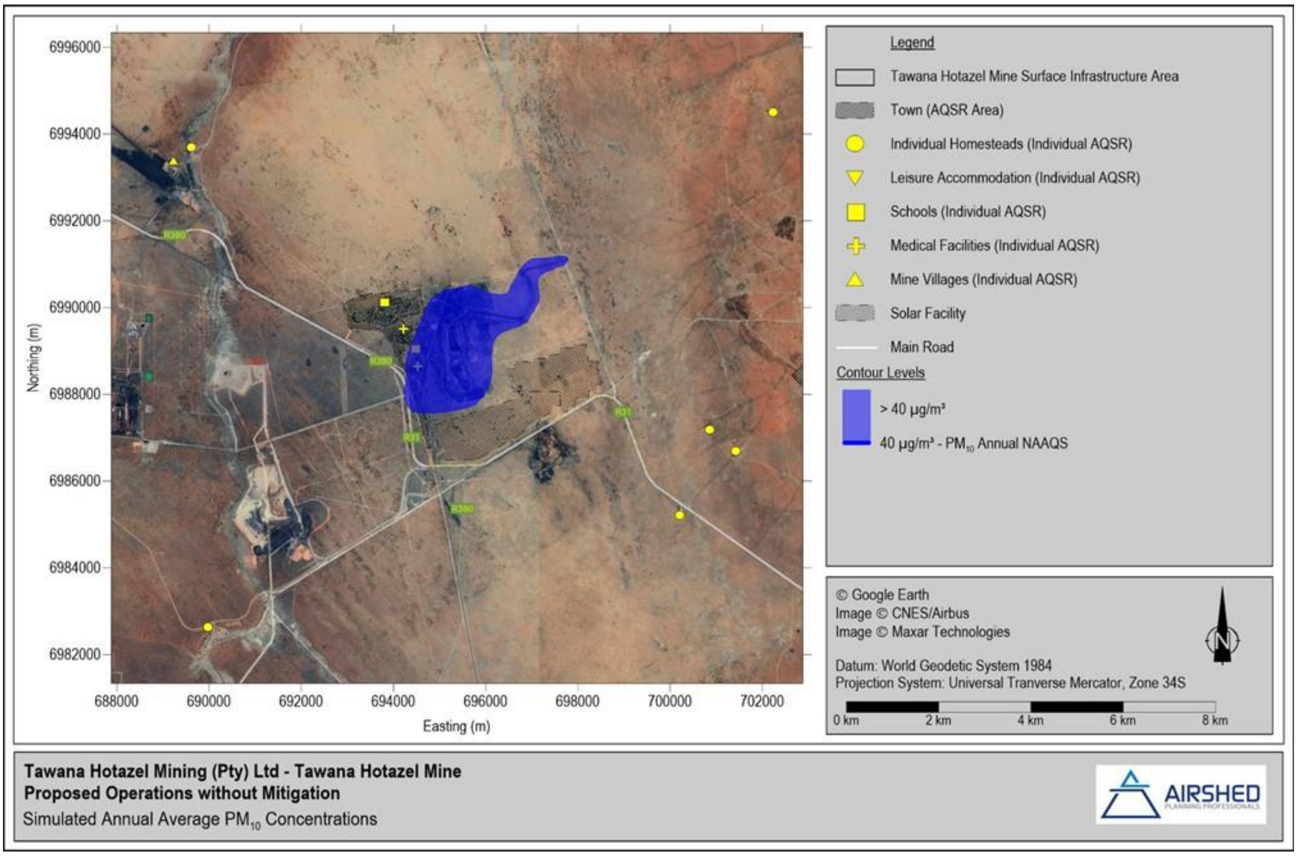

Figure 1: Simulated annual average PM10 concentrations as a result of the THM without mitigation measures

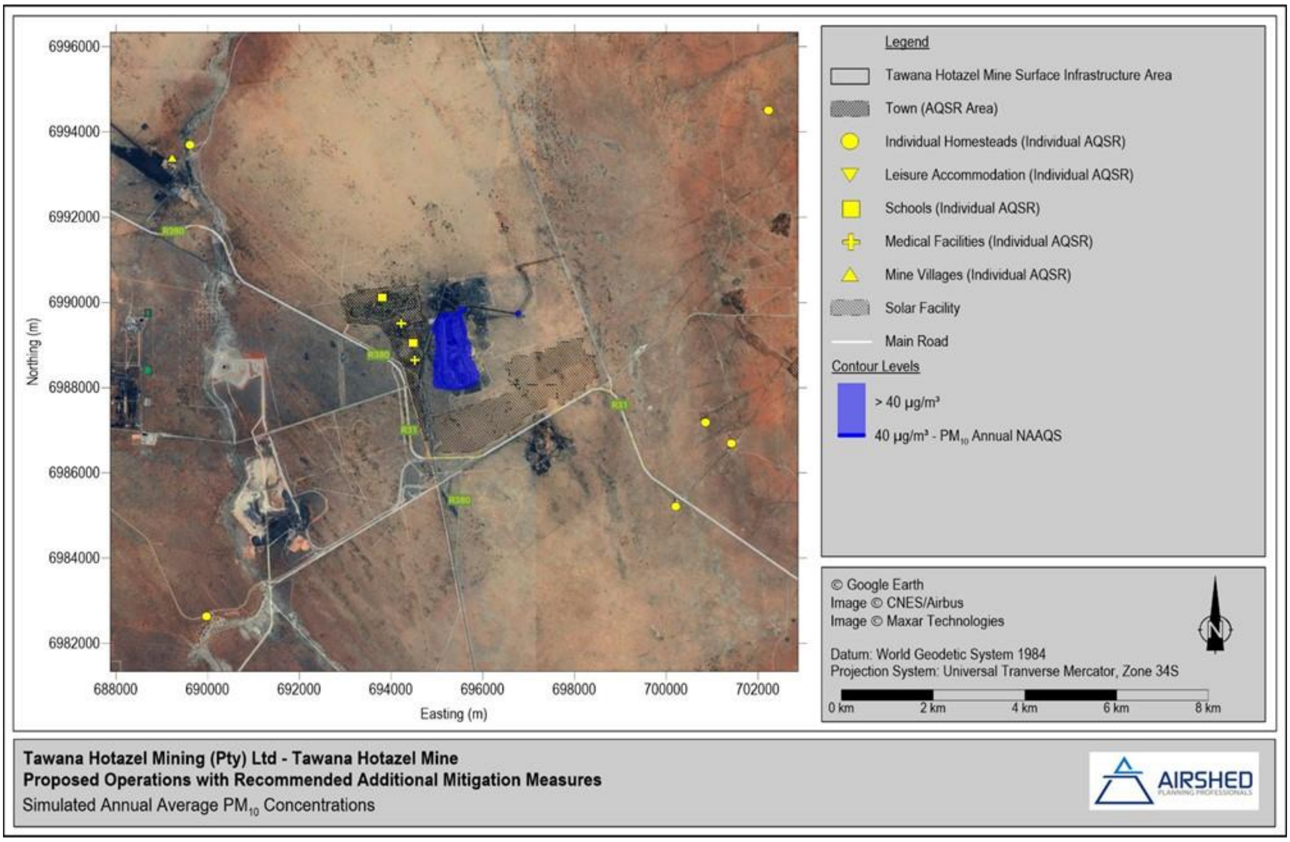

Figure 2: Simulated annual average PM_{10} concentrations as a result of the THM with mitigation measures applied

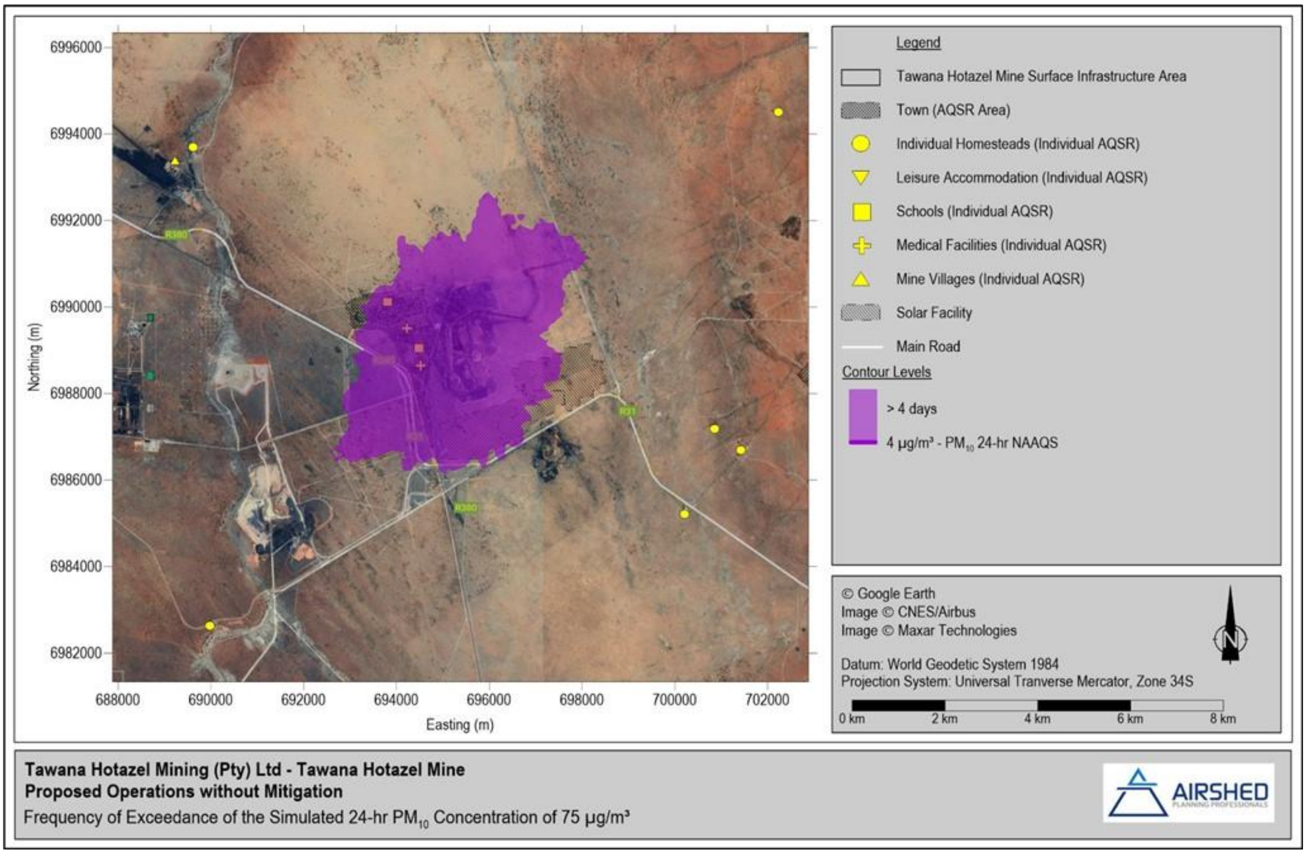

Figure 3: Simulated area of exceedance of the 24-hr PM_{10} NAAQS concentration as a result of the THM without mitigation measures

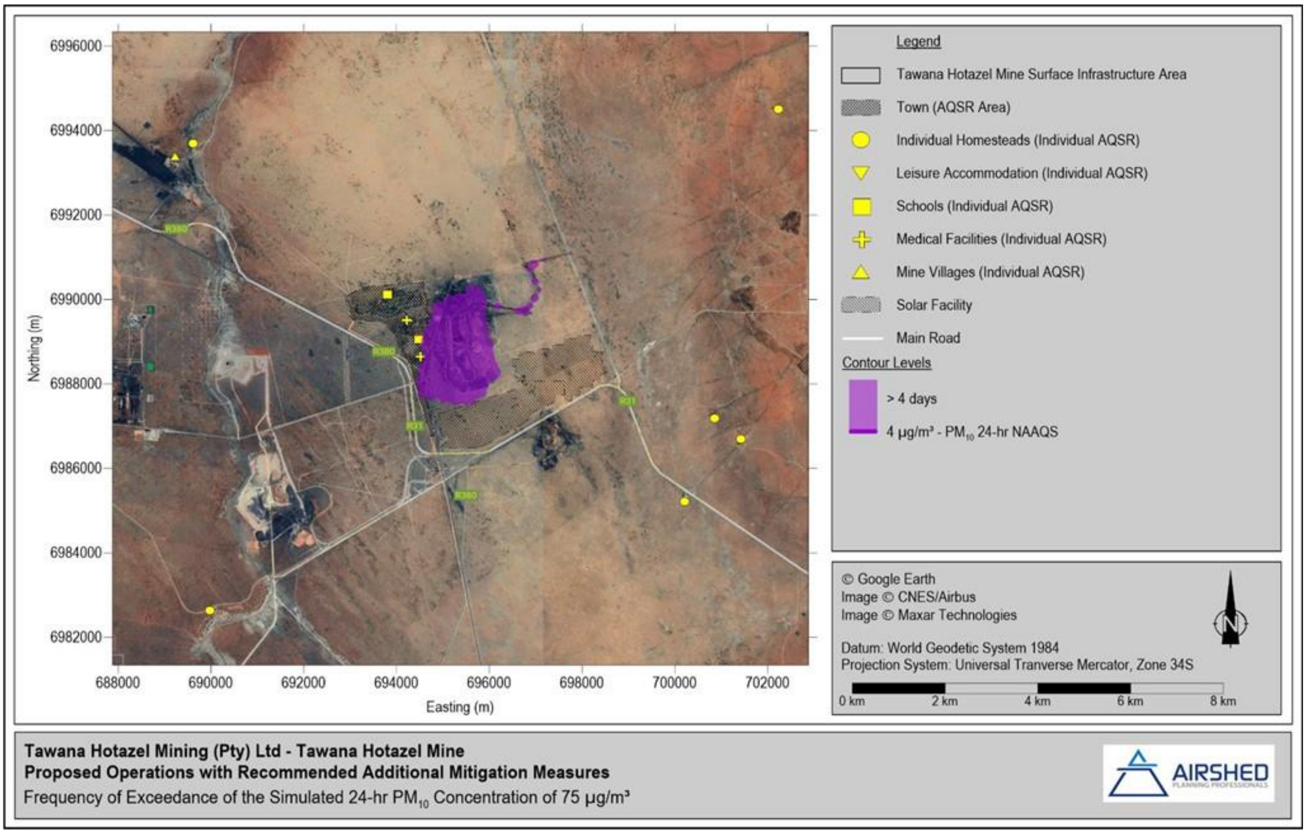

Figure 4: Simulated area of exceedance of the 24-hr PM_{10} NAAQS concentration as a result of the THM with mitigation measures applied

Respirable particulate matter ($PM_{2.5}$)

Without and with mitigation applied, simulated annual average $PM_{2.5}$ concentrations exceed the current and future NAAQS of 20 µg/m^3 and 15 µg/m^3 but not at any AQSRs (Figure 5 and Figure 6).

Without mitigation applied, the current 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) and with design mitigation measures applied, the current 24-hour NAAQS is exceeded but not at any AQSRs (Figure 7). Without and with mitigation applied, the 24-hour future NAAQS (4 days of exceedance of 25 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 8).

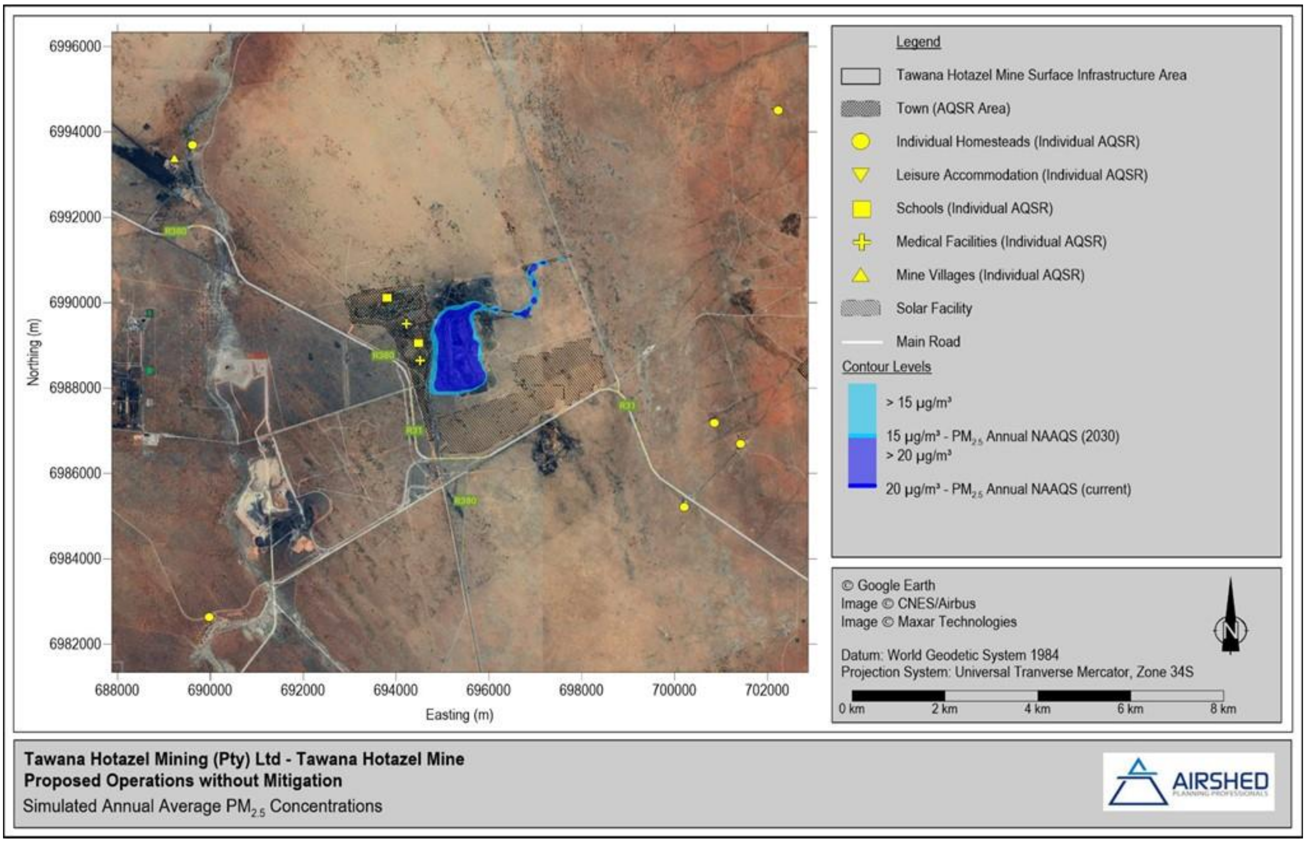

Figure 5: Simulated annual average PM2.5 concentrations as a result of the THM without mitigation measures

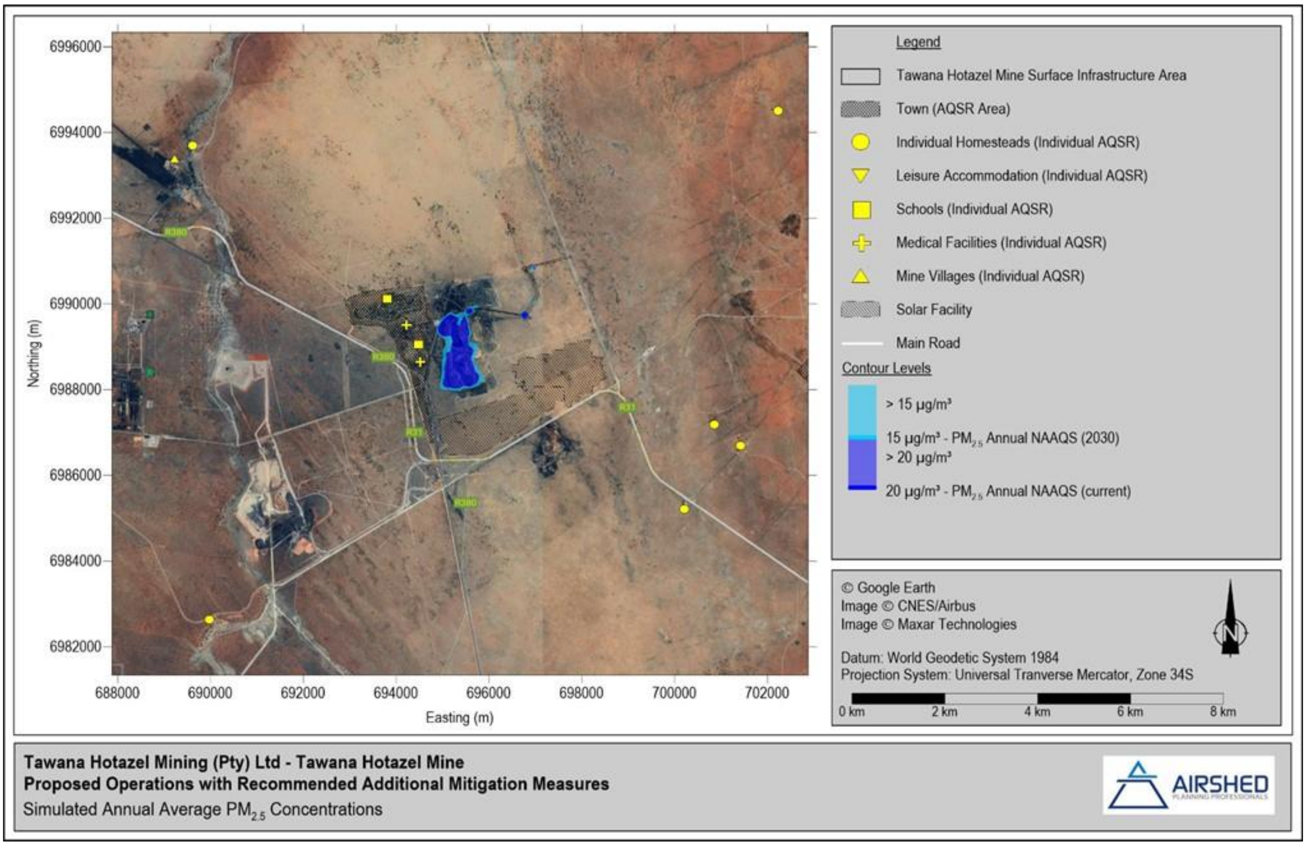

Figure 6: Simulated annual average $PM_{2.5}$ concentrations as a result of the THM with mitigation measures applied

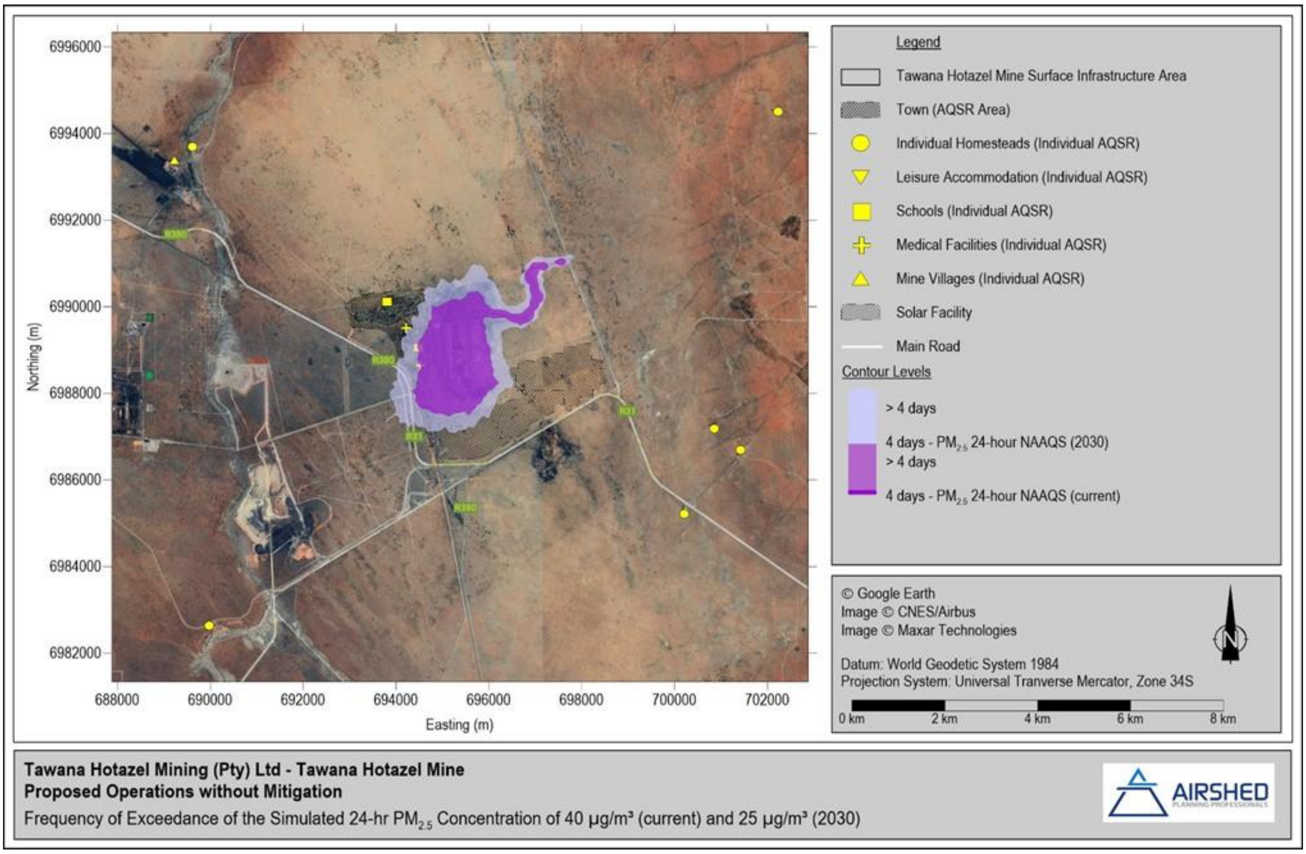

Figure 7: Simulated area of exceedance of the current and future 24-hr $PM_{2.5}$ concentration as a result of the THM without mitigation measures

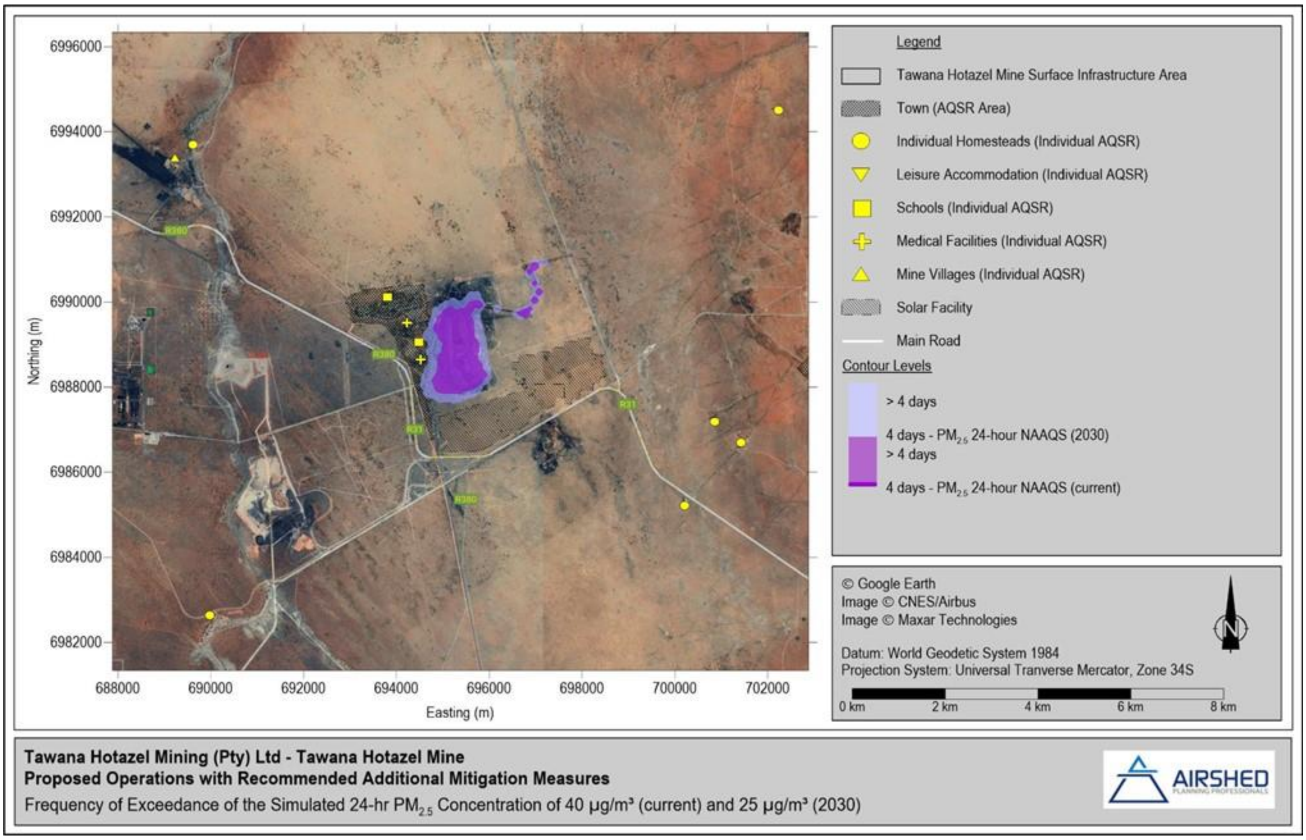

Figure 8: Simulated area of exceedance of the current and future 24-hr $PM_{2.5}$ concentration as a result of the THM with mitigation measures applied

Manganese (Mn)

The potential Mn GLCs is based on applying 32% Mn content to simulated PM_{10} concentrations as a result of activities associated with RoM and product material. The calculated annual average Mn concentrations (based on simulated PM_{10}) exceed the WHO Chronic Inhalation Guideline Value of 0.15 µg/m^3 at all AQSR in Hotazel town without and with mitigation measures applied.

Diesel Particulate Matter (DPM)

Simulated annual average DPM concentrations without mitigation exceeded the United States Environmental Protection Agency (EPA) Integrated Risk Information System Inhalation reference concentrations of 5 µg/m^3 but not at any of the AQSRs. The California EPA cancer unit risk factors URF of $3x10^{-4}$ (µg/m^3)$^{-1}$ was applied to simulated annual average concentrations to provide a conservative estimate of increased lifetime cancer risk (ILCR) since it assumes an individual will be exposed to this concentration constantly over a period of 70 years. Increased lifetime cancer risk at AQSRs range between very low (less than 1:1 000 000) and low (between 1:1 000 000 and 1:10 000); the AQSRs where the ILCR was estimated to be low are all residences in Hotazel town as well as Hotazel College, Hotazel Combined School, Life Occupational Health, Hotazel Manganese Mines Clinic and Wessels Clinic.

Sulfur dioxide (SO_2)

Simulated annual average SO_2 concentrations without mitigation do not exceed the NAAQS of 50 µg/m^3. The 24-hour NAAQS (4 days of exceedance of 125 µg/m^3) and 1-hour NAAQS (88 hours of exceedance of 350 µg/m^3) are also not exceeded and the concentrations are below the NAAQ limits.

Nitrogen dioxide (NO_2)

Simulated annual average NO_x concentrations without mitigation exceed the NAAQS of 40 µg/m^3 at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic). The 1-hour NAAQS (88 hours of exceedance of 200 µg/m^3) is exceeded at multiple AQSRs (most residences in Hotazel as well as Hotazel College, Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic). The simulated annual NO_x concentrations without mitigation exceed the critical level for all vegetation types. It was conservatively assumed that all NO_x is converted to NO_2. The simulated operations could be a risk to flora health and indirectly fauna health and aesthetic preferences for the surrounding (undeveloped) environment (nuisance impact).

Carbon monoxide (CO)

The 8-hour NAAQS (11 of exceedance of 8-hour rolling average concentrations of 10 000 µg/m^3) and 1-hour NAAQS (88 hours of exceedance of 30 000 µg/m^3) are not exceeded and the concentrations without mitigation are below the NAAQ limits.

There may also be a direct impact on amenities from an **increase in nuisance dust fall rates** (total suspended particulates (TSP)/ PM_{30}) as a result of the operational activities. Dust fallout is associated with nuisance impacts and not human health impacts; however, it could also compromise photosynthetic rates depending on species sensitivity.

Based on the highest monthly simulated TSP deposition rates for unmitigated operations, the daily average dustfall rates exceed the National Dust Control Regulations (NDCR) limit for non-residential areas (1 200 mg/m^2-day); but are below the NDCR limit for residential areas (600 mg/m^2-day) at AQSRs and the selected limit for agricultural areas (400 mg/m^2-day) at all agricultural operations (Figure 9). The highest dustfall rate at the solar facility to the south-east is 103 mg/m^2-day and the lowest is 6 mg/m^2-day.

Based on the highest monthly simulated TSP deposition rates for mitigated operations, the daily average dustfall rates exceeds the NDCR limit for non-residential areas (1 200 mg/m^2-day) on-site only; but are below the NDCR limit for residential areas (600 mg/m^2-day) at AQSRs and the selected limit for agricultural areas (400 mg/m^2-day) at all agricultural operations (Figure 10). The highest dustfall rate at the solar facility to the south-east is 24 mg/m^2-day and the lowest is 1 mg/m^2-day.

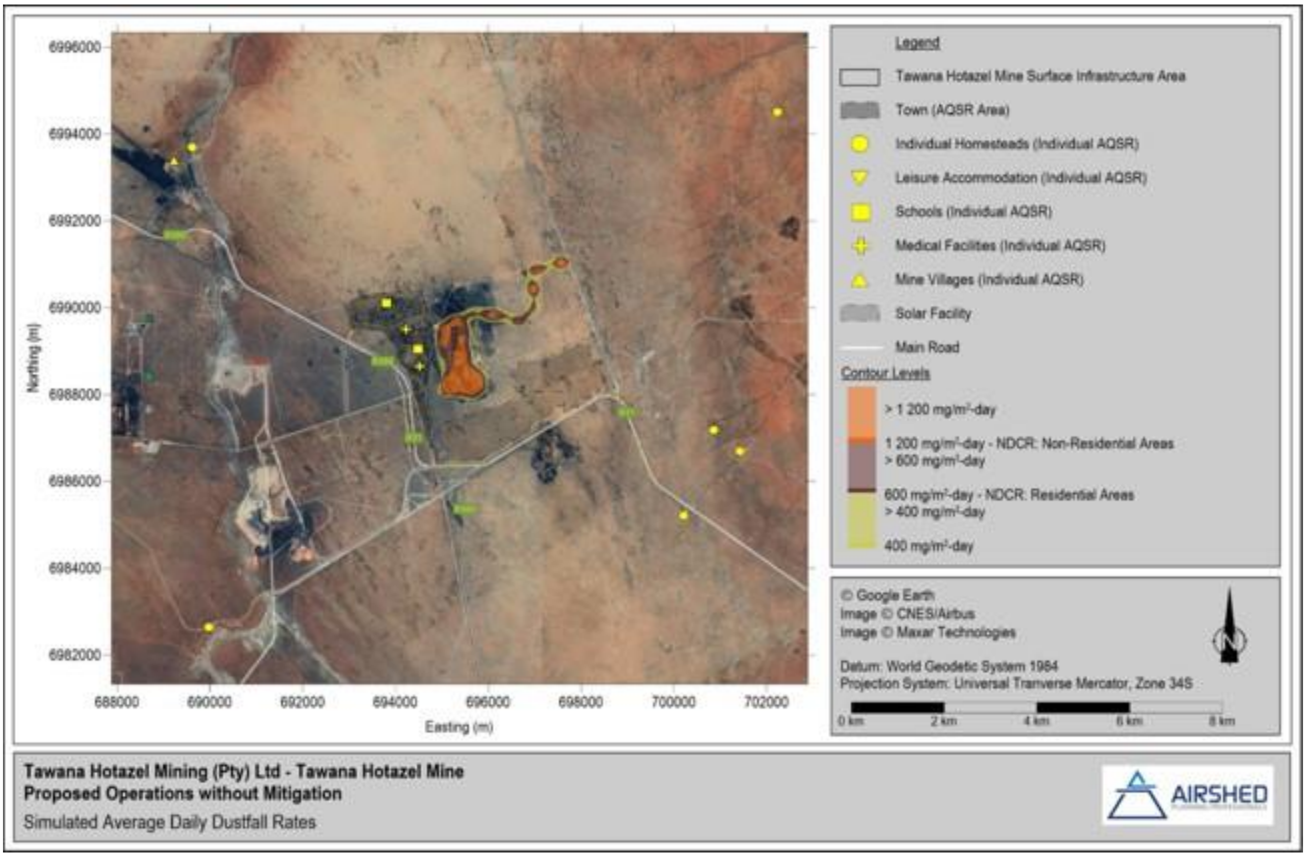

Figure 9: Simulated average daily dustfall rates as a result of the THM without mitigation measures

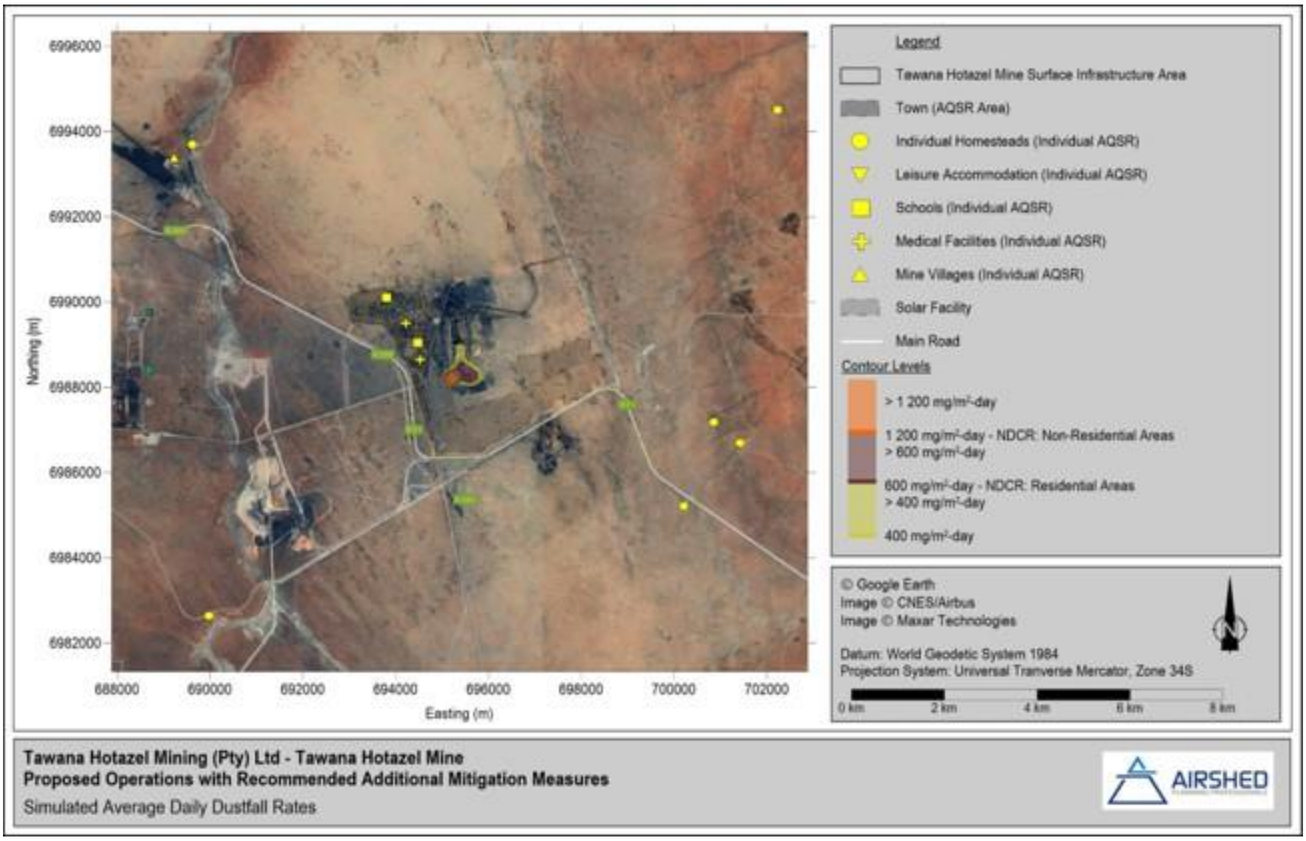

Figure 10: Simulated average daily dustfall rates as a result of the THM with mitigation measures applied

Mitigation and management measures for the potential impacts include the following:

- Level 2 watering (> 2 litres/m^2/h) on in-pit and waste stockpiles unpaved roads;
- Use chemical suppressants on the surface haul roads and access road; and
- Use water sprays at the crusher and screen.
- Implement an effective inspection and maintenance program to ensure vehicles remain in good condition and to reduce emissions from vehicles.
- Mobile equipment emission testing for PM, SO_2 and NO_x should be conducted regularly as part of the inspection and maintenance program.

2.1.3. Decommissioning and closure phase

It is assumed that all operations will have ceased by the decommissioning phase. It is expected that all surface infrastructure will be demolished and removed except for roads which will remain for public use. It is also expected that the stockpile surfaces will be covered with topsoil and vegetated. The potential for air quality impacts during the closure phase will depend on the extent of demolition and rehabilitation efforts during decommissioning and on features which will remain.

The likely activities associated with the decommissioning phase of the operations are:

- infrastructure removal/demolition.
- topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings.
- vehicle entrainment on unpaved road surfaces during rehabilitation. Once that is done, vehicle activity associated with THM should cease.
- exhaust emissions from vehicles utilised during the closure phase. Once that is done, vehicle activity associated with THM should cease.

The closure phase includes the period of aftercare and maintenance after the decommissioning phase. During this phase rehabilitated areas are checked and maintained. The activities that may be included are irregular and minimal vehicle entrainment on roads and vehicle exhaust emissions when the property is checked on. It is anticipated that the various activities would not result in higher $PM_{2.5}$ and PM_{10} GLCs and dustfall rates than the operational phase activities.

Human health may be impaired as a result of increased pollutant concentrations associated with the decommissioning and closure activities. There may also be an **increase in nuisance dust fall rates** as a result of the decommissioning activities.

Mitigation and management measures for the potential impacts include the following:

- Measures specified for the construction and operational phase must continue to be implemented into the closure and decommissioning phase until such time as closure objectives for air quality and dust fallout are achieved.

2.1.4. Post closure phase

There is a risk of **emissions arising from the in-pit waste rock dumps** and denuded during dry and windy conditions due to ineffective rehabilitation which may have the potential for dispersion to sensitive receptors.

Mitigation and management measures for the potential impacts include the following:

- Shape dumps to achieve deposit stabilisation and establish vegetation on the crests of the dumps.

Table 1: Air quality impact assessment

Activity	Potential impact	M	S	D	P		Significance
Construction phase							
Pit dewatering, clearing of vegetation, topsoil stripping and sand removal, and stockpiling of these soil resources, handling and storage of construction materials, collection, storage, and removal of construction related waste, transportation of materials and waste on-site and along the access roads, construction of infrastructure required for the operational phase, diesel generators and construction equipment operation	Direct impact on human health may be impaired as a result of increased pollutant concentrations	3 [3]	2 [1]	2 [2]	3 [2]	21 [12]	Low [Low]
	Direct impact on vegetation health and an indirect impact on animal and human health, and amenities from increased dustfall rates and pollutant concentrations	3 [1]	2 [0]	2 [2]	2 [1]	14 [3]	Low [Low]
	Direct impact on amenities from an increase in nuisance dust fall rates	2 [1]	2 [1]	2 [2]	2 [2]	12 [8]	Low [Low]
Operational phase							
Mining activities including stockpiling of topsoil and drilling, blasting, excavations, materials handling, crushing and screening, bulldozing, wind erosion, vehicle entrained dust from unpaved roads, vehicle exhausts, grading of unpaved roads and diesel generator exhausts	Direct impact on human health may be impaired as a result of increased pollutant concentrations	6 [4]	2 [2]	4 [4]	4 [3]	48 [30]	Med [Med]
	Direct impact on vegetation health and an indirect impact on animal and human health, and amenities from increased dustfall rates and pollutant concentrations	3 [1]	2 [0]	4 [4]	2 [1]	18 [5]	Low [Low]
	Direct impact on amenities from an increase in nuisance dust fall rates	4 [4]	2 [2]	4 [4]	3 [2]	30 [20]	Med [Low]
Decommissioning and closure phase							
Decommissioning and rehabilitation of the THM-infrastructure removal/demolition, topsoil placement and re-vegetation of surroundings, vehicle entrainment on unpaved road surfaces and exhaust emissions from vehicles	Human health may be impaired as a result of increased pollutant concentrations	4 [2]	2 [1]	2 [2]	2 [2]	18 [10]	Low [Low]
	Increase in nuisance dust fall rates	2 [2]	1 [1]	2 [2]	2 [2]	15 [15]	Low [Low]
Post closure							
Ineffective rehabilitation/ re-vegetation	Nuisance dust fall arising from the in-pit waste rock dumps and denuded areas during dry and windy conditions	6 [4]	2 [1]	3 [2]	3 [2]	33 [14]	Med [Low]

2.2. Soil, land use and land capability

2.2.1. Construction phase

Most of the site footprint is dominated by historic mining activities and therefore minimal soil is present. During construction, **soil at the site may be exposed to contamination by hydrocarbon spills, and topsoil may be lost during the clearing of vegetation**. The integrity and capability of soil may also be lost due to compaction from the movement of heavy vehicles and machinery as well as ineffective stockpiling and management of soil stockpiles. The potential impact of soil loss is permanent, and the soil will be needed for rehabilitation during the closure phase of the project. Large areas of the site are situated on previously disturbed land where the soil integrity has already been altered.

Mitigation and management measures for the potential impacts include the following:

- Employing effective soil management, minimising the extent of areas disturbed by vehicles and machinery, implementing a waste and hydrocarbon management plan which addresses storage and handling of hydrocarbons, cleaning up spillages of hazardous material, employing good waste management and housekeeping practices, managing contaminated soil appropriately (remediation or disposal) and regularly monitoring the project areas for any erosion.

2.2.2. Operational phase

During operations, **soil contamination** could occur due to hydrocarbon leaks from vehicles and heavy earthmoving machinery, inappropriate storage and handling of hazardous substances (including cement), and spills and run-off as a result of ineffective dirty water management on-site. **Poor soil stockpiling and compaction** may also impact on soil quality. The potential impact is expected to occur for the duration of the mine's operation.

- The potential soil contamination impact can be mitigated by ensuring machinery is in good working order, by implementing a spill management plan and clean up measures, by implementing good housekeeping such as storage of potentially hazardous material, explosive storage and dangerous goods will be within properly constructed and lined or paved areas, storing potentially contaminated water within the properly constructed and lined PCD, and by sizing, operating and maintaining oil traps.
- The potential impact of poor soil stockpiling and compaction can be mitigated by undertaking effective and planned stockpiling to retain soil quality and fertility, ensuring that soil is dry prior to stripping, using truck and shovel equipment instead of bowlscrapers where possible, regularly overseeing soil stripping activities to ensure orderly stockpiling. Soil boundaries of soil types that should be stripped and stockpiled separately should be staked at 50 m intervals before any soil stripping commences. Topsoil should be stockpiled separately for later rehabilitation and adequately protected from being blown or washed away or being eroded.

2.2.3. Decommissioning and closure phase

Backfilling/ rehabilitation of the currently disturbed area upon completion of mining may improve the visual and aesthetic features of the site while simultaneously transforming the area into a usable landform. Therefore, it is possible that the land capability, if rehabilitation is implemented optimally, may be returned to a state that is better than the pre-construction land use. The positive impact of rehabilitation will be permanent however, there is a possibility that the closure objectives will not be realised. The impact can be enhanced through the implementation of the closure plan, adequately provisioning financially for closure. Ineffective rehabilitation and incorrect soil handling and placement could cause compaction and lead to exposed/ denuded areas post closure.

Table 2: Soil, land use and land capability impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Surface preparation, clearing of land and construction of surface infrastructure including the construction of new on-site hauls roads and widening of the existing access roads	Erosion from stormwater runoff.	4 [2]	1 [1]	2 [2]	3 [3]	21 [15]	Low [Low]
	Contamination of soils from pollution, spillages and unsafe storage of chemicals.	4 [2]	1 [0]	2 [2]	3 [2]	21 [6]	Low [Low]
Operational phase							
▪ Handling, storage and disposal of residue material to in pit dumps. ▪ Storage and handling of ore and waste materials ▪ Soil stripping and stockpiling	Contamination of soils from pollution, spillages and unsafe storage of chemicals. Poor soil stockpiling and compaction may reduce the soil quality.	6 [2]	1 [0]	3 [2]	3 [2]	30 [8]	Med [Low]
Decommissioning and closure phase							
Decommissioning, removal and rehabilitation	Change in land use potential / capability to an improved condition.	2	2	5	4	+44	Med+
Ineffective backfilling, rehabilitation and incorrect soil handling and placement	Soil compaction, exposed and impacted areas beyond the clearance footprint, unsafe voids, denuded areas,	6 [4]	2 [1]	3 [2]	3 [2]	33 [14]	Med [Low]

2.3. Archaeology and Palaeontology

2.3.1. Construction phase

From a palaeontological perspective, there are no UNESCO World Heritage Sites in the vicinity of the proposed THM. The mining area lies on the aeolian sands of the Kalahari Group (Quaternary age). Rocks bearing iron and manganese are below the surface and they do not preserve any fossils. Aeolian sands do not preserve fossils as they are windblown. Rarely the sands will entrap more robust fossils, such as fragments of bones or wood, but these are not in situ. If palaeopans or palaeosprings are in the area they might preserve fossils. No such deposits have been recorded from the proposed THM area; most of the area has been disturbed by previous mining operations and the Google Earth imagery does not show any pan or spring deposits. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

From a cultural perspective, known heritage sites are situated at a distance to the west of the proposed THM on the opposite side of the town of Hotazel and are therefore not threatened by the proposed development. No sites of cultural heritage importance were identified within the surveyed area.

However, surface preparation, clearing of land and construction of surface infrastructure including the construction of new on-site hauls roads and widening of the existing access roads may result in the **loss of subterranean / previously unidentified heritage and paleontological resources.**

Mitigation and management measures for the potential impacts include the following:

- Implementing a Heritage Protocol and Chance Finds Procedure.
- A Fossil Chance Finds Protocol shall be implemented only if fossils are seen on the surface when drilling/excavations commence.

2.3.2. Operational phase

It is possible that subterranean objects of cultural heritage value may be disturbed. The potential impact can be mitigated by implementing a chance finds procedure for the resources.

2.3.3. Decommissioning and closure phase

No impacts to objects of heritage value are expected during the decommissioning and closure phase.

Table 3: Heritage and paleontological impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Surface preparation, clearing of land and construction of surface infrastructure including the construction of new on-site hauls roads and widening of the existing access roads	Loss of subterranean / previously unidentified heritage and paleontological resources.	4 [2]	1 [1]	2 [2]	2 [1]	14 [5]	Low [Low]
Operational phase							
Opencast mining	Loss of subterranean / previously unidentified heritage and paleontological resources.	4 [2]	1 [1]	3 [3]	2 [1]	16 [6]	Low [Low]

2.4. Noise

From the baseline short-term noise sampling campaign that was carried it was found that day time noise measurements in the area range from lower than rural districts to urban districts with main roads. Night time noise measurements range from lower than rural districts to urban districts. When the difference in noise levels is more than 5 dBA above the ambient noise level a person with normal hearing will start to hear the difference. Exceedance of the IFC NLGs at noise receptors could result not only in nuisance impacts but also possibly human health impacts. Noise impacts are expected to be slightly more notable to the south of the operations during the day and to the southwest and north-northwest of the operations during the night.

2.4.1. Construction phase

It is assumed that the construction activities will only take place during daylight hours. The construction machinery involved with site clearing and the construction of the surface infrastructure will be a source of continuous noise throughout the construction phase.

Void/pit dewatering activities, including a diesel powered barge with a pump system that will pump water to evaporators, will be a source of nuisance noise during the construction phase. The simulations indicate that there will be no exceedance of the International Finance Corporation (IFC) noise level guideline (NLG) at the noise receptors during the day however there may be exceedances during the night.

2.4.2. Operational phase

The mine and plant will operate on a continuous basis with 330 working days per annum. Only opencast mining methods will be used, i.e., no underground mining is proposed. Noise generating activities at THM will include mainly engine and exhaust noise generated by the on-site mobile and stationary equipment, the crusher, screen and conveyor, as well as handling of run-of-mine, waste, product, topsoil and sand material. Noise impacts will likely decrease as the opencast mining area deepens as the “pit walls” will dampen the noise, thus in the simulations all operations will be at the surface to establish the simulated worst-case impact area.

Noise propagation simulations indicate that noise generated during day will be detectable in Hotazel town but will likely not result in disturbance or complaints. However, due to low baseline night-time noise levels, night-time activities at THM could have a significant impact on environmental noise levels at Hotazel town during the night (22:00 to 06:00). The increase in noise levels in a large portion of Hotazel town may exceed the 3-dBA limit and complaints are expected. The increase in noise levels at receptors outside Hotazel town will be slight or mostly undetectable and complaints are not expected.

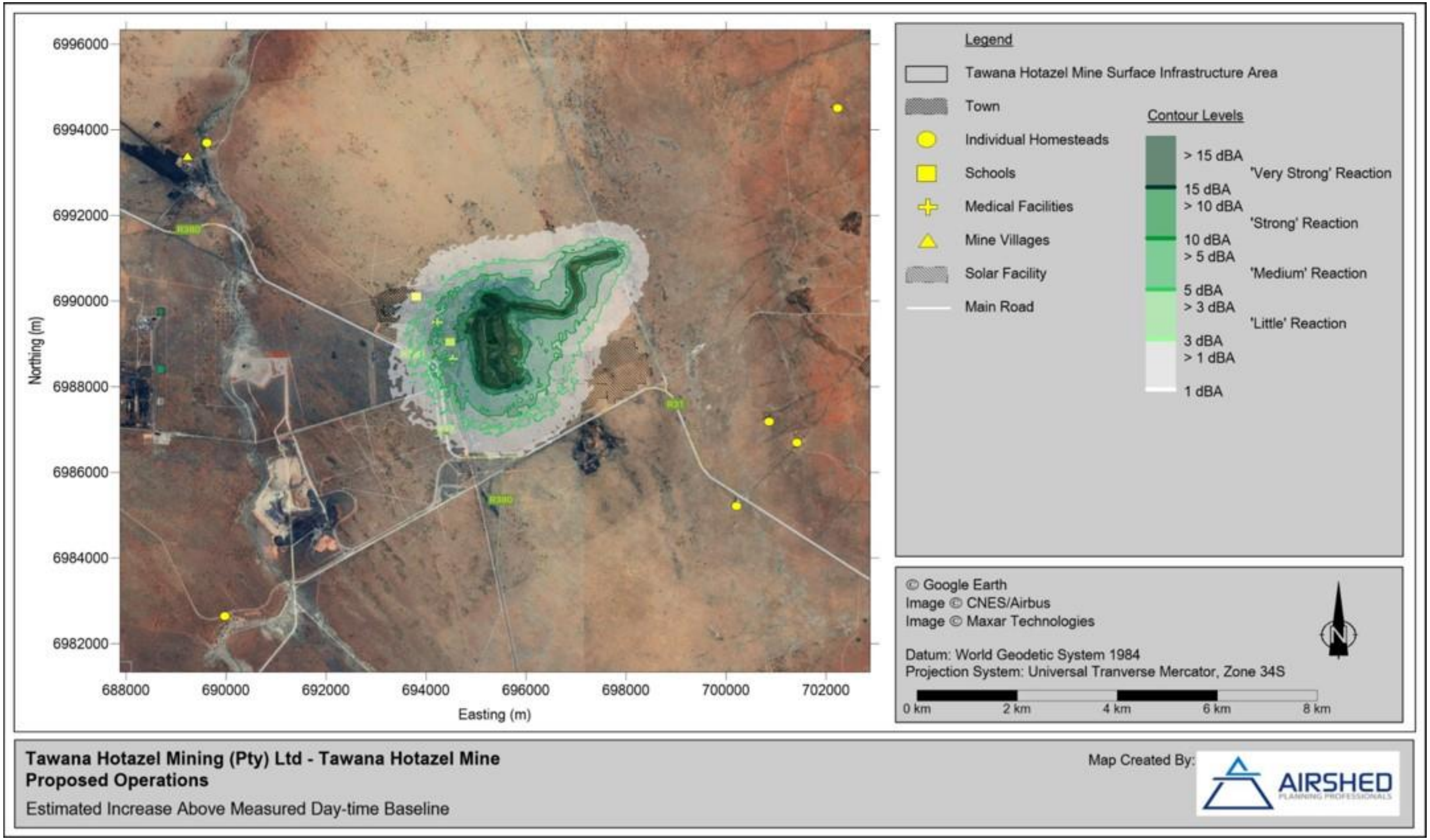

Figure 11: Estimated noise level increase above measured day time baseline without mitigation measures applied

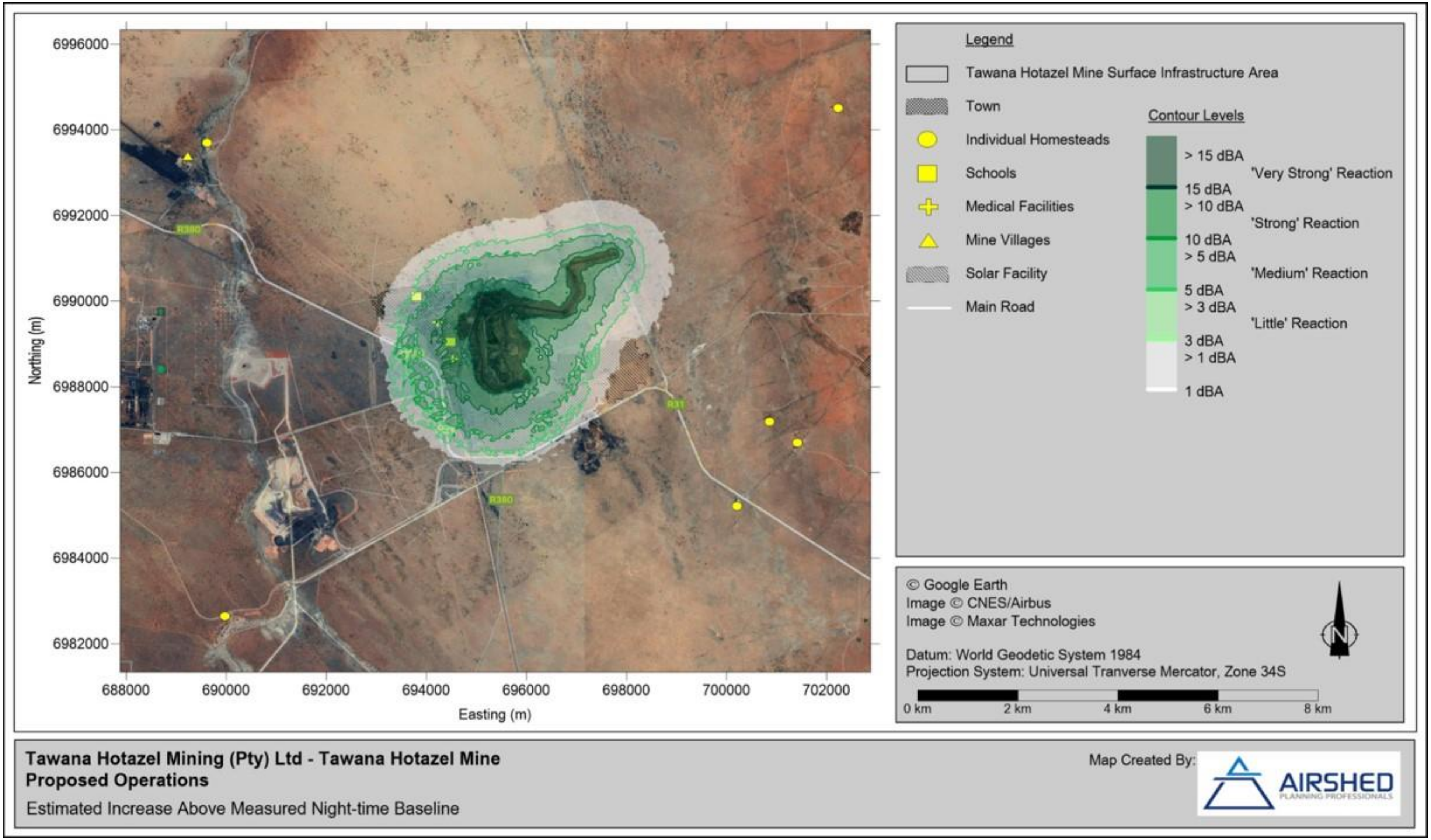

Figure 12: Estimated noise level increase above measured night time baseline without mitigation measures applied

2.4.3. Decommissioning and closure phase

It is assumed that the decommissioning activities will only take place during daylight hours. Only the machinery to be used for demolishing and removal of infrastructure and rehabilitation activities will be a source of continuous noise during daylight hours throughout the decommissioning phase.

Due to low baseline noise levels in Hotazel town, especially during the night, strong community action can be expected if noise generating sources are not properly mitigated and controlled. The extent to which the below mitigation measures will reduce the noise is currently unknown but it is expected that the implementation of these mitigation measures will reduce the expected levels of noise significantly.

Mitigation and management measures for the potential impacts include the following:

- Wherever possible significant noise generating activities be limit to the daytime (06:00 to 22:00).
- Evaporators in the pit to be positioned such as to minimize noise and dust fallout, taking account of prevailing wind direction and pit topography.
- Position the crushing and screening plant as far away from noise receptors as possible.
- Machines (e.g., drill rigs) used intermittently should be shut down between work periods or throttled down to a minimum and not left running unnecessarily. This will reduce noise and conserve energy.
- Equipment from which noise generated is known to be particularly directional (such as those related to the processing plant), should be orientated so that the noise is directed away from noise receptors.
- Acoustic covers of engines should be kept closed when in use or idling.
- Construction materials such as beams, and bricks should be lowered and not dropped.
- Restrict travel during night-time.
- Implement good engineering and operational practices:
    - Regular and effective maintenance of equipment is essential to noise control. Increases in equipment noise are often indicative of eminent mechanical failure. All diesel-powered equipment should be kept at a high level of maintenance. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
    - Minimise individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
    - Maintain road surfaces regularly to avoid corrugations, potholes etc. and avoid steep inclines.
    - Use rubber linings in for instance chutes and dump trucks to reduce impact noise of dropped material.
    - Minimise the need for trucks/equipment to reverse.
- Select equipment with lower sound power levels.
- Enclose sources of significant noise as far as is practically possible.
- A noise reduction barrier, such as an earth berm, must be considered for the western side of the THM, between the THM operations and Hotazel town where noise receptors are located close to the operations.

- Sound insulation of nearby buildings can be considered if the above measures for source control are insufficient.
- Monitor noise levels from the activities throughout the proposed project to determine level of mitigation required. Regular (at least annual) monitoring of environmental noise is recommended.
- Keep a noise complaints register. In the event that noise related complaints are received it is recommended that short term (24-hour) ambient noise measurements should be conducted as part of investigating the complaints.

Table 4: Noise impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Clearing of land and construction of surface infrastructure including the construction of new on-site hauls roads and widening of the existing access roads and mechanical evaporation of pit water	Increase in ambient noise levels and nuisance noise to surrounding sensitive receptors	6 [4]	2 [1]	2 [2]	3 [2]	30 [14]	Med [Low]
Operational phase							
Blasting and mobile crushing and screening, operational traffic and product loading / hauling	Increase in ambient noise levels and nuisance noise to surrounding sensitive receptors	6 [4]	2 [2]	4 [4]	4 [3]	48 [30]	Med [Med]
Decommissioning and closure phase							
Decommissioning and rehabilitation of the THM	Increase in ambient noise levels and nuisance noise to surrounding sensitive receptors	4 [2]	2 [1]	2 [2]	2 [1]	16 [5]	Low [Low]

2.5. Hydrology

2.5.1. Construction phase

Areas that have been stripped of vegetation and topsoil as well as topsoil stockpiles will be prone to erosion. This could lead to increased suspended solids being transported with storm water. Runoff from the area is very low. The existing site topography and the flat surrounding topography result in storm water flows that are very small in aerial extent and this impact is considered very small.

Pollution from poorly maintained construction vehicles and hydrocarbon spills could be washed off roads by storm water and if soils have become contaminated, this will leach out into the groundwater over a prolonged period. Spillage and unsafe storage of chemicals could result in surface water contamination.

Mitigation and management measures for the potential impacts include the following:

- Areas that are stripped should be optimised to limit unnecessary stripping.
- Storm water from upslope of the stripped areas should be diverted around these areas to limit the amount of storm water flowing over from these areas.
- The timing of the topsoil stripping should be optimised to limit the time between stripping and construction. Where practical constraints exist and areas need to be left stripped for long periods, contour ploughing, or ripping could reduce run-off and hence reduce erosion.
- Dry season construction is preferable where practical.

- If natural revegetation does not cover the topsoil stockpiles, they can be hydro seeded to speed up vegetation cover.
- All construction vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Wash bay discharge water should flow through an oil separator.
- Fuel depots and refuelling areas should be bunded.
- Chemicals should be stored in a central secure area.
- Regular toolbox talks on the responsible handling of chemicals should be undertaken.

2.5.2. Operational phase

Contaminated runoff (storm water and seepage) from the opencast pit, RoM and product stockpiles, the processing plant, waste dumps, vehicle yard and workshops, and the fuel station could have a detrimental effect on the water quality in the Ga-Mogara River, should runoff reach the Ga-Mogara River. Leaking or burst dirty water pipes may also result in the contamination of surface water.

Storm water generated from the dirty areas must be collected in the dirty water system. This water would have contributed to the flow into the surface water systems and in the local wetlands. The impounding of this water will result in a reduction in the yield of the catchment, however the loss of yield on the Ga-Mogara River is negligible.

Surface water contamination and a decrease in water quality in the surrounding surface water systems may occur as a result of contamination from wash bays and workshops, chemicals and hydrocarbon spillages.

Mitigation and management measures for the potential impacts include the following:

- Evaporator fans should be ideally located below the pit perimeter.
- Forced evaporation should be limited to dewatering the existing water body in the pit and should not be used for operational pit water management.
- Pollution control facilities are to be correctly sized to accommodate a 1:50 year flood event.
- Water reuse from the pollution control dam must be maximised.
- Run the dirty water pipelines through areas already serviced by dirty water systems where possible.
- Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.
- Dirty areas should be minimised. This will have the dual benefit of smaller dirty water management systems and reduction in catchment yield loss.
- All drains that collect the wash water and storm water must be maintained regularly. These should be free of debris and silt.
- All diversion canals, trenches and conduits are to be correctly sized to accommodate a 1:50 year flood event.
- The wash bays and workshops must be bunded and all water should be contained, collected and routed to an appropriate treatment facility.
- The wash bays and workshops must be equipped with oil separators to remove hydrocarbons from wash down water.
- Diesel storage and refuelling areas should be concrete bunded, with bunds sized to accommodate at least the volume of a single diesel tank with a freeboard greater than the 50-year storm depth.

- All vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Chemicals should be stored in a central secure area. Regular training on the responsible handling of chemicals should be undertaken. If contract plant is being used, responsible handling of chemicals and vehicle maintenance should be a key performance objective of the plant contractor.

2.5.3. Decommissioning and closure phase

The removal of surface infrastructure and rehabilitation may result in increased erosion potential in previously vegetated areas that may be disturbed.

Mitigation and management measures for the potential impacts include the following:

- Plant should be well maintained to ensure that hydrocarbon spills are minimised.
- Existing roads should be used where possible.
- New disturbed areas should be minimised.

Table 5: Hydrology impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Surface preparation, clearing of land and construction of surface infrastructure including the construction of new on-site hauls roads and widening of the existing access roads	Erosion and increased suspended solids being transported with storm water.	4 [2]	1 [1]	2 [2]	3 [3]	21 [15]	Low [Low]
	Surface water quality deterioration from pollution, spillages and unsafe storage of chemicals.	6 [4]	2 [1]	2 [2]	2 [2]	20 [14]	Low [Low]
Operational phase							
Mining activities including stockpiling of topsoil and subsoil, opencast mining and blasting, loading and hauling, processing and ore stockpiles. Storage and handling of dangerous goods (bulk fuel storage and explosives handling).	Loss of surface water quality	4 [4]	1 [1]	2 [2]	3 [2]	21 [14]	Low [Low]
Dirty water management	Alteration of surface hydrology	4 [4]	3 [3]	3 [3]	2 [2]	20 [20]	Low [Low]
Decommissioning and closure phase							
Decommissioning, removal and rehabilitation	Surface water quality deterioration	3 [2]	2 [0]	2 [1]	3 [2]	21 [6]	Low [Low]

2.6. Groundwater

2.6.1. Construction phase

The construction phase for the proposed THM will entail construction of surface infrastructure, including the access roads, offices, loading station, processing plant, product stockpile areas, berms, ROM pad, haul road, and PCD. The water currently present in the existing opencast and underground workings will also be dewatered over a period of approximately 14 months.

Impacts on groundwater volumes - Dewatering of the existing opencast pit lake and the water contained in the existing underground mine to the PCD will cause a lowering of the groundwater levels within the surrounding aquifers. The groundwater levels in the area could be reduced by up to 40 m (refer to Figure

13). Due to the low aquifer transmissivity, the low vertical drawdown in water level, and the relatively short time frame of the construction period, the zone of influence of the groundwater level drawdown cone will be relatively small at less than 400 m from the mine boundary. No surface streams or privately owned boreholes will be impacted by the drawdown in groundwater level.

Groundwater inflow volumes - Groundwater inflow volumes during the construction phase into the existing mine workings are expected to be on average 170 m^3/day.

Impacts on groundwater qualities - The surface infrastructure that will be constructed all lies close to the existing underground mine and opencast pit and will fall within the existing groundwater level drawdown cone. Any contamination that enters the underlying aquifers will migrate towards the pit where it will be dewatered and directed into the mine water management system. No contamination is expected to migrate significantly off-site during the construction phase and no surface streams or private boreholes are expected to be impacted. The groundwater level in this area lies at 31 to 53 m below surface. The aquifers have a low horizontal and even lower vertical permeability. Therefore, there will a significant lag period between contamination entering the soil and eventually reaching the saturated zone. In general, the vertical hydraulic conductivity is 10 % of the horizontal hydraulic conductivity. It has therefore been calculated that it can take up to 600 days for contamination to reach the saturated zone, which is near, or past, the end of the construction phase.

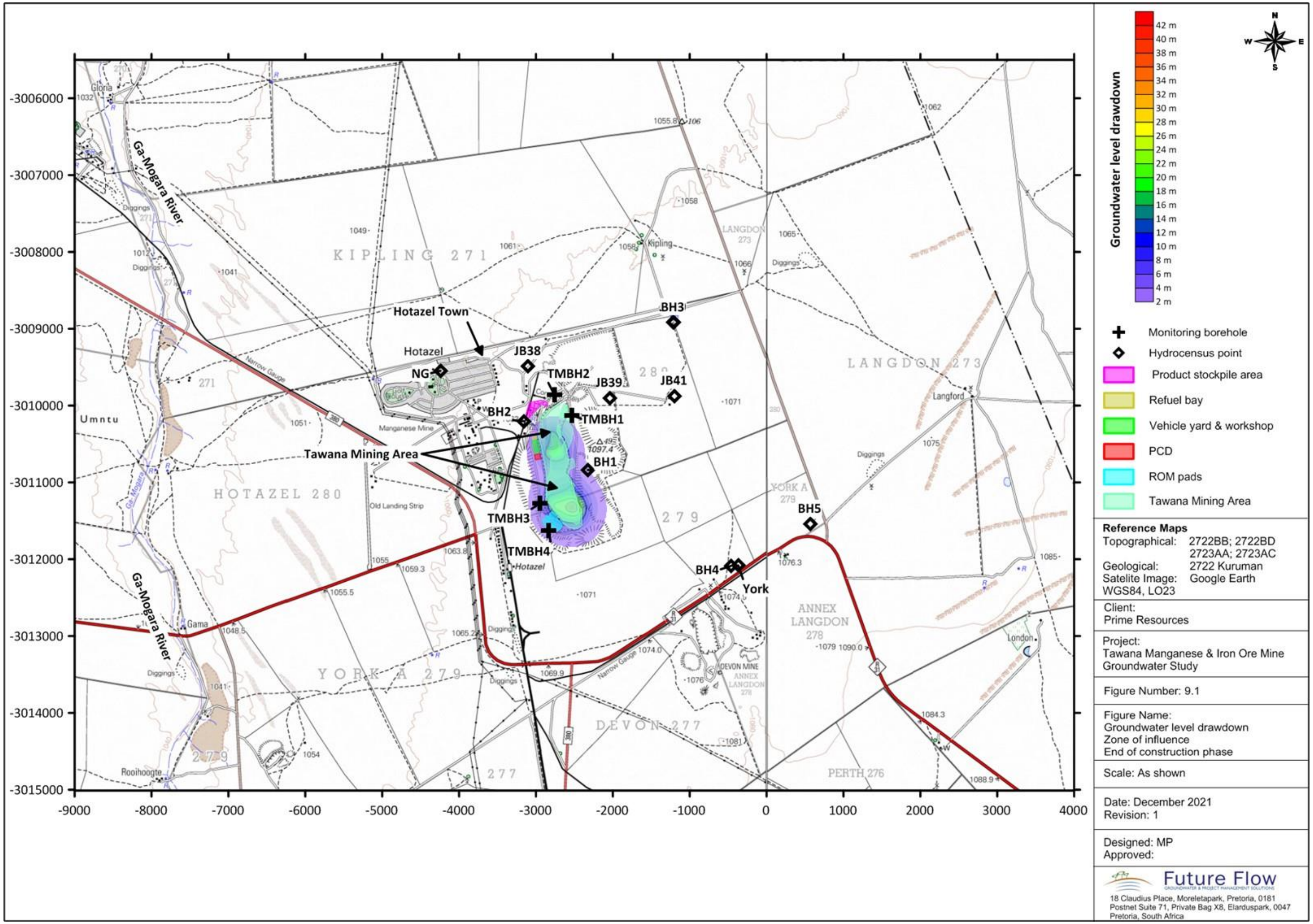

Figure 13: Groundwater level drawdown zone of influence at the end of construction phase

2.6.2. Operational phase

The operational phase for the proposed THM will entail operation of surface infrastructure, including the access roads, offices, loading station, processing plant, product stockpile areas, berms, ROM pad, haul road, and PCD. The existing opencast pit and underground mine will be further excavated as an opencast pit, with a maximum depth of approximately 110 m (minimum pit elevation is planned to lie at 957 mamsl according to the pit shell showing the final pit at the end of life of mine).

The opencast mine area and surface stockpiles act as potential sources of contamination to the aquifers in the area. Residue material (overburden and waste rock) arising from the development and ongoing operation of the opencast mine pit will be disposed back into the existing historical opencast void and the trailing mined out opencast void through backfilling. There will be 3 waste dumps. There will also be a topsoil stockpile and a sand stockpile. A geochemical assessment of the waste rock and ore material of the THM was undertaken by Prime Resources (refer to Appendix 20). Composite samples representative of the various types of rock material arising at the project were assessed and analysed at an accredited laboratory. It was found that:

- The waste rock and ore material were non-acid forming and presented a very low risk in terms of acid generation. The waste rock presented a low geochemical risk in terms of metal leaching and can be considered for backfilling into the opencast pit.
- The samples of high- and low-grade ore also present a low risk in terms of metal leaching, with the exception of low concentrations of copper which slightly exceed general discharge standards. The fine fraction of material arising from ore stockpiles was found to leach manganese in concentrations which could exceed guidelines.
- Geochemical modelling of the evaporation of the pit water was undertaken to assess the suite of minerals likely to precipitate during a mechanical evaporation process as well as to predict the evolving water quality of the brine solution remaining. It was found that most of the chemical constituents remain in solution until the late stages of the evaporative process resulting in a brine solution with high total dissolved solids.

Impacts on groundwater volumes - There is an existing drawdown in groundwater level around the historical opencast pit and underground mine due to the previous mine dewatering and ongoing evaporation of water from the pit lake in the opencast pit. During excavation of the proposed mine pit the existing groundwater level drawdown cone will develop further to become deeper and larger. The groundwater level can be drawn down by 68 m from the current water levels in the aquifer. In the south, where the pit will be the deepest, the groundwater level drawdown cone can extend 1.7 - 1.9 km from the pit boundary, while in the north the zone of influence is expected to reach 1.1 km from the pit boundary (refer to Figure 14). Boreholes BH1, JB38, JB39, JB41 are expected to fall within the zone of influence of the groundwater level drawdown cone. The boreholes are all monitoring boreholes operated by South32. None of the impacted boreholes are used for private domestic or agricultural purposes. No surface water streams fall within the zone of influence of the groundwater level drawdown cone.

Groundwater inflow volumes - During the construction phase, and the associated initial dewatering of the water in the existing pit and underground, water currently in storage in the aquifer will enter the excavation. Then, as the groundwater in storage is depleted inflows will be controlled by regional migration of groundwater towards the pit and the aquifer transmissivities. The average groundwater inflows will reduce to 155 m^3/day for the period 2025 to 2035 after which it will increase again as the pit increases in depth (and depth below the regional groundwater levels). During the period 2035 to 2045 the average daily inflow volumes will be in the order of 180 m^3/day. For the period 2045 to the end of life of mine the average inflows are expected to be in the order of 245 m^3/day. It is considered that these modelled inflows are high compared to what will enter the mine during the life of mine. Also, with the high evaporation rate of 2 026 mm/a it can be expected that a large percentage of the water entering the pit from the surrounding aquifers will evaporate before it must be pumped to surface.

Impacts on groundwater qualities - Fuel will be stored in sealed containers in the refuel area and the area will be paved. The vehicle yard and workshop will be paved, with appropriate oil traps and other infrastructure in place. Based on this, it is assumed that there will be limited hydrocarbon contamination from these areas. The water will collect in the pit sump from where it will be pumped to surface and be incorporated into the mine water management system. Due to ongoing dewatering of the pit, no driving head will form that causes contamination to migrate away from the pit. Based on this, it is expected that the pit will not be a notable source of pollution during the operational phase. The PCD will be lined; therefore, it is assumed that there will be no contamination entering the underlying aquifers from the PCD. Results from the geochemical assessment show that none of the material that will be mined, processed and stored on site, is likely to be acid forming. In addition, leach testing shows that there are no elements that can be said to generally be present in elevated concentrations in the material that will be processed at the plant and stored on the ROM pads and the product stockpiles. Results from the contaminant migration modelling show that the contaminant plume from the ROM pads and processing plant area, as well as the product stockpiles, will migrate towards and into the pit. No contamination is expected to migrate away from the mining area, and no surface water bodies, or privately owned boreholes will be impacted.

Mitigation and management measures for the potential construction and operational impacts include the following:

- Updating the geochemical assessment of the waste rock, ROM stockpile, product stockpile once the mine is operational;
- Monitoring groundwater levels around the pit;
- Monitoring dewatering volumes;
- Monitoring climate factors such as rainfall and evaporation;
- Using the above information the numerical groundwater flow model can be updated regularly (2 yearly) over the life of mine to increase the model accuracy in predicting the expected groundwater level drawdown cone and the expected impacts on the surrounding environment. This will include identifying private water supply boreholes and surface streams that might be impacted;
- Once boreholes and streams that will be impacted are identified and the impacts quantified using the updated numerical groundwater flow model, then further management plans must be put into place where required.
- Dams are to be sized and constructed correctly and maintained properly;
- Safe storage of chemicals;
- Store fuel in sealed tanks and containing walls around tanks;

- Proper sizing and operation of oil traps; and
- Placing the ROM pads and product stockpiles close to the pit boundary, and within the zone of influence of the groundwater level drawdown cone is a mitigatory measure.

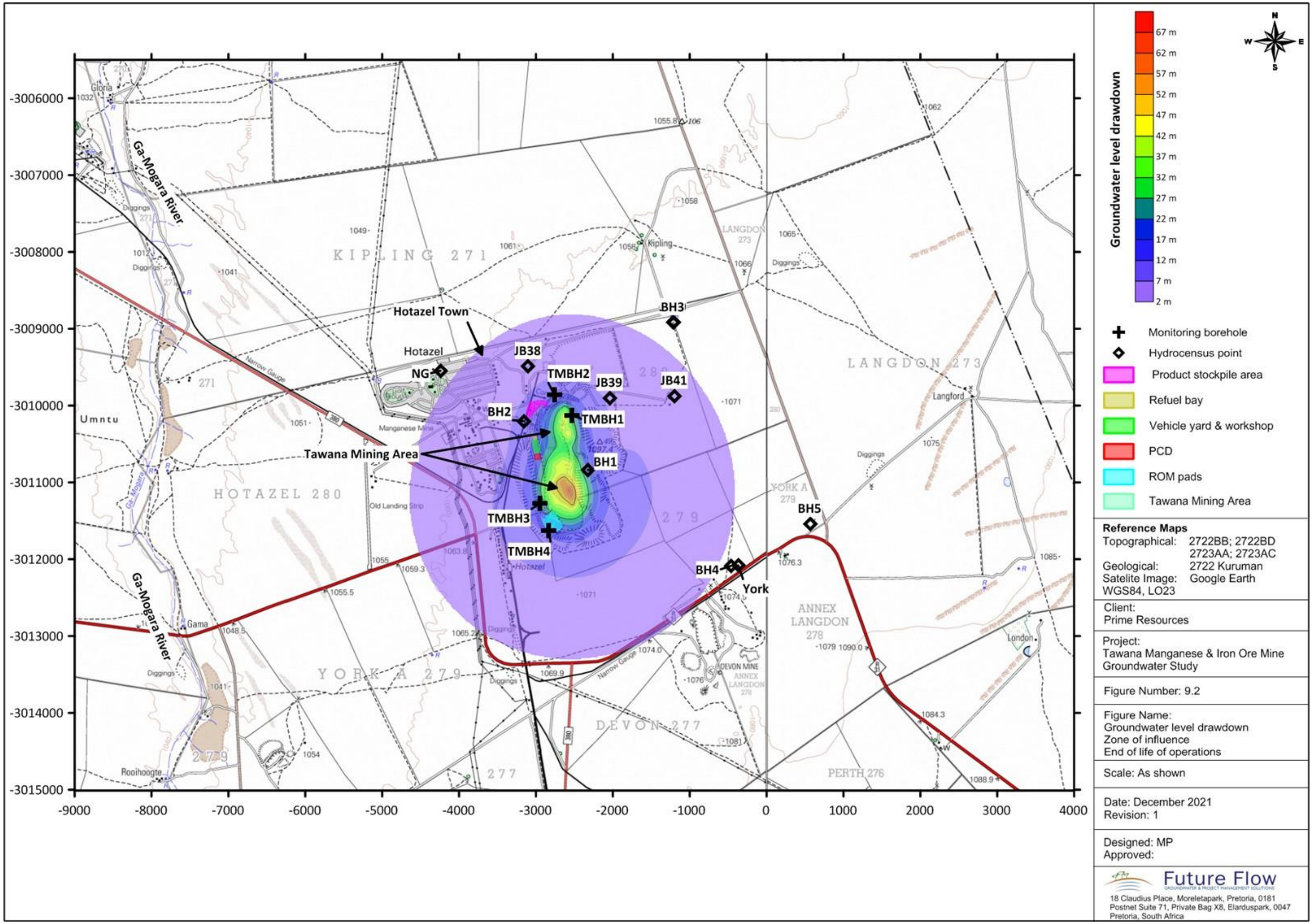

Figure 14: Groundwater level drawdown zone of influence at the end of operational phase

2.6.3. Decommissioning and closure phase

Impacts on groundwater volumes - During the decommissioning phase the mining activities, and any dewatering of the pit that takes place, will be stopped. This will allow the groundwater level in the pit area to recover. The recovery rate is expected to be slow, and it is not expected that a significant pit lake will form by the end of the 3-year decommissioning phase.

Impacts on groundwater qualities - During the decommissioning phase the ROM pads and the product stockpiles will be removed, and the footprint areas rehabilitated. The waste rock and topsoil will be used to finalise backfilling and rehabilitation of the pit. Contamination that has already entered the aquifers underlying the ROM pads and the product stockpile areas during the operational phase will continue to migrate towards the pit. No additional contamination will enter the underlying aquifers in future.

2.6.4. Post closure phase

Recovery of groundwater levels and decant potential - The water level within the rehabilitated pit will continue to recover in the long term. After 40 to 50 years post closure the water level in the rehabilitated pit is expected to reach 1 040 mamsl, which is the elevation of the natural regional groundwater levels. The natural groundwater levels range between 20.3 and 32.0 m with an average of 26.76 m. The water level in the rehabilitated pit will then continue to slowly rise above the regional groundwater levels due to the higher recharge from rainfall into the rehabilitated pit than into the surrounding, undisturbed, aquifers. Once the water level in the rehabilitated pit rises above the regional groundwater level water will start to flow from the pit towards the surrounding area. It is expected that by 100 years post closure the groundwater level in the rehabilitated pit will have risen to around 10 m above the regional groundwater levels. It will not have reached decant elevation and no decant is expected by 100 years post closure.

Impacts on groundwater qualities - During the initial years post closure the contamination that has already entered the aquifers from the ROM pads, processing plant footprint, and product stockpile footprint will continue to migrate towards the pit where the water levels are expected to rise but remain beneath the regional groundwater levels up to 40 to 50 years post closure. Once the water level in the rehabilitated pit has reached the regional groundwater levels and started to rise above it due to continuing recharge from rainfall, contaminants can start to migrate away from the opencast pit area. At 50 years post closure the contamination will mostly be contained within the pit area (refer to Figure 15). Over time the plume will start to migrate radially away from the pit area. The radial spread of the plume is because the region has a flat topography and the water level within the rehabilitated pit will rise above the surrounding topographical elevations. By 100 years post closure it is expected that the plume will not have spread more than 200 m from the pit boundary (refer to Figure 16). No surface water bodies, or privately owned boreholes fall within the expected zone of influence of the plume.

Mitigation and management measures for the potential impacts include the following:

- Monitor the groundwater quality for 5 years post closure;
- Remove surface storage facilities such as ROM pads and product stockpiles and rehabilitate footprint area; and
- Backfill and rehabilitate the final remaining void of the opencast pit.

Figure 15: Contaminant plume 50 years post closure

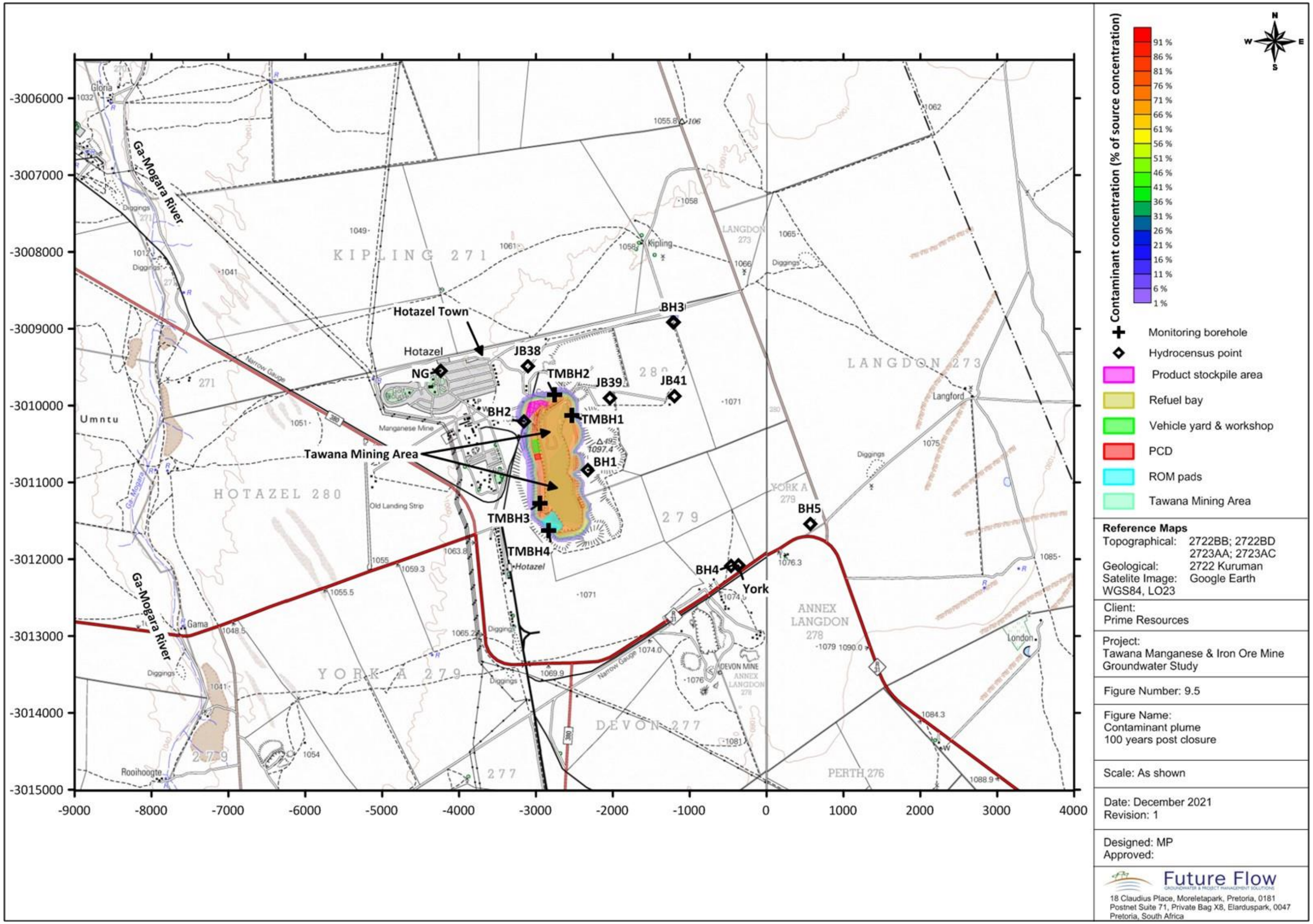

Figure 16: Contaminant plume 100 years post closure

Table 6: Geohydrology impact assessment

Process	Impact	M	S	D	P	Significance	
Construction phase							
Active dewatering of the existing opencast pit lake and the water contained in the existing underground mine	Lowering of the groundwater levels within the surrounding aquifers and impact on groundwater volumes	4 [2]	2 [2]	2 [2]	5 [5]	40 [30]	Med [Low]
Seepage of pollution and accidental chemical and hydrocarbons spills	Contamination of groundwater and reduced groundwater qualities.	4 [2]	1 [1]	2 [2]	2 [2]	14 [10]	Low [Low]
Operational phase							
Excavation of the proposed mine pit and active dewatering of the opencast mine	Lowering of the groundwater levels within the surrounding aquifers. None of the impacted boreholes are used for private domestic or agricultural purposes. No surface water streams fall within the zone of influence of the groundwater level drawdown cone.	6 [4]	2 [2]	4 [4]	5 [5]	60 [50]	High [Med]
Seepage from the mining area and surface ROM pads and the product stockpiles	Contamination of groundwater and reduced groundwater qualities.	4 [2]	2 [2]	5 [5]	5 [5]	55 [45]	Med [Med]
Seepage of pollution and accidental chemical and hydrocarbons spills		4 [2]	1 [1]	2 [2]	2 [2]	14 [10]	Low [Low]
Post closure phase							
Recovery of groundwater levels and decant potential	It is expected that by 100 years post closure the groundwater level in the rehabilitated pit will have risen to around 10 m above the regional groundwater levels. No decant is expected by 100 years post closure.	6	2	5	5	+65	High Positive
Migration of contamination plume due to poor quality seepage from the mining area	By 100 years post closure it is expected that the plume will not have spread more than 200 m from the pit boundary. No surface water bodies, or privately owned boreholes fall within the expected zone of influence of the plume.	4 [2]	2 [2]	5 [5]	5 [5]	55 [45]	Med [Med]

2.7. Biodiversity

Significant levels of habitat modification have occurred within the project area, however remnant, modified Kathu Bushveld occur within the MR area and along the main access road within the north-eastern portion of the project area. Areas of secondary thornveld have also established on surface dumps in the south and east where adequate growing medium is present. The Modified Kathu Bushveld habitat unit provides improved habitat for floral and faunal species, while the in-pit aquatic habitat unit has allowed for aquatic communities to establish within the historical void. The historical open-cast pit has provided suitable nesting platforms and prey base for the Verreaux's Eagle *Aquila verreauxii* to thrive over the last 11 years.

2.7.1. Construction and operational phase

Loss of terrestrial floral and faunal habitat may occur because of the proposed mining activities and upgrades to the access road due to clearance of vegetation and impacts vehicles. Further disturbances may occur during the construction phase as a result of dust, unauthorised vehicle access, and edge effects. Disturbance to/ removal of aquatic vegetation that has established within the pit lake will occur when the pit lake is drained.

Indirect impacts may also occur such as increased runoff and erosion, an increase in dust, the fragmentation of habitat and the indirect loss of floral and faunal habitat within areas adjacent to the development footprint as a result of edge effects such as alien vegetation proliferation and encroachment and a decline in faunal refugia and food resources.

Reduced floral and faunal diversity within the project area will occur as a result of initial site clearance activities, construction/ pre-mining activities and mining, which may also result in inadvertent burial or mortalities of faunal species. An influx of people and associated increased human activity during the construction/pre-mining and operational phases of the project may lead to negative human-faunal interactions in more intact habitats, including increased poaching and trapping of faunal species within the project area and immediate surroundings, while the potential harvesting of plants, including species with medicinal or human use value, may also take place.

Displacement of faunal species as a result of habitat loss or transformation or as a result of disturbance may occur as a result of the initial vegetation clearing, movement of construction and mining vehicles, increased human activity, drilling, blasting, noise pollution, vibrations and excessive dust through areas of increased faunal sensitivity. This will result in a localised decline in biodiversity as certain species are more sensitive to disturbances.

Species present on site are however likely to already have adapted to living within mining areas. Disturbance impacts on fauna are likely to be the highest surrounding the access road to the northeast and within remnant Kathu Bushveld within the MR area. Furthermore, the drilling and blasting will also likely have some degree of disturbance extending outside of the project area (noise and vibrations). A Verreaux's Eagle breeding site and waterbody habitat are present and remain areas of refuge for priority avifaunal species. Development within these focal sites will be a significant source of disturbance and is likely to result in displacement. The loss of the breeding habitat contained with the existing pit is likely to be permanent since similar habitat is not available on this property.

Species of Conservation Concern (SCC), protected, Threatened or Protected Species (TOPS)-listed and endemic species may be lost due to site clearance activities, increased human activity and collection or harvesting of species. The probability of floral and faunal SCC occurring within the project area is low or unlikely (with the exception of Verreaux's eagle (*Aquila verreauxii*), however certain TOPS-listed species, nationally or provincially protected species, including protected tree species in terms of the National Forests Act (Act No. 84 of 1998), and protected species in terms of the Northern Cape Nature Conservation Act (NCNCA) (Act No. 9 of 2009), are known to occur within the Modified Kathu Bushveld habitat unit, with protected tree species also occurring within the Secondary Thornveld habitat unit. The removal of fauna that has been artificially translocated to the pit lake such as *Tilapia sparrmanii* (provincially Protected fish species) will occur when the lake is drained.

Direct mortality as a result of construction and operational activities - Bird mortality as a result of construction activities is improbable because birds are incredibly mobile and able to move out of harm's way. If mortality does occur, it is likely to be confined to a localised area and restricted to immobile species e.g., nestlings. No terrestrial bird species (ground) nest locations were observed during the site visit. Should nests or breeding locations, pertaining to Red List species, be identified during the avifaunal inspection prior to the construction phase of this project, site specific mitigation must be implemented to ensure that this impact is reduced to negligible levels.

Roadside verges are an attractive habitat to a diversity of bird species. Vegetation is often dense and lush (when compared to surrounding areas, due to protection from grazing animals and an increased supply water from road surface runoff) supporting high densities of rodents that in turn attract predatory birds such as owls, raptors and herons. Swallows and swifts are attracted to culverts and bridges because of the nesting opportunities they provide. For these species that are attracted to roads, collisions with motor vehicles are a significant impact.

Mortality due to electrocutions within the on-site substation - Electrocutions within the proposed on-site substation are possible but should not affect the more sensitive Red List bird species as these species are unlikely to use the infrastructure within the yard for perching or roosting. Since it is difficult to predict with any certainty where birds are likely to nest within the substation, coupled with the costs associated with insulating the infrastructure, electrocutions will need to be mitigated using site-specific recommendations if and when they occur.

Increased alien invasive species and other detrimental edge effects may occur due to further disturbance within the project area. An increase in alien invasive species could continue during the operational phase should eradication and control measures not be implemented. Alien and invasive floral species have the potential to outcompete indigenous vegetation and reduce faunal habitat quality. Edge effects such as alien vegetation proliferation and encroachment, changes to runoff patterns, erosion and compaction resulting from disturbances to soils, as well a decline in faunal refugia and food resources may occur. Altered ecosystem processes resulting from the proposed project may also lead to changes to the community composition within adjacent areas.

The following mitigation measures are proposed to limit or reduce the impact of the proposed project on the terrestrial ecology within the project area:

- No areas should be cleared of natural vegetation if not required for construction and operation of the proposed mining operation and related infrastructure.
- The extent of construction/ pre-mining activities (site clearance) and operational activities (drilling, blasting and hauling) must be limited to the approved development footprint area and the boundaries clearly demarcated on site prior to commencement of site clearance.
- Due to the occurrence of a high abundance of priority floral species adjacent to the existing access road, the widths of proposed road upgrades should be kept to a minimum.
- Areas of increased ecological importance and sensitivity (notably the remnant Kathu Bushveld habitat along the main access road and within the MR area, of Medium ecological sensitivity) should be avoided due to this habitat harbouring most priority floral species. Consideration should be given to conserve these relatively intact remnant habitats as part of the mine and access road upgrades as far as possible.

- Construction and operational vehicles should be restricted to travelling on designated roadways only and vehicle access beyond the designated and approved clearance footprint areas should be prohibited.
- Construction and site personnel should receive environmental awareness and biodiversity education training and site induction procedures should include a discussion of key ecological aspects (such as the necessary procedures for working in proximity to sensitive habitats).
- Areas of increased ecological sensitivity and floral species diversity within natural habitat bordering the project area and the main access road, should be off limits to construction vehicles and workers.
- The project footprint (including all surface infrastructure) must be clearly demarcated.
- Rescue and relocation should be undertaken of bulbous species for use in landscaping or in rehabilitation of disturbed areas. This should include provincially protected species such as *Crinum* sp., *Ammocharis coranica* and *Boophone disticha*.
- Any fires made by workers and site personnel, if unavoidable, should be restricted to designated areas, where accidental spread thereof can be avoided.
- All vehicles accessing the project must adhere to a 30 km/hr speed limit and vigilant driving techniques.
- No harvesting of firewood, plant material or collection of floral species by construction workers or mine personnel from the project area or natural areas surrounding the project footprint should be allowed.
- No wild animals may under any circumstance be handled, interfered with or removed by construction workers or any personnel.
- Hunting/ killing of fauna is prohibited.
- Any snares or traps found on or adjacent to the project area must be removed and disposed of.
- To reduce noise pollution, proper maintenance of equipment is required, and the implementation of low noise techniques is recommended.
- Light pollution must be kept to a minimum. Any lighting required must be directed away from sensitive habitats and the use of sodium vapour lights is recommended to not impact nocturnal faunal-invertebrate dynamics, through the attraction of species to these artificially lit areas.
- No dumping of waste (domestic or mining) may take place outside of the project area. All non-hazardous waste must be stored temporarily within a covered bins / skip.
- The placement of the proposed refuelling station must occur outside of any delineated sensitive habitat and take into consideration potential buffers imposed within other specialist studies.
- Where possible, the direct loss of protected and TOPS-listed species should be avoided, with specific mention of protected and TOPS-listed plants falling outside of the immediate mine development footprint area. It is recommended that trees located in proximity to the development footprint be clearly marked by means of danger tape or similar for the duration of the construction phase. Large, prominent *V. erioloba* trees in proximity to mining operations could be mapped by means of GPS coordinates and indicated on mine plans to promote their conservation.
- The establishment of a site nursery where smaller plants with relocation potential, including *V. erioloba* seedlings and saplings, can be kept and propagated during the construction and operational phases should be considered. These plants could be used in the rehabilitation works.

- The estimated number of protected and TOPS-listed plants per species should be determined prior to site clearance taking place by means of a site walkthrough of the final proposed development footprint areas. Priority floral species are confined the Modified Bushveld habitat unit, which includes areas adjacent to the existing access road.
- Where any protected or TOPS-listed species are to be rescued and relocated, this process should be overseen by a suitably qualified botanist or horticulturalist. Permits for the destruction or relocation of nationally and provincially protected tree, shrub and forbs species must be applied for and obtained from the relevant authorities:
    - For the destruction, removal or relocation of *Vachellia erioloba* and *V. haematoxylon* trees that are protected in terms of the National Forests Act (Act No. 84 of 1998), the required permit must be applied for and obtained from the Department of Fisheries, Forestry and the Environment (DFFE).
    - For the destruction, removal or relocation of the TOPS-listed species *Harpagophytum procumbens*, the required permit must be applied for and obtained from the DFFE.
    - For the destruction or removal of plant species that are protected in terms of the NCNCA (Act No. 9 of 2009), including *H. procumbens*, a permit should be applied for and obtained from the Northern Cape Department of Environment and Nature Conservation (NCDENC) after consultation with the relevant authorities.
    - Any conditions attached to tree and plant removal permits issued should be strictly implemented. This may require the planting of additional trees, shrubs and/ or forbs species in proportion to the number of plants lost, as specified by the relevant Departments.
- Any removed trees could be mulched and used as soil moisture protection during concurrent rehabilitation or made available to local communities as firewood.
- Should any faunal SCC be noted within the project area, the relevant authorities must be notified. Input into the possible relocation of such species must be provided by a suitably qualified ecologist.
- An Alien and Invasive Plant Species Management Programme, including consideration of the bush encroacher species, *Senegalia mellifera* subsp. *detinens* should be developed for the mine and updated to include any additional species that may be noted during the mining operations.
- Special attention must be paid to the control of NEMBA Category 1b alien invasive species, as well as *Prosopis glandulosa* var. *torreyana*, specifically along the MR area boundaries to prevent the spread of such species into adjacent properties and surrounding natural habitat.
- Bare soils should be avoided, and adequate indigenous grass cover must be achieved on any exposed slopes. Rehabilitation should take place concurrently, as alien species tend to proliferate within bare, disturbed soils.
- Excessive erosion where noted should be rectified immediately making use of soft engineering techniques. Where required, topsoil and hessian material must be placed over such areas to encourage the establishment of indigenous grass cover.
- Should indigenous grass cover not establish successfully after one growing season, active reseeding will be required.
- Adequate storm water management measures must be put in place to limit increased runoff and sedimentation of water resources.

Mitigation measures specific to the avifaunal impacts include the following:

- A pre-construction inspection prior to the removal of the water within the open void and the construction of the mine to confirm Verreaux's Eagle nest inactive status. However, should the nest be active it is recommended that the Endangered Wildlife Trust: Birds of Prey Programme be contacted to ensure the appropriate measures are taken to incubate and/or relocate the chick and/or eggs.
- The removal of the water within the open void and underground workings to be done between April and June outside of the waterfowl breeding season. Full dewatering will take longer than three months and it is proposed that dewatering will be carried out from April until September.
- The construction of an island within the proposed stormwater ponds, utilising the existing vegetation (i.e., do not remove large trees in these areas) will provide alternative nesting habitat for the resident waterfowl species.
- Bird flight diverters to be maintained on sections of power line during the operational life span of the overhead power line.
- Power line and servitude manager/ECO is requested to report all bird collisions encountered during routine line patrols of the overhead power line to the Eskom-Endangered Wildlife Trust Strategic Partnership who will provide reactive mitigation recommendations if necessary.
- The overhead power line must be constructed using a bird friendly structure (Inverted Delta-T).
- Additional mitigation in the form of insulating sleeves on jumpers present on strain poles, terminal poles and box transformers must also be considered.
- Insulating material to be maintained during the operational life span of the overhead power line.
- Should electrocutions occur within the on-site substation yard, mitigation can be applied reactively using a range of insulation devices. Site-specific recommendations should be sought from the Endangered Wildlife Trust's Wildlife & Energy Programme.
- Vehicles must utilise existing roads only.
- Speed restrictions to be enforced for all vehicles to limit avifaunal collisions.
- Awareness initiatives to educate road users about the presence of avifaunal species utilising the roads.
- Should collisions persist mitigation recommendations to be sought from Endangered Wildlife Trust's Wildlife & Transport Programme.

Mitigation measure specific to the aquatic biodiversity impacts include the following:

- A detailed assessment of the fish species present within the lake must be conducted by an accredited aquatic specialist prior to draining of the pit lake, to advise on permit requirements.
- Depending on the number of fish species present and when the pit is drained, a suitably qualified and accredited aquatic specialist must be present so as to identify species for further actions (e.g., translocation, euthanasia, etc.).
- Under no circumstances are fish to be removed for the purpose of consumption due to potential metal accumulation within tissues of the fish and associated liabilities.

2.7.2. Decommissioning and closure phase

The current proposed rehabilitation strategy includes concurrent rehabilitation measures, whereby as much material as available will be used to re-fill the opencast void, which at closure will be revegetated and covered. Backfilling/ rehabilitation will commence immediately after the commencement of the mining operation and its advance will match the depletion rate of the open pit. The establishment of vegetation within the existing infrastructure areas that are currently devoid of vegetation may contribute towards improved habitat conditions in these areas. Ineffective backfilling and rehabilitation may lead to exposed and impacted areas beyond the clearance footprint.

Table 7: Terrestrial Ecology impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Dust, unauthorised vehicles access, and edge effects from clearance of vegetation and impacts of construction vehicles	Loss of floral and faunal habitat	6 [4]	2 [1]	3 [2]	4 [3]	44 [21]	Med [Low]
Site clearance, construction/ pre-mining activities, an influx of people and associated increased human activity, poaching and trapping of faunal species and potential harvesting of plants.	Reduced floral and faunal diversity	6 [4]	2 [1]	3 [2]	4 [3]	44 [21]	Med [Low]
Initial vegetation clearing, movement of construction and mining vehicles, increased human activity, noise pollution, vibrations and excessive dust.	Displacement of faunal species	8 [6]	2 [1]	4 [3]	4 [3]	56 [30]	Med [Med]
Site clearance activities increased human activity and collection or harvesting of species. Draining of the pit lake.	Loss of Species of Conservation Importance	8 [6]	2 [1]	5 [3]	4 [3]	60 [30]	High [Med]
Disturbance within the project area and eradication and control measures not implemented.	Alien Invasive Species and other detrimental edge effects	6 [4]	2 [1]	4 [3]	3 [3]	36 [24]	Med [Low
Operational phase							
Proposed mining activities and upgrades to the access road	Loss of floral and faunal habitat	6 [4]	2 [1]	4 [3]	4 [3]	48 [24]	Med [Low
Mining activities, an influx of people and associated increased human activity, poaching and trapping of faunal species and potential harvesting of plants.	Reduced floral and faunal diversity	6 [4]	2 [1]	4 [3]	4 [3]	48 [24]	Med [Low]
Movement of mining vehicles, increased human activity, drilling, blasting, noise pollution, vibrations and excessive dust.	Displacement of faunal species	8 [6]	2 [1]	4 [3]	4 [3]	56 [30]	Med [Med]
Site clearance activities, increased human activity and collection or harvesting of species.	Loss of Species of Conservation Importance	8 [6]	2 [1]	5 [3]	4 [3]	60 [30]	High [Med]
Disturbance within the project area and eradication and control measures not implemented.	Alien Invasive Species and other detrimental edge effects	6 [4]	2 [1]	4 [3]	3 [3]	36 [24]	Med [Low]
Decommissioning and closure phase							
Establishment of vegetation within areas currently devoid of vegetation	Improved habitat conditions in these areas	10	1	3	4	+56	Med Positive
Ineffective backfilling and rehabilitation	Exposed and impacted areas beyond the clearance footprint	6 [4]	2 [1]	3 [2]	3 [2]	33 [14]	Med [Low]

2.8. Socio-economic

2.8.1. Construction and operational phase

Direct impacts

It is estimated that approximately **73 construction-related job opportunities** will be created. The THM will employ approximately **177 people (inclusive of outsourced service providers) during operations**. The bulk of these positions will consist of semi-skilled labour and will be sourced from the nearby residential areas of Hotazel, Tsineng, Mothibistad and Kuruman. Local labour will be prioritised to discourage the in-migration of jobseekers to the area.

- The potential impact is applicable in the construction and operational phases.
- The potential impact can be enhanced through the implementation of the Skills Development Plan (SDP) and measures regarding the management of downscaling and retrenchment as detailed in the Social Labour Plan (SLP), prioritizing persons with requisite skills from the surrounding areas for employment opportunities, and implementing a Stakeholder Engagement Plan to allow communication of the recruitment process with community members.

There will be increased opportunities for Small, Medium and Micro Enterprises (SMMEs) and stimulation of growth in the local area to provide goods and services to the mine and its employees.

- The potential impact is applicable in the construction and operation phases.
- The potential impact can be enhanced by identifying suitable Historically Disadvantaged South African (HDSA) and locally based companies that currently, or in future, could provide local procurement to the mine, maximising the potential benefits to the local economy by ensuring that local labour and service providers are utilised wherever possible, and implementing the Procurement Progression Plan detailed in the SLP.

Potential decline in community health and safety from the resumption of mining and associated activities.

- The potential impact is applicable in the construction, operation and decommissioning phases.
- The potential impact can be mitigated by controlling access to the mine site, putting up signs warning people of the danger of entering the mine site in unfenced areas, conducting regular security patrols to check for trespassers, developing a Community Health and Safety Policy, adhering to the mine Health and Safety polices and the mitigation measures relating to air quality, noise, traffic safety and blasting.

Indirect impacts

Influx of jobseekers into existing residential areas or the formation of new informal settlements leading to pressure on existing infrastructure and services, nuisance and social ills.

- The potential impact is applicable in the construction, operation and decommissioning phases.
- Local labour will be prioritised to discourage the in-migration of jobseekers to the area.

- The potential impact cannot be mitigated to a lower significance. Contractors that are appointed by the mine should be encouraged to provide transport for the employees to avoid them setting up near the mine site.
- Management measures will include prohibiting recruitment (by the mine and contractors) from occurring at the mine gate.

Impact on property values adjacent to the project.

- The potential impact is applicable in the construction, operation and decommissioning phases.
- The potential impact can be mitigated by implementing all mitigation measures relating to noise, dust, visual intrusion and the influx of people into the area, adhering to blasting levels, standards and controls as detailed in the Blasting Impact Assessment, and encouraging ongoing open communication between the mine and all stakeholders near the mine to improve relations.

2.8.2. Decommissioning and closure phase

When the THM is decommissioned, all activities associated with them will cease resulting in the loss of the permanent employment positions. Temporary employment opportunities for the decommissioning, demobilisation, demolition and rehabilitation activities will be available however, the long-term consequence will be small compared to the loss of opportunities due to the closure of the THM.

- The potential impact can be mitigated by implementing the measures in the SLP relating to employee education and upskilling to mitigate the impacts of unavoidable job losses. These include the establishment of future forums, providing information and counselling to retrenched employees to promote their absorption into the labour market, and offering a post-retrenchment programme to equip retrenchees with knowledge and skills.

The backfilling and rehabilitation of the current open pit void would improve the safety of the area, for both livestock and people.

Table 8: Social impact assessment

Activity	Potential impact	M	S	D	P		Significance
Direct Impacts							
Construction and Operational Phases							
Employment of mine staff / contractors	Employment opportunities	2	4	2	4	+32	Med+
	Increased opportunities for SMMEs and stimulation of the local economy	2	4	2	3	+24	Low+
	In-migration of jobseekers into the project area and associated negative impacts	6 [6]	4 [4]	2 [2]	3 [2]	36 [24]	Med [Low]
Operation of the mine and implementation of the SDP	Skills development for employees and community members	2	3	2	4	+28	Low+
Transportation of employees to and from the mine, and transportation of materials and ore	Safety impacts on people and animals	4 [3]	2 [2]	3 [3]	3 [2]	27 [16]	Low [Low]
Operation of the mine and associated activities	Decline in community health and safety	6 [4]	4 [4]	2 [2]	3 [2]	36 [20]	Med [Low]
Decommissioning Phase							
Decommissioning or downscaling at the mine	Loss of employment / retrenchment	4 [4]	3 [3]	2 [2]	4 [4]	36 [36]	Med [Med]

Activity	Potential impact	M	S	D	P	Significance	
Backfilling and rehabilitation of the currently open pit void	Improved safety of the area, for both livestock and people.	2	1	5	4	+32	Med+
Indirect Impacts							
Construction, Operation and Decommissioning Phases							
Influx of people around the project area	Pressure on existing infrastructure and services, nuisance and social ills	2	4	2	2	16	Low
Operation of the mine and associated activities	Impact on property values adjacent to the project	6	4	2	3	36	Med

2.9. Blasting/ vibrations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of the blasting process.

2.9.1. Construction phase

During the construction phase no mining, drilling or blasting is expected.

2.9.2. Operational phase

Ground vibration and air blast was calculated from the edge of the pit outline (as the worst case) and modelled accordingly. Blasting further away from the pit edge will have a lesser influence on the surroundings.

Ground vibration, air blast and fly rock impacts may occur as a result of the blasting process on structures (e.g., houses, general structures, substation and power lines, roads, railway lines, solar facilities, pipelines, reservoirs, sewage plant, shops, schools, gathering places, possible historical sites, etc.), consequent devaluation and impact on adjacent communities (human and animal perception and interface).

- The influence of ground vibrations will vary with distance from the pit area. The model used for the evaluation of ground vibrations indicate significant levels of ground vibrations.
- The minimum and maximum charge used indicated no potential structural damage is foreseen for any of the surrounding points of interest.
- Based on the maximum charge and ground vibration predicted over distance, people up to 1565 m may experience levels of ground vibration as perceptible and there will be the possibility of upsetting the households within these ranges. At 417 m and closer the perception of ground vibration could be unpleasant. Within this area 33 points of interest were identified where vibration levels may be perceptible and 1 point of interest (historical mine structure) may experience unpleasant ground vibration for the maximum charge.
- The proposed blasting limits are considered sufficient to ensure that additional damage (cracking and consequent devaluation to structures) is not introduced and the possibility of inducing damage is limited.

- Air blast levels indicate some concerns, however there are no levels of air blast greater than the current accepted limit at any points of interest. The levels predicted may contribute to effects such as rattling of roofs or door or windows. Maximum charge predictions identified 42 points of interest that could experience levels of air blast that could lead to complaints.
- The absolute minimum unsafe zone for fly rock is 291 m and there are no points of interest within the unsafe zone.

Noxious fumes may be released as a result of blasting activities. The occurrence of fumes in the form the NOx gas is not a given and is very dependent on various factors.

Mitigation and management measures for the potential impacts include the following:

- No specific mitigation will be required with regards to ground vibration provided blasting is done according to the blast designs provided. Changes to the blast designs must however be re-evaluated for possible influence from ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms.
- Blasting operations in the pit area will require meticulous application of stemming lengths and correct stemming material to manage air blast properly. The information from the proposed blast design is sufficient guidance to manage air blast properly.
- Maintain safe blasting radius - clearance distances must be set, and road travel managed during blasting operations.
- Specific blast design to be undertaken, shorter blast holes, smaller diameter blast hole, ensure design provided is applied, use of proper stemming procedures and stemming materials as recommended in the designs.
- The occurrence of noxious fumes will need to be closely monitored.
- Proper and appropriate communication with neighbours about blasting, monitoring and actions undertaken for proper control will be required. Monitoring results can be shared and discussed with the local communities according to the stakeholder engagement plan.

2.9.3. Decommissioning and closure phase

During the closure phase no mining, drilling or blasting operations are expected. It is uncertain if any blasting will be done for demolition. If any demolition blasting will be required, it will be reviewed as civil blasting and addressed accordingly.

Table 9: Blasting and vibrations impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Operation							
Blasting operations to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work.	Ground vibration - perceptible levels	6 [4]	2 [2]	4 [4]	3 [3]	36 [30]	Med [Med]
	Air blast - rattling of roofs or doors or windows	6 [4]	2 [2]	4 [4]	3 [3]	36 [30]	Med [Med]
	Fly rock	4 [2]	2 [2]	4 [4]	3 [2]	30 [16]	Med [Low]
	Noxious fumes	4 [2]	2 [2]	1 [1]	3 [2]	21 [10]	Med [Low]

2.10. Visual Aesthetics

The visual character of the regional landscape is already considerably impacted on by mining.

2.10.1. Construction phase

The visual aesthetics of the area will be impacted the most during the construction phase where vegetation is cleared, and infrastructure is installed.

- Due to the existing mine related infrastructure in the area, the magnitude of the impact is expected to be minor however the probability that the impact will take place is certain.
- The impact can be mitigated by limiting the area cleared.

2.10.2. Operational phase

For safety and security, the THM is expected to require lighting which may cause visual intrusion for sensitive receptors.

- The magnitude of the impact is expected to be minor as the surrounding infrastructure will be lit at night, therefore it is unlikely the additional lighting will be noticeable.
- The potential impact can be mitigated by avoiding unnecessary illumination, providing lights with cover fittings that limit lateral and upwards "light spill" and positioning lights to shine towards the intended areas of illumination rather than using floodlights, making use of Low-Pressure Sodium lighting or other types of low impact lighting, using low wattage bulbs to further reduce the impact, and using motion sensor activated lighting instead of lights that illuminate continuously.

2.10.3. Decommissioning and closure phase

It is anticipated that the project may result in an **improved environmental condition** at closure if the recommended rehabilitation measures be implemented, as the proposed THM is currently considered significantly impacted by historical mining activities with vegetation not being representative of the natural indigenous vegetation. If the mine were to improve the environment through rehabilitation measures and the removal of invasive species it could potentially improve the functioning of the ecosystems and reinstate indigenous and healthy environments that would be of benefit to the surrounding communities from an ecosystem services and beneficial / suitable end land-use perspective, also improving the aesthetics of the area.

The THM will be decommissioned at the time of closure of the mine. The in-pit waste dumps will remain on site resulting in a **permanent change to the visual character of the area**. Unsuccessful rehabilitation may also permanently change the visual character of the area.

- The potential impact can be mitigated by shaping the dumps to achieve deposit stabilisation and to blend with the natural topography and establishing vegetation on the crests of the dump.

Table 10: Visual impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Clearing of land, surface preparations and site establishment	Loss of visual aesthetics	2 [2]	2 [2]	3 [3]	5 [3]	35 [21]	Med [Low]
Operational phase							
Lighting	Visual intrusion at night from additional lighting	2 [2]	1 [0]	2 [2]	5 [4]	25 [16]	Low [Low]
Decommissioning and closure phase							
Decommissioning and rehabilitation of the THM	Positive visual aesthetics impacts associated with the removal of infrastructure and rehabilaition of the area	2	1	5	4	+32	Med+
In-pit dumps will remain on site	Permanent change to the visual character of the area.	2 [2]	2 [2]	3 [3]	5 [3]	35 [21]	Med [Low]

2.11. Traffic and road conditions

The main transport route to the northeast will be for Heavy Vehicles (HVs), and the main entrance to the west will be for Light Delivery Vehicles (LDVs). In addition, on-site access roads will be constructed for use by the secondary support fleets and earthmoving haul trucks, with ramps that lead in and out of the pit and haul roads for the transportation of processed products and waste amongst others.

2.11.1. Construction phase

Additional traffic will be generated during the construction phase and the impact of this traffic is generally of a short duration. All construction activities will be spread over a minimum period of 12 months. The THM construction related vehicle trips will be generated from the following construction activities:

- Access roads and parking facilities
- Office blocks
- Bulk civil services – water supply, sewer and septic tanks
- Power supply
- Weighbridge
- PCD and Stormwater ponds
- Diesel refuelling bay
- Plant/vehicle yard and workshop

The development will generate an **additional 59 trips/hr along the R31 and Boardman Road during the peak hours.** The existing road network has capacity to process these additional trips.

Heavy vehicles can be expected to travel to the site utilising the R31, R380 and DR3463 during the construction period. This this will be for a short duration and thus impact to the pavement on the surrounding road network will be minor.

The proposed heavy vehicle access road connecting to road DR3463 will be widened at identified sections and will result in the **removal of vegetation and trees and the disturbance and fragmentation of natural fauna and flora**.

- The potential impacts can be mitigated by limiting vegetation clearing to the necessary area of construction of the access road and revegetating disturbed areas with native trees, shrubs and herbaceous plants.

2.11.2. Operational phase

Operational traffic will be generated post construction. Operational traffic is generally long term and lasts for the duration that the mine continues to be active. Ore materials from the mine will be transported with heavy vehicles from THM to Lohatla for further distribution to customers via rail.

The heavy vehicles make use of the following routes to travel between THM and Lohatla: DR3463, R31, R380, N14 and the R325.

Including 10 heavy vehicles trips transporting materials to Lohatla, an estimated total of **49 trips/hour can be expected to arrive/depart at the mine during the morning and afternoon peak hours** (Figure 17). The existing road network has capacity to process these additional trips.

Additional traffic loading/ increased vehicle trips generated by activities at the mine could have an impact on the **surrounding road network**, **volume of traffic and intersection capacity,** an **increase in CO_2 emissions**, **dust generation and noise pollution and reduced road safety**.

- The potential impact is expected to occur in the construction and operational phases.
- The THM is located adjacent the town of Hotazel with residential properties being within a 1 km radius of the mining site.
- The proposed main entrance access road to the mine (near Hotazel) appears to be a stabilised road with some dust palliative in place.
- The identified critical intersections have adequate capacity to process current and future traffic volumes generated by the proposed THM development.
- Additional traffic volumes will be adequately and safely processed on the surrounding road network. No capacity improvements are triggered.
- Mitigation measures include making public transport available and encouraging the use of public transport by staff to reduce trips and emissions.
- Abatement strategies for dust pollution from the roads include reducing the speed limit to lower the amount of dust generated by moving vehicles, adding a gravel layer to the road and installing a permeable paver to lock the gravel in place and prevent pulverisation of the rock over time.
- Abatement strategies for noise pollution because of vehicles include working within normal work hours as far as possible, restricted travel during night-time conditions and notifying persons likely to be affected.
- Abatement measures to improve road safety conditions for all include limiting heavy deliveries to daytime to avoid the risk of collision due to poor sight, limiting abnormal loads to daytime and dry weather, providing escort, and applying stop-go control at locations of restricted road width will largely avoid the risk of collision in these instances and regular grading of the road surface of the main access road.

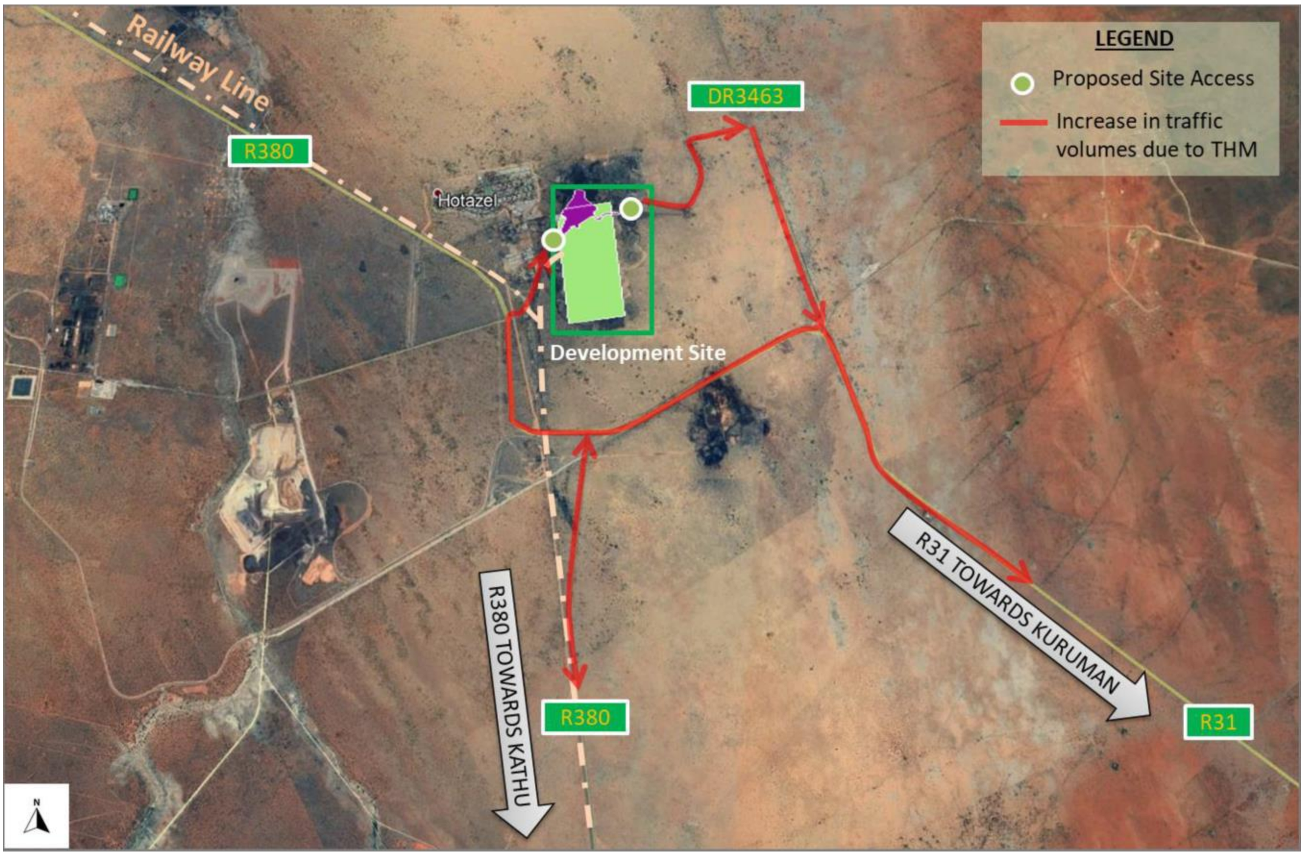

Figure 17: Expected trip increases on the surrounding road network

Increases in heavy vehicle volumes may result in the **deterioration of pavement condition/ quality**.

- The potential impact is expected to occur in the construction and operational phases.
- Heavy vehicles can be expected to travel to the site utilising the R31, R380 and DR3463 during the construction period. This will be for a short duration and thus impact to the pavement on the surrounding road network will be minor.
- The overall pavement condition on road DR3463 is in fair condition, while the pavement condition can be considered as poor on the R31.
- As a national road, the maintenance and rehabilitation of the R31 is the responsibility of SANRAL and mitigation measures should be developed in conjunction with the road agency.
- The potential impacts can be mitigated by not overloading trucks and ensuring that wheel/axle loading is in accordance with legislation.

2.11.3. Decommissioning and closure phase

The mine is expected to continue ore extraction for the next 20 years. Once this activity comes to an end, the mine will be decommissioned, rehabilitated, and closed. During rehabilitation, a few trucks can be expected to operate to/from site, related to vegetation watering and monitoring, and maintenance. From a transport perspective, the rehabilitation and decommissioning phase will have minimal impact on the road network.

Table 11: Traffic / road impact assessment

Activity	Potential impact	M	S	D	P	Significance	
Construction phase							
Widening of heavy vehicle access road connecting to road DR3463	Removal of vegetation and trees and the disturbance and fragmentation of natural fauna and flora	4 [3]	1 [1]	2 [2]	5 [3]	35 [15]	Med [Low]
Construction and operational phase							
Additional traffic loading/ increased vehicle trips generated by activities at the mine	Surrounding road network congestion and reduced intersection capacity, increase in CO_2 emissions and reduced road safety.	2 [2]	2 [2]	4 [4]	2 [2]	24 [24]	Low [Low]
	Dust pollution to residential properties adjacent to access road	4 [3]	2 [2]	3 [3]	3 [2]	27 [16]	Low [Low]
Transportation of ore, materials and supplies by heavy vehicles and increased volumes of heavy vehicle	Deterioration of pavement condition/ quality resulting in unsafe driving conditions	2 [2]	2 [2]	2 [2]	3 [2]	18 [12]	Low [Low]
	Noise pollution to nearby residential areas within earshot	4 [3]	2 [2]	2 [2]	3 [2]	24 [14]	Low [Low]

2.12. Cumulative Impacts

Cumulative impacts have been commented on in terms of their qualitative impact and impact significance ratings have not been assigned.

Air Quality

Baseline dust fallout monitoring undertaken between December 2020 – April 2021 showed that the dustfall rates at the unit on the boundary of Hotazel is below the NDCR limit for residential areas for all four months. As only four months of sampling was undertaken and there was high rainfall in the area during the first month the sampling period there is still the potential that the dustfall rates in the area may be non-compliant with the NDCR, considering the mining activities in the area, high erodibility of the area/ region due to the limited vegetation and disintegration of surface material, dryness of the region and frequent elevated wind speeds. Based on sampled fine PM concentrations and simulated results, the proposed THM operations could result in a doubling of annual average PM_{10} concentrations in Hotazel town should the recommended dust suppression measures not be implemented. Based on the highest sampled dustfall rate, as well as the simulated results for unmitigated THM operations, the dustfall rates at the solar facility could range between 164 mg/m^2-day and 766 mg/m^2-day as a result of all activities in the region.

The potential cumulative scenario includes the following atmospheric emissions:

- Particulate and gaseous emissions from THM operations.
- Particulate and gaseous emissions from other mining, processing and industry related power generation operations.
- Particulate emissions form miscellaneous fugitive dust sources including vehicle entrainment on local roads and wind-blown dust from open areas.
- Particulate and gaseous emissions from vehicles exhausts.
- Particulate and gaseous emissions from household fuel burning.
- Particulate and gaseous emissions from biomass burning (e.g., wildfires).

Soil and land use

The site is already being degraded and the potential loss of soil / land use is negligible / minimal. Although several mining relative activities are occurring in the vicinity of the project, no cumulative soil related impacts were identified.

Noise

From the short-term noise sampling campaign that was carried it was found that day time noise measurements in the area range from lower than rural districts to urban districts with main roads. Night time noise measurements range from lower than rural districts to urban districts. Cumulative noise impacts are expected.

Hydrology

There is a lack of naturally occurring surface water features within the general study area. Surface water runoff in the area is low making cumulative impacts in terms of pollution from the site and water quality deterioration in the surrounding area negligible.

Groundwater

The area is extremely dry, and water is scarce. The limited water resources are thus sensitive and extremely vulnerable. The large-scale regional impacts on the groundwater environment, from the different mining operations (current and proposed), in the region is difficult to assess and quantify but can be considered significant. The aquifers present in the area are classified as minor aquifers. The aquifers are of high importance to the local landowners outside of town as it is their only source of water for domestic, gardening, and agricultural purposes. Results from the groundwater monitoring borehole drilling and aquifer testing show that groundwater yields in the area are low, and there is a limited groundwater availability associated with the Kalahari formation and the Ongeluk lava. The zone of influence of THM extends to a maximum of 1.9 km from the pit boundary.

Biodiversity

Cumulative impacts are those impacts from the project combined with the impacts from past, existing and reasonably foreseeable future projects that would affect the same biodiversity or natural resources (e.g., a number of development projects in the same catchment or ecosystem type collectively affecting water quality or flow or impacting the same endemic species). Due to various similar mining projects being active in the immediate region, further mining and loss of habitat within the project area is likely to contribute towards a reduction in local *Vachellia erioloba* and *V. haematoxylon* communities, either directly or through lowering of the groundwater table, as well as regional ecosystem functioning and connectivity. Although the nationally and provincially protected floral species recorded within the project area are locally relatively common, and not restricted to the project area, the ongoing cumulative loss of these species within the larger region, mostly due to the establishment of new mines in the area, could however become significant over time.

Socio-economic

Apart from the expansion of informal residential areas in Ward 4 and JMLM, as well as general mining expansions, there is also a proposed solar PV development adjacent to the THM.

The communities nearby and the affected land users around the THM already experience impacts as a result of mining activities (e.g., dust / noise / water supply / influx of job seekers). An existing high unemployment, coupled with a potential influx of jobseekers could also lead to the social ills. Since limited employment opportunities are expected to be created because of the THM, community expectations must be proactively managed. The influx of jobseekers around the project area would place pressure on local infrastructure and services and may result in the establishment of informal settlements in the area, which may introduce a suite of social ills, including an increase in crime around the mine area and town of Hotazel.

Visual

The proposed THM is currently considered significantly impacted by historical mining activities and there are various other operational and historical mining features within sighting distance of the proposed THM. The following existing landscape features dominate the character of the project site and surrounds:

- Mining and associated infrastructure (including voids below natural ground-level and large residue deposits above ground-level);
- Overhead railway structures/ lines and power lines;
- Rural and residential land-use features.

The historical residue deposits and berms can be seen from viewpoints within Hotazel town. No cumulative visual related impacts were identified. Backfilling/ rehabilitation of the currently disturbed area upon completion of mining may improve the visual and aesthetic features of the site while simultaneously transforming the area into a usable landform.

Traffic and road conditions

The pavement condition of the R31 and R380 road is poor. Additional traffic loading/ increased vehicle trips on these roads, particularly heavy vehicles, may result in further damage to the existing road network.

APPENDIX 22

CLOSURE PLAN

Prime Resources (Pty) Ltd
The Workshop 70–7th Avenue Parktown North 2193
PO Box 2316 Parklands 2121
T +27 11 447 4888 **F** +27 86 604 2219 **E** prime@resources.co.za
www.resources.co.za

prime | resources
environmental
consultants

TAWANA HOTAZEL MINING (PTY) LTD

DRAFT FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE PLAN INCORPORATING AN ANNUAL REHABILITATION PLAN AND ENVIRONMENTAL RISK ASSESSMENT FOR THE PROPOSED TAWANA HOTAZEL MINE, PREPARED IN TERMS OF THE NEMA EIA REGULATIONS (GN982 OF 2014) AND THE NEMA FINANCIAL PROVISIONING REGULATIONS (GN1147 OF 2015)

JANUARY 2022

Prepared for:

Tawana Hotazel Mining

Tawana Hotazel Mining (Pty) Ltd

124 Beyers Naude Drive
Roosevelt Park
Johannesburg
2195

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ACRONYMS

CA	Competent Authority
CR	Critically Endangered
CRR	Comments and Response Report
DFFE	Department of Forestry, Fisheries and the Environment
DMR/ DMRE	Department of Mineral Resources/ Department of Mineral Resources and Energy
DWS	Department Water and Sanitation
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMPr	Environmental Management Programme
GIS	Geographic Information Systems
HMM	Hotazel Manganese Mine
IAPs	Interested and Affected Parties
IDP	Integrated Development Plan
JMLM	Joe Morolong Local Municipality
JTGDM	John Taolo Gaetsewe District Municipality
LED	Local Economic Development
LoM	Life of Mine
mamsl	Metres above mean sea level
mbgl	Metres below ground level
MPRDA	Minerals and Petroleum Resources Development Act (No. 28 of 2002)
MR	Mining Right
NBA	National Biodiversity Assessment (2018)
NCNCA	Northern Cape Nature Conservation Act (No. 9 of 2009)
NC DENC	Northern Cape Department of Environment and Nature Conservation
NEMA	National Environmental Management Act, No. 107 of 1998
NEMBA	National Environmental Management: Biodiversity Act, No. 10 of 2004
NEMWA	National Environmental Management Waste Act, No. 59 of 2008
NHRA	National Heritage Resources Act, No. 25 of 1999
NWA	National Water Act, No. 36 of 1998
RoM	Run of Mine
SAHRA	South African Heritage Resources Association
SAHRIS	South African Heritage Resources Information System
SANS	South African National Standards
TDS	Total Dissolved Solids
THM	Tawana Hotazel Mine
WMA	Water Management Area
WML	Waste Management Licence
WUL	Water Use Licence

1. DETAILS

1.1 Expertise of the EAP

Name of Firm	Prime Resources (Pty) Ltd
Physical Address	70 - 7th Avenue, Parktown North, Johannesburg
Postal Address	PO Box 2316, Parklands, 2121
Telephone Number	011 447 4888
Fax Number	086 604 2219
Email	prime@resources.co.za
Professional Affiliations	PrEng, SACNASP, PrSciNat, SAIMM, EAPASA

Jonathan van de Wouw (BSc Hons) is a Principal Environmental Consultant and Registered EAP (EAPASA Reg No 2019/909) with 14 years' experience managing projects in the mining and industrial sectors, including financial liability assessments associated with mine closure and rehabilitation, mine waste and water management planning, environmental impact assessments and management planning and environmental auditing. He also has a detailed knowledge of environmental law and precedents, both locally and internationally.

Louise Jones is a Senior Environmental Scientist with 8 years' experience in the field of environmental science. Her expertise includes environmental impact assessments and management planning in the mining sector as well as environmental compliance auditing in the waste management sector.

1.1.1 Declaration of Independence

Prime Resources (Pty) Ltd is an independent environmental consulting firm with no vested interest in the activities being undertaken at Tawana Hotazel Mine (THM) other than to fulfil the contract for delivery of specialised environmental consulting and auditing services including, among others, those stipulated in the terms of reference. It is hereby declared that the environmental consultants-, scientists and engineers under the employ of Prime Resources, insofar as the undertaking of this assignment:

- Act as independent consultants;
- Do not have any financial interest in the undertaking of the activity, other than fair remuneration for the work performed;
- Have not, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the Competent Authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document;
- Will provide the competent authority with access to all information at our disposal, whether such information is favourable to the applicant or not;
- Based on information provided to us by the project proponent and in addition to information obtained during the course of this study, have presented the results within the associated document to the best of our professional ability;
- Reserve the right to modify aspects pertaining to the present investigation should additional information become available through ongoing research and/or further work in this field; and
- Undertake to have our work peer reviewed on a regular basis.

Report compiled by:	Report reviewed by:
Louise Jones Senior Environmental Scientist	Jonathan van de Wouw Principal Environmental Consultant EAPASA Reg: 2019/909

1.1.2 Disclaimer

Prime Resources has expressed due and diligent care to comprehensively evaluate the proposed activities and operations to be undertaken at the mine. This assignment was conducted by reviewing various external specialist studies and other relevant technical documentation compiled for the site. Therefore, the various gaps, assumptions and limitations in the various reports reviewed, are also relevant here. It is assumed that all data provided by THM is true and correct.

1.2 Details of the holder

Name	Tawana Hotazel Mining (Pty) Ltd
Physical Address	124 Beyers Naude Drive Roosevelt Park Johannesburg 2195
Postal Address	PO Box 48477, Roosevelt Park, 2129
Contact Person	Tebogo Louw
Telephone Number	+27 (0) 11 782 4322
Email	tebogo@sebiloresources.co.za
Rights, permits, licences and authorisations	Prospecting Right (NC 30/5/1/1/3/2/1/12148 PR) Mining Right not yet granted (NC 30/5/1/2/2/10197 MR) The process of applying for a Water Use Licence (WUL) from DWS has commenced (reference no. WU21348)

2. INTRODUCTION AND BACKGROUND

The Department of Mineral Resources and Energy (DMRE) has accepted an application for Environmental Authorisation (ref No. NC 30/5/1/2/3/2/1/10197MR) in support of a Mining Right (MR) made by Tawana Hotazel Mining (Pty) Ltd (THM) in terms of Section 22 of the Minerals and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA). The THM covers portions of two farms within the Joe Morolong Local Municipality (JMLM) in the Northern Cape Province; Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel.

The THM largely incorporates the historical Hotazel Manganese Mine (HMM), and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining.

The overall area applied for is approximately 154 Ha (inclusive of the MR application area and access road). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure.

Section 11 of the current National Environmental Management Act (No. 107 of 1998) (NEMA) Financial Provisioning Regulations, GN1147 of 2015 *as amended*), requires the following three reports to be compiled:

- Annual Rehabilitation Plan;
- Final Rehabilitation, Decommissioning and Closure Plan; and
- Environmental Risk Assessment Report.

The holder of a right must, once per financial year, review and update the closure plans and reports, with a view to re-assessing the environmental impacts, closure objectives and sustainable end state of land to determine the appropriateness of the mitigation and rehabilitation measures, the acceptability of the risks and the adequacy of the financial provision.

THM has therefore employed Prime Resources to calculate the financial provision as per the requirements of GN1147 of 2015 and compile this final rehabilitation, decommissioning and closure plan incorporating an annual rehabilitation plan and environmental risk assessment.

3. LEGISLATIVE REQUIREMENTS

This section details the prescribed environmental management standards or practices, and applicable provisions of the Act regarding closure.

3.1 The Mineral and Petroleum Resources Development Act, No. 28 of 2002

The mining industry is regulated at a national level by the DMRE (previously the Department of Mineral Resources) which, through its regional offices, implements and administers the MPRDA. In respect of environmental matters, the Department of Forestry, Fisheries and the Environment (DFFE) is responsible for drafting all relevant legislation and regulations governing mining and environmental issues. In 2014, the One Environmental System was implemented, which resulted in a collaborative governance approach between the MPRDA and NEMA. The DMRE, in turn, is responsible for implementing these laws or regulations insofar as the laws/ regulations pertain to the mining sector.

Sections 41 to 47 of the MPRDA addressed legislative closure requirements. Section 41 stipulated that the holder of any prospecting right, mining right or mining permit must include the prescribed financial provision in the EMPr for the rehabilitation or management of negative environmental impacts. Should the license holder be unable to fulfil the rehabilitation obligations, the Minister of Mineral Resources may then employ the funds of the financial provision for the said rehabilitation. Section 41(3) required that the financial provision be assessed annually to the satisfaction of the Minister. Section 41 of the MPRDA has subsequently been repealed and is addressed under NEMA.

While the methodology for assessing the financial provision in terms of the MPRDA was previously provided for in Regulation 54 to the MPRDA (GNR527 of 2004), amendments published in Government Gazette Number 43172, Regulation Notice 420, which came into effect on 27 March 2020, repealed Regulation 54 in its entirety.

Regulation 56 (Principles for mine closure)

Stipulates that, in accordance with applicable legislative requirements for mine closure, the holder of a prospecting right, mining right, retention permit or mining permit must ensure that:

- the closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continue throughout the life of the operation;
- risks pertaining to environmental impacts must be quantified and managed proactively, which includes the gathering of relevant information throughout the life of a prospecting or mining operation; in accordance with the provisions of the NEMA, GN1147 of 2015 and the EIA Regulations, 2014.
- the safety and health requirements in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) are complied with;
- residual and possible latent environmental impacts are identified and quantified; in accordance with the provisions of the NEMA, GN1147 of 2015 and the EIA Regulations, 2014.

- the land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development; in accordance with the provisions of the NEMA, GN1147 of 2015 and the EIA Regulations, 2014; and
- prospecting or mining operations are closed efficiently and cost effectively.

Regulation 61 (Closure objectives)

Stipulates that closure objectives form part of the draft EMPr or environmental management plan, as the case may be, and must:

- identify the key objectives for mine closure to guide the project design, development and management of environmental impacts;
- provide broad future land use objective(s) for the site; and
- provide proposed closure costs.

Regulation 62 (Contents of closure plan)

Stipulates that a closure plan, forms part of the EMPr or environmental management plan, as the case may be, and must include:

- a description of the closure objectives and how these relate to the prospecting or mine operation and its environmental and social setting;
- a plan contemplated in regulation 2(2), showing the land or area under closure;
- a summary of the regulatory requirements and conditions for closure negotiated and documented in the environmental authorisation, as the case may be;
- a summary of the results of the environmental risk report and details of identified residual and latent impacts, in accordance with the NEMA and the EI) Regulations, 2014;
- a summary of the results of progressive rehabilitation undertaken in accordance with the NEMA and the EIA Regulations, 2014;
- a description of the methods to decommission each prospecting or mining component and the mitigation or management strategy proposed to avoid, minimize and manage residual or latent impacts;
- details of any long-term management and maintenance expected;
- details of a proposed closure cost and financial provision for monitoring, maintenance and post closure management; in accordance with the NEMA and the Financial Provision Regulations, 2015;
- a sketch plan drawn on an appropriate scale describing the final and future land use proposal and arrangements for the site;
- a record of interested and affected persons consulted; and
- technical appendices, if any.

3.2 NEMA and the EIA Regulations

The NEMA now regulates mine rehabilitation, closure cost assessment and closure planning. Section 24P of NEMA deals with financial provision for remediation of environmental damage and Section 24P(3) states that every holder of a Mining Right must annually assess their environmental liability and must adjust their financial provision accordingly to the satisfaction of the Minister responsible for Mineral Resources. Section

24R(3) states that every holder must plan, manage and implement procedures and requirements in respect of the closure of a mine as may be prescribed. Appendix 5 of the EIA Regulations (GN982 of 2014 as amended) provides the prescribed content to be included in the closure plan.

Current Financial Provisioning Regulations (GN1147 of 2015)

The NEMA Financial Provisioning Regulations (GN1147 of 2015 *as amended*), published in accordance with NEMA Section 24P, officially came into effect on 20 November 2015, with amendments, GN1314 in October 2016, GN452 in April 2018, GN991 in September 2018, GN24 in January 2020 and GN495 in June 2021.

An applicant or holder of a right or permit must determine and make financial provision to guarantee the availability of sufficient funds to undertake rehabilitation and remediation of the adverse environmental impacts of prospecting, exploration, mining or production operations, as contemplated in the Act and to the satisfaction of the Minister responsible for mineral resources. In accordance with Section 6 and Section 11 of the GN1147 the financial provision must be determined through a detailed itemisation of all activities and costs, calculated based on the actual costs of implementation of the measures required for and the following three reports need to be compiled:

- Annual Rehabilitation Plan;
- Final Rehabilitation, Decommissioning and Closure Plan; and
- Environmental Risk Assessment Report.

As per GN1147, the objectives of the Annual Rehabilitation Plan, Final Rehabilitation, Decommissioning and Closure Plan and Environmental Risk Assessment Report are described in Table 1 below.

Table 1: Report objectives

Annual Rehabilitation Plan	Final Rehabilitation, Decommissioning and Closure Plan	Environmental Risk Assessment
• Review concurrent rehabilitation and remediation activities already implemented; • Establish rehabilitation and remediation goals and outcomes for the forthcoming 12 months, which contribute to the progressive achievement of the closure objective and post-mining sustainable and state as identified in the final rehabilitation, decommissioning and mine closure plan; • Establish a plan, schedule and budget for rehabilitation for the forthcoming 12 months based on the calculated costs; • Identify gaps in knowledge and research to be undertaken to address shortcomings experienced in the preceding 12 months of rehabilitation; • Provide an overview of the monitoring results and effect of rehabilitation; • Highlight any risks emerging from monitoring; and	• Determine, review and revise as required, a sustainable end state for the mining operation, which includes a sustainable and achievable end state of the land, as well as sustainable post-closure management and monitoring measures; • Ensure early-, and regular, consultation throughout the Life of Mine (LoM) on closure objectives and the sustainable end state objectives; • Predict and model the mining activities, expected environmental impacts, the mineral extraction schedule and by applying and explaining a risk-based approach and hierarchy linked to closure activities throughout the LoM; • Determine, review and revise the rehabilitation and remediation activities related to the sustainable end state of the environment at closure and post-closure; • Determine an overall cost for implementing the avoidance, management and rehabilitation activities;	• Ensure the timeous prediction and quantification of environmental risk associated with the operations; • Ensure timeous risk reduction through appropriate interventions; • Identify the potential residual and latent environmental risks which will manifest post-closure; • Detail the approach to manage post-closure risks; • Quantify the potential risks and liabilities associated with the management of the risks based on market related costs; • Calculate a risk threshold and timeframe in which to reach the risk threshold; and

• Identify knowledge gaps which could have an impact on achieving the end state and the intervention, including research interventions to address the gaps.	• Determine the annual budget and schedule for the implementation of the avoidance, management and rehabilitation activities; • Audit and report on the implementation of the plan; and • Identity knowledge gaps and propose actions to actively address the identified gaps through among others, applicable research.	• Outline and cost the post-closure monitoring, auditing and reporting requirements.

This Preliminary Final Rehabilitation, Decommissioning and Closure Plan incorporating an Annual Rehabilitation Plan and Environmental Risk Assessment has been prepared in accordance with the requirements of Appendix 5 of GN982 *as amended* and Appendices 3, 4 and 5 of GN1147 as follows –

Minimum Content of an Annual Rehabilitation Plan (Appendix 3)	[Relevant section of this document]
(3)(a) Details of the- i. person or persons that prepared the plan; ii. professional registrations and experience of the person or persons; iii. timeframes of implementation of the current, and review of the previous rehabilitation activities;	[1]
(3)(b) the pertinent environmental and project context relating directly to the planned annual rehabilitation and remediation activity;	[4] and [5]
(3)(c) results of monitoring of risks identified in the final rehabilitation, decommissioning and mine closure plan with a view to informing rehabilitation and remediation activities;	[12]
(3)(d) an identification of shortcomings experienced in the preceding 12 months;	[13]
(3)(e) details of the planned annual rehabilitation and remediation activities or measures for the forthcoming 12 months, including those which will address the shortcomings contemplated in (d) above or which were identified from monitoring in the preceding 12 months, and including– i. if no areas are available for annual rehabilitation and remediation concurrent with mining, an indication to that effect and motivation why no annual rehabilitation or remediation can be undertaken; ii. where areas are available for annual rehabilitation and remediation concurrent with mining, annual rehabilitation and remediation activities related to previous disturbance or expected planned impacts and disturbance, as per the mine works programme, in the period under consideration, which should be tabulated and must indicate, but not necessarily be limited to,-- a) nature or type of activity and associated infrastructure; b) planned remaining life of the activity under consideration; c) area already disturbed or planned to be disturbed in the period of review; d) percentage of the already disturbed or planned to be disturbed area available for concurrent rehabilitation and remediation activities; e) percentage of the already disturbed or planned to be disturbed area available as per (d) and on which concurrent rehabilitation and remediation can be undertaken; f) notes to indicate why total available or planned to be available area differs from area already disturbed or planned to be disturbed; g) notes to indicate why concurrent rehabilitation will not be undertaken on the full available or planned to be available area; h) details of rehabilitation activity planned on this area for the period of review; i) the pertinent closure objectives and performance targets that will be addressed in the forthcoming year, which objectives and targets are aligned to the final rehabilitation, decommissioning and mine closure plan; j) description of the relevant closure design criteria adopted in the annual rehabilitation and remediation activities and the expected final land use once all rehabilitation and remediation activities are complete for the activity or aspect; and iii. a site plan indicating at least the total area disturbed, area available for rehabilitation and remediation and the area to be rehabilitated or remediated per aspect or activity;	[13]

(3)(f) a review of the previous year's annual rehabilitation and remediation activities, indicating a comparison between activities planned in the previous year's annual rehabilitation and remediation plan and actual rehabilitation and remediation implemented, which should be tabulated and as a minimum contain– i. area planned to be rehabilitated and remediated during the plan under review; ii. actual area rehabilitation or remediated; and iii. if the variance between planned and actual exceeds 15%, motivation indicating reasons for the inability to rehabilitate or remediate the full area; and	[13]
(3)(g) costing, including– i. an explanation of the closure cost methodology; ii. auditable calculations of costs per activity or infrastructure; iii. cost assumptions; and iv. monitoring and maintenance costs likely to be incurred both during the period of the annual rehabilitation plan and those that will extend past the period of the final rehabilitation, decommissioning and mine closure plan, on condition that the monitoring and maintenance costs included in previous annual rehabilitation plans must be accumulated into subsequent versions of the annual rehabilitation plan until such time as the monitoring and maintenance obligation is discharged.	[13]

GNR982 of 2014 (Appendix 5) Minimum Content of a Closure Plan	GNR1147 of 2015 Minimum Content of a Final Rehabilitation, Decommissioning and Closure Plan (Appendix 4)	[Relevant section of this plan]
(1)(f)(iii) comply with any prescribed environmental management standards or practices; and (iv) comply with any applicable provisions of the Act regarding closure		[3]
(1)(a)Details of– (i) the EAP who prepared the closure plan; and (ii) the expertise of that EAP	(3)(a) Details of– (i) the team that prepared the plan (ii) the professional registrations and experience of the preparers	[1]
	(3)(b) The context of the project including– (i) material project description information and issues that have guided the development of the plan	[4]
	(ii) an overview of environmental and social context that may influence closure activities or be influenced by closure activities	[5]
(1)(i) details of all public participation processes conducted in terms of regulation 41 of the Regulations, including— (i) copies of any representations and comments received from registered interested and affected parties; (ii) a summary of comments received from, and a summary of issues raised by registered interested and affected parties, the date of receipt of these comments and the response of the EAP to those comments; (iii) the minutes of any meetings held by the EAP with interested and affected parties and other role players which record the views of the participants; (iv) where applicable, an indication of the amendments made to the plan as a result of public participation processes conducted in terms of regulation 41 of these	(iii) stakeholder issues and comments that have informed the plan	[6]

Regulation		
	(iv) the mine plan and schedule for the full approved operations, and must include (aa) appropriate description of the mine plan (bb) drawings and figures to indicate how the mine develops (cc) what areas are disturbed (dd) how infrastructure and structures (including ponds, residue stockpiles etc.) develops during the life of the mine	[4]
(1)(e) information on any proposed avoidance, management and mitigation measures that will be taken to address the environmental impacts resulting from the undertaking of the closure activity (1)(f) a description of the manner in which it intends to— (i) modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation during closure; (ii)remedy the cause of pollution or degradation and migration of pollutants during closure; (1)(h) the process for managing any environmental damage, pollution, pumping and treatment of extraneous water or ecological degradation as a result of closure	(3)(c) Findings of an environmental risk assessment leading to the most appropriate closure strategy including— (i) description of the risk assessment methodology including risk identification and quantification. This to be undertaken for all areas of infrastructure or activity or aspects for which an operation has a responsibility to mitigate an impact or risk at closure	[8]
	(ii) identification of indicators that are most sensitive to potential risks and the monitoring of such risks with a view to informing rehabilitation and remediation activities	[8.1]
	(iii) identification of conceptual closure strategies to mitigate the impacts and risks	[9]
	(iv) a reassessment of the risks to determine whether, after the implementation of the closure strategy, the residual risk has been avoided and / or how it has resulted in avoidance, rehabilitation and management of impacts and whether this is acceptable to the mining operation and stakeholders	[10]
	(v) explanation of changes to the risk assessment results as applicable in annual updates to the plan	No changes as of yet
	(3)(d) Design principles including— (i) legal and governance framework and interpretation of these requirements for the closure design principles	[2]
(1)(b) closure objectives	(ii) closure vision and objectives. The objectives must reflect the local environmental and socio-economic context and reflect regulatory and corporate requirements and stakeholder expectations	[7]
	(iii) description and evaluation of alternative closure and post-closure options where these exist that are practicable within the socio-economic and environmental opportunities and constraints in which the operation is located	[7.4]
	(iv) motivation for the preferred closure action within the context of the risks and impacts that are being mitigated	[7.4]
	(v) definition and motivation of the closure and post-closure period taking cognisance of the probable need to implement post-closure monitoring and maintenance for a period sufficient to demonstrate that relinquishment criteria have been achieved	[7.5]
	(vi) details associated with any on-going research on closure options	[15]
	(vii) detailed description of the assumptions made to develop closure actions in the absence of detailed knowledge on site conditions, potential impacts, material availability, stakeholder requirements and other factors for which information is lacking	[8.4]
	(3)(e) Proposed final land use—	[7.3]

	(i) descriptions of appropriate and feasible final post-mining land use for the overall project and per infrastructure or activity and a description of the methodology used to identify final post-mining land use, including the requirements of the operations stakeholders (ii) map of proposed final post-mining land use	
(1)(d) measures to rehabilitate the environment affected by the undertaking of any listed activity or specified activity and associated closure to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development, including a handover report, where applicable	(3)(f) Closure actions— (i) the development and documenting of a description of specific technical solutions related to infrastructure and facilities for the preferred closure option or options, which must include all areas, infrastructure, activities and aspects both within the mine lease area and off of the mine lease area associated with mining for which the mine has the responsibility to implement closure actions;	[9]
	(ii) development and maintenance of a list and assessment of threats and opportunities and any uncertainties associated with the preferred closure option, which list will be used to identify and define any additional work that is needed to reduce the level of uncertainty	[8.4]
(1)(g) time periods within which the measures contemplated in the closure plan must be implemented	(3)(g) Schedule of actions for final rehabilitation, decommissioning and closure which will ensure avoidance, rehabilitation, management of impacts including pumping and treatment of extraneous water— (i) linking to mine works programme (if greenfields) or to the current mine plan (if brownfields) (ii) assumptions and schedule drivers (iii) spatial map of schedule showing planned spatial progression throughout operations	[7.5]
	(3)(h) Indicate the organisational capacity that will be put in place to implement the plan including— (i) organisational structure as it pertains to the plan (ii) responsibilities (iii) training and capacity building that may be required to build closure competence	[11]
	(3)(i) An indication of gaps in the plan, including an auditable action plan and schedule to address the gaps	[15]
	(3)(j) Relinquishment criteria for each activity or infrastructure in relation to environmental aspects with auditable indicators	[12.2]
(1)(j) where applicable, details of any financial provision for the rehabilitation, closure and on-going post decommissioning management of negative environmental impacts	(3)(k) Closure cost estimation procedure, which ensures that identified rehabilitation, decommissioning, closure and post-closure costs, whether on-going or once-off, are realistically estimated and incorporated into the estimate, on condition that— (i) cost estimates for operations, or components of operations that are more than 30 years from closure will be prepared as conceptual estimates with an accuracy of ± 50 per cent. Cost estimates will have an accuracy of ± 70 per cent for operations, or components of operations, 30 or less years (but more than ten years) from closure and ± 80 per cent for operations, or components of operations ten or less years (but more than five years) from closure. Operations with 5 or less years will have an accuracy of ± 90 per cent. Motivation must be provided to indicate the accuracy in the reported number and as accuracy improves, what actions resulted in an improvement in accuracy;	[14]

	(ii) the closure cost estimation must include the following (aa) explanation of the closure cost methodology (bb) auditable calculations of costs per activity or infrastructure (cc) cost assumptions (iii) the closure cost estimate must be updated annually during the operation's life to reflect known developments, including changes from the annual review of the closure strategy assumptions and inputs, scope changes, the effect of a further year's inflation, new regulatory requirements and any other material developments;	
(1)(c) proposed mechanisms for monitoring compliance with and performance assessment against the closure plan and reporting thereon	(3)(l) Monitoring, auditing and reporting requirements which relate to the risk assessment, legal requirements and knowledge gaps as a minimum and must include— (i) a schedule outlining internal, external and legislated audits of the plan for the year, including— (aa) the person responsible for undertaking the audit(s) (bb) the planned date of audit and frequency of audit (cc) an explanation of the approach that will be taken to address and close out audit results and schedule; (ii) a schedule of reporting requirements providing an outline of internal and external reporting, including disclosure of updates of the plan to stakeholders (iii) a monitoring plan will be provided outlining (aa) parameters to be monitored, frequency of monitoring and period of monitoring (bb) an explanation of the approach that will be taken to analyse monitoring results and how these results will be used to inform adaptive or corrective management and/or risk reduction activities	[12]
	(3)(m) Motivations for any amendments made to the final rehabilitation, decommissioning and mine closure plan, given the monitoring results in the previous auditing period and the identification of gaps	No amendments as of yet

Minimum Content of an Environmental Risk Assessment (Appendix 5)	**[Relevant section of this document]**
(3)(a) Details of (i) The person or persons that prepared the plan; (ii) The professional registrations and experience of the preparers;	[1]
(3)(b) details of the assessment process used to identify and quantify the post closure, residual and possible latent risks, including -	
(i) description of the risk assessment methodology inclusive of risk identification and quantification;	[8]
(ii) substantiation why each risk will occur post closure, including why the risk was not or could not be mitigated during concurrent rehabilitation and remediation or during the implementation of the final rehabilitation, decommissioning and mine closure plan;	
(iii) a detailed description of the drivers that could result in the manifestation of the risks, to be presented within the context of closure actions already having been implemented during the execution of concurrent rehabilitation or during the implementation of the final rehabilitation, decommissioning and closure plan;	
(iv) a description of the expected timeframe in which the risk is likely to manifest, typically as expected years after closure, and the duration of the impact, including motivation to support these timeframes;	
(v) a detailed description of the triggers which can be used to identify that the risk is imminent or has manifest, how this will be measured and any cost implications thereof;	

(vi) results and findings of the risk assessment;	
(vii) an explanation of changes to the risk assessment results as applicable in annual updates to the plan;	
(3)(c) Management activities, including -	
(i) monitoring of results and findings, which informs that adaptive or corrective management and/or risk reduction activities;	[12 and 7.4]
(ii) an assessment of alternatives to mitigate or manage the impacts once the risk has become manifested, which must be focussed on practicality as well as cost of the implementation;	
(iii) motivation why the selected alternative is the appropriate approach to mitigating the impact;	
(iv) a detailed description of how the alternative will be implemented;	
(3)(d) Costing, calculated using the current value of money and no discounting or net present value calculations included in the determination of the quantum of the liability, including -	
(i) a cost estimation, which must include - (aa) an explanation of the closure cost methodology; (bb) an auditable calculations of costs per activity or infrastructure; (cc) cost assumptions; (dd) monitoring costs post closure to determine whether the risk is imminent or has manifest are to be included in the assessment as are monitoring costs likely to be incurred during the implementation of the strategy to manage or mitigate the impacts once the risk has become manifest;	[13]
(ii) where appropriate a differentiation between capital, operating, replacement and maintenance costs;	
(iii) cost estimates for operations, or components of operations that are more than 30 years from closure prepared as conceptual estimates within an accuracy of ± 50 per cent. Cost estimates will have an accuracy of ± 70 per cent for operations, or components of operations, 30 or less years (but more than ten years) from closure and ± 80 per cent for operations, or components of operations ten or less years (but more than five years) from closure. Operations with 5 or less years will have an accuracy of ± 90 per cent. Motivation must be provided to indicate the accuracy in the reported number and as accuracy improves, what actions resulted in an improvement of accuracy; and	
(3)(e) Monitoring, auditing and reporting requirements, which must include requirements prior to the manifestation of the risk and impacts as well as those once the impacts resulting from the manifestation of the risk are realised, inclusive of the approach that will be taken to analyse monitoring results and how these results will be used to inform adaptive or corrective management and/or risk reduction activities.	[12]
Minimum Content of an Environmental Risk Assessment (Appendix 5)	**[Relevant section of this document]**
(3)(a) Details of (i) The person or persons that prepared the plan; (ii) The professional registrations and experience of the preparers;	[1]
(3)(b) details of the assessment process used to identify and quantify the post closure, residual and possible latent risks, including -	
(viii) description of the risk assessment methodology inclusive of risk identification and quantification;	[8]
(ix) substantiation why each risk will occur post closure, including why the risk was not or could not be mitigated during concurrent rehabilitation and remediation or during the implementation of the final rehabilitation, decommissioning and mine closure plan;	
(x) a detailed description of the drivers that could result in the manifestation of the risks, to be presented within the context of closure actions already having been implemented during the execution of concurrent rehabilitation or during the implementation of the final rehabilitation, decommissioning and closure plan;	
(xi) a description of the expected timeframe in which the risk is likely to manifest, typically as expected years after closure, and the duration of the impact, including motivation to support these timeframes;	
(xii) a detailed description of the triggers which can be used to identify that the risk is imminent or has manifest, how this will be measured and any cost implications thereof;	
(xiii) results and findings of the risk assessment;	

(xiv) an explanation of changes to the risk assessment results as applicable in annual updates to the plan;	
(3)(c) Management activities, including -	
(v) monitoring of results and findings, which informs that adaptive or corrective management and/or risk reduction activities;	[12]
(vi) an assessment of alternatives to mitigate or manage the impacts once the risk has become manifested, which must be focussed on practicality as well as cost of the implementation;	
(vii) motivation why the selected alternative is the appropriate approach to mitigating the impact;	
(viii) a detailed description of how the alternative will be implemented;	
(3)(d) Costing, calculated using the current value of money and no discounting or net present value calculations included in the determination of the quantum of the liability, including -	
(iv) a cost estimation, which must include - (aa) an explanation of the closure cost methodology; (bb) an auditable calculations of costs per activity or infrastructure; (cc) cost assumptions; (dd) monitoring costs post closure to determine whether the risk is imminent or has manifest are to be included in the assessment as are monitoring costs likely to be incurred during the implementation of the strategy to manage or mitigate the impacts once the risk has become manifest;	[14]
(v) where appropriate a differentiation between capital, operating, replacement and maintenance costs;	
(vi) cost estimates for operations, or components of operations that are more than 30 years from closure prepared as conceptual estimates within an accuracy of ± 50 per cent. Cost estimates will have an accuracy of ± 70 per cent for operations, or components of operations, 30 or less years (but more than ten years) from closure and ± 80 per cent for operations, or components of operations ten or less years (but more than five years) from closure. Operations with 5 or less years will have an accuracy of ± 90 per cent. Motivation must be provided to indicate the accuracy in the reported number and as accuracy improves, what actions resulted in an improvement of accuracy; and	
(3)(e) Monitoring, auditing and reporting requirements, which must include requirements prior to the manifestation of the risk and impacts as well as those once the impacts resulting from the manifestation of the risk are realised, inclusive of the approach that will be taken to analyse monitoring results and how these results will be used to inform adaptive or corrective management and/or risk reduction activities.	[12]

4. PROJECT DESCRIPTION

The THM covers portions of two farms within the JMLM in the Northern Cape Province; Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel (refer to Figure 1).

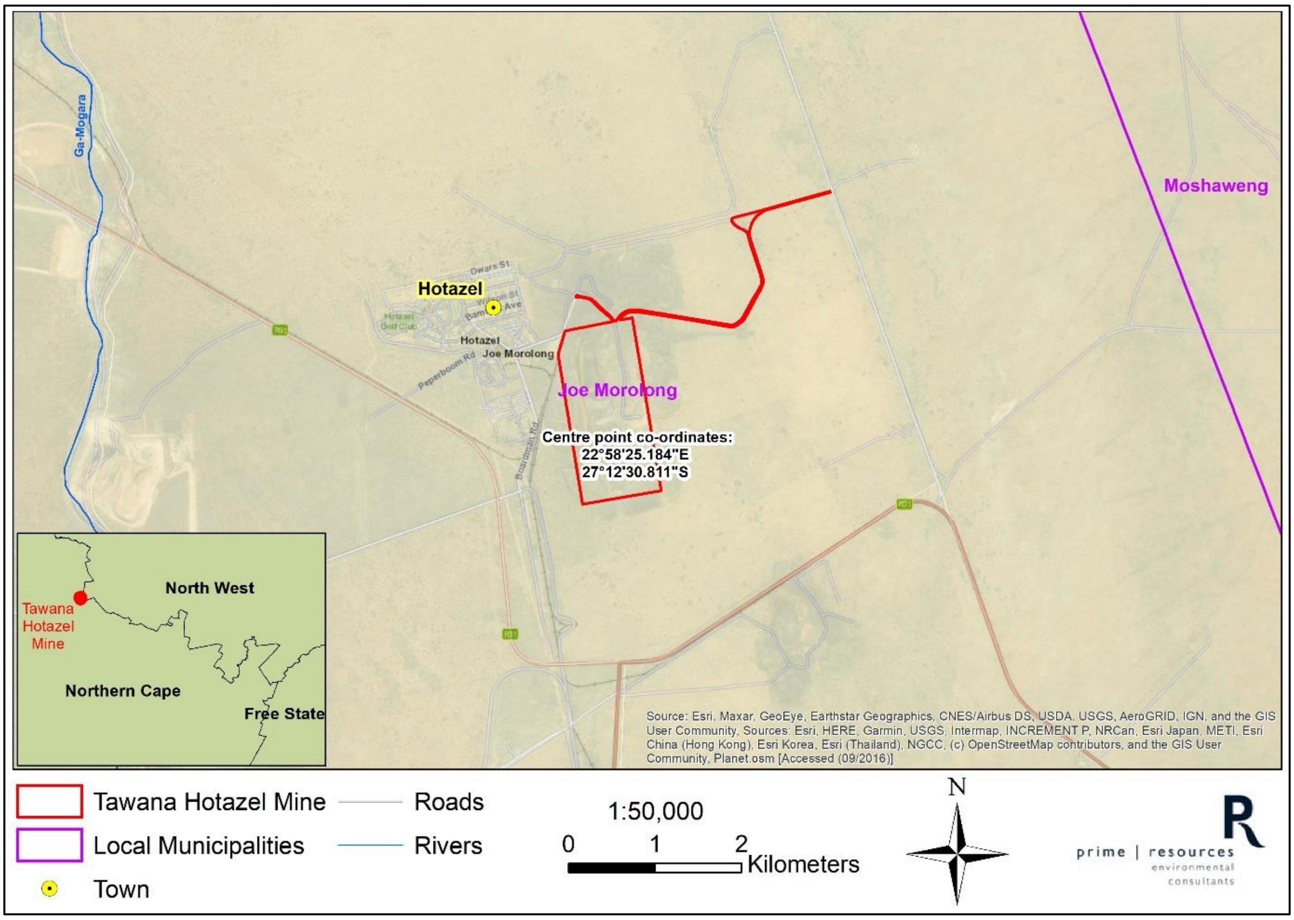

Figure 1: Locality map for the proposed THM

The THM largely incorporates the historical HMM, and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining.

The overall area applied for is approximately 154 Ha (inclusive of the MR application area and access road). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure (refer to Figure 2).

Figure 2: Layout of the proposed THM

4.1 Mining

- Opencast mining methods will be used to a maximum depth of 95 m.
- The ore zone of the various seams is found at depths from 25 to 91 m below the surface and the manganese seam thicknesses varies from 3 to 27 m.
- The proposed mining process is as follows: drilling → blasting → load and haul → dry crushing and screening plant → product stockpiling → road truck loading.
- The annual Run of Mine (RoM) ore production is estimated at 500 000 tpa.
- The mining of the opencast pit will require as many as two active work areas in certain schedule overlap years.

4.2 Processing

- From the RoM stockpile, front end loaders (FELs) or excavators will feed the ore into a semi mobile primary crusher (jaw crusher).
- The primary crusher will feed the screening plant. In the initial stages these will be semi mobile units.
- The semi mobile crushing and screening plant is currently planned to be located at the southern end of the open pit.
- The different size fractions will be sampled and stockpiled into separate stockpiles according to grade and size at the dedicated stockpile area.
- From these stockpiles, the product will be loaded onto road trucks using a FEL according to the customer's requirements in terms of size and grade (some blending may be required).
- Fines will be stockpiled for sale as and when the demand arises.
- Road transport loading, with suitable weighbridges, will take place via a dedicated loading facility. Road trucks will then transport product to Lohatla for train loading, after passing over the weighbridge.

4.3 Mine entrance and access roads

- There are two main access roads to the mine, one intersects with Provincial Road D3463 from Kuruman to Severn and enters the mine at the north eastern corner, while the other road is from Hotazel town in the west and enters the mine from the north. The two roads intersect before entering the mining area.
- The main transport route to the north east will be for Heavy Vehicles (HVs) and the main entrance to the west (near Hotazel) will be for Light Delivery Vehicles (LDV's).
- In addition, on-site access roads will be required for use by the secondary support fleets and earthmoving haul trucks, with ramps that lead in and out of the pit and haul roads for the transportation of processed products and waste amongst others.
- In order to improve mobility around the mine and to potentially reduce road user costs, a ring road (haul road) around the mine pit has been proposed. This road will also intercept stormwater which will be channelled to the stormwater ponds.
- The minimum width of all the roads is 10 m (and up to 20 m) as they generally have to accommodate large trucks, with sufficient space for surface water flow.

4.4 Electricity

- The mine reticulation will be provided from the existing 11 kV Eskom overhead power supply line from a substation in the Hotazel railway substation area, which terminates close to the north-western corner of the mine, next to the existing railway line.
- A new mini-substation will be installed to connect to the Eskom substation near the South 32 Offices, from where the mine office and weighbridge will be connected by an overhead 11 kV power line.
- The expected full load power requirement is calculated as 3 326 kVA. An application for 4.0 mVA has been submitted to cover the power requirements for the proposed THM.
- The remaining facilities and plant (i.e., processing plant) will not be connected to the grid as they will use their own power. The entire processing plant will be diesel operated.
- Until such time as power infrastructure is installed on site a mix of solar and diesel generators will be used as an alternate supply source.

4.5 Water

- All potable water will be supplied through the Vaal Gamagara water scheme via a bulk water meter, managed by Sedibeng Water.
- Sedibeng Water has therefore been engaged and has provisionally approved a connection point for water supply approximately 2 km south west of the mine. A design is required to be submitted to Sedibeng Water for approval.
- Water will be required for processing, mining, change houses, offices, and workshops. Each supply area will be individually metered to enhance control and minimize wastage.
- Water supply for other purposes (i.e. dust suppression and industrial use on site) will be sourced from the either the stormwater ponds or the PCD.
- The estimated potable water consumption volume is 4800 – 6480 litres per day plus 10% for wastage/ losses.
- The remainder of the water to be used for general purposes (i.e. dust suppression and process water purposes) will be sourced from the PCD and the stormwater ponds.
- An application for a water connection has been submitted to Sedibeng Water.
- Precipitation has collected in the open void and underground workings since the mine stopped production in 1989. This water will need to be fully removed before mining work can commence. A forced-evaporation system to remove water from the initial void may be implemented for water management purposes.
- A lined 5 m deep Pollution Control Dam (PCD) is planned with a minimum capacity of 20 000 $m^{3.}$
- The site has been split into three main catchment areas, excluding the mining pit, resulting in a total of three planned stormwater ponds to store as much of the surface water as practically possible. The surface water will mainly be intercepted by the roads and channelled to the respective stormwater ponds. The capacity of the stormwater ponds is as follows: Stormwater Pond 1 (12 250 m^3), Stormwater Pond 2 (6500 m^3) and Stormwater Pond 3 (7313 m^3). The ponds have been sized for a 1 in 50-year return flood.
- Mine dewatering will be carried out using diesel powered submersible pumps installed in sumps at the bottom of the pit.

4.6 Waste

- The mining project will generate general (domestic) waste and mining waste.
- Sanitation from the mine will be piped to a septic tank which will be located on the eastern side of the offices. This septic tank will have a capacity of a minimum two (2) weeks before it is filled-up. Design drawings are to be submitted to the municipality for approval prior to start of construction. Similar to the water supply, sanitation infrastructure will only be connected to the office block.
- Non-hazardous domestic and industrial waste will be stored temporarily within a hard-standing area for covered bins / skips.
- All recyclable waste will be collected by a contractor where it will be recycled off-site. Only materials which cannot be reused, recycled or recovered will be disposed of at an appropriately licensed facility by a licensed contractor.
- An estimated stripping ratio is calculated at 2.98 t of waste per tonne of ore. Residue material (overburden and waste rock) arising from the development and ongoing operation of the opencast mine pit will be disposed back into the existing historical opencast void and the trailing mined out opencast void through backfilling. There will be 3 waste dumps with the following capacities and maximum heights:
    - Waste dump no.1 (3 859 493 m^3) – 15 m above current surface
    - Waste dump no.2 (3 487 682 m^3) - level with current surface
    - Waste dump no.3 (5 783 722 m^3) – 30 m above current surface and to be developed on top of waste dump 2 once that dump reaches surface level
- There will also be a topsoil stockpile with a capacity of 210 000 m^3 and estimated height of 10 m and a sand stockpile with a capacity of 1 185 000 m^3 and estimated height of 20m.

4.7 Other infrastructure

- A new weighbridge facility, which will comprise of a weighbridge and an office, is planned to be constructed between the offices and the product stockpile area, close to the northern boundary of the of the mine. This facility will be manned as per the operational requirements of the mine. In order to cater for trucks that may be overload or underloaded, a turning loop will be constructed next to the weighbridge facility to allow for easy access back to the product stockpile area.
- The new offices and parking will be located along the northern boundary of the mine. The offices will be accessible via the new access road that ties-in with the main access road from the north, used by LDVs.
- A plant yard/ workshop will be located on the western side of the pit, between the mine pit and a haul road that links the processing plant and the product stockpile area. This facility will mainly be used for repairs, servicing and washing of vehicles/plant. The surface will be a concrete slab with a slope towards various sumps to contain oil and contaminated water.
- A Refuelling Station will be located on the western side of the pit. This facility is anticipated to have at least two 35 000 l refuelling tanks and will have a concrete slab with sumps to contain oil and contaminated water.

4.8 Operating hours and staff

- The mine and plant will operate on a continuous basis with 330 working days per annum.

- The mine will employ approximately 177 people (inclusive of outsourced service providers).

4.9 Mine Plan Schedule

Table 2: Mine plan schedule

Main activity	2 years	30 years	1 year	3 - 5 years
Construction phase: Pre-stripping and mining infrastructure construction				
Operation phase: Opencast mining				
Closure phase: Decommissioning and mine rehabilitation				
Post closure phase: Final Rehabilitation and post closure monitoring				

4.10 Information sources

The information used to compile this report was obtained from the EIAR and EMPr as well as the following specialist studies:

Report	Author
Mining Work Programme	THM, dated 2021
Social and Labour Plan (SLP)	THM, dated 2021
Air Quality, Greenhouse Gas Emissions and Climate Change Impact Assessment	Airshed Planning Professionals (Pty) Ltd, dated 2021
Agricultural Compliance Statement	Digital Soils Africa (Pty) Ltd, dated 2021
Heritage Impact Assessment	Archaetnos Culture & Cultural Resource Consultants, dated 2021
Palaeontological Impact Assessment	Professor Marion Bamford, dated 2021
Noise Impact Assessment	Airshed Planning Professionals (Pty) Ltd, dated 2021
Hydrology Impact Assessment	iLanda Technologies (Pty) Ltd, dated 2021
Geohydrology Impact Assessment	Future Flow Groundwater and Project Management, dated 2021
Geochemical Assessment	Prime Resources (Pty) Ltd, dated 2021
Terrestrial Biodiversity Impact Assessment	Field and Form Landscape Science in collaboration with Malachite Ecological Services, dated 2021
Avifaunal Impact Assessment	Feathers Environmental Services, dated 2021
Aquatic Biodiversity Compliance Statement	Ecology International (Pty) Ltd, dated 2021
Blasting and Vibrations Impact Assessment	Blast Management and Consulting, dated 2021
Traffic Impact Assessment	Merchelle's Collective (Pty) Ltd, dated 2021

5. ENVIRONMENTAL AND SOCIAL CONTEXT

This section summarises the current environmental and social context of the proposed site. The site is a brownfields site with most of it having been disturbed during previous mining operations. The information provided here is therefore, baseline information indicating the pre-project environmental and social context however, this will change considerably before closure is attempted therefore, this section will require updating as the project progresses towards closure. Further details on the project and environmental context can be found in the EIAR and associated Environmental Management Programme (EMPr). All specialist studies undertaken for the THM are included as appendices to the EIAR/EMPr.

5.1 Climate and Air Quality

The proposed site is located in the Northern Cape province which is generally hot and dry. Maximum summer temperatures often exceed 40°C. During winter, the average daytime temperatures are mild and night-time temperatures may drop below 0°C.

The prevailing air quality in the study area is mostly influenced by mining and processing activities at other surrounding operations, as well as farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles. The main sources of air pollution in the Northern Cape are biomass burning and mining, followed by industry and motor vehicles. Biomass burning is a major contributor of carbon monoxide (CO) whereas mining contributes particulate matter (PM_{10}, $PM_{2.5}$) and total suspended particles (TSP). Motor vehicles are the largest source of Oxides of nitrogen (NO_X) and Volatile organic compounds (VOC) emissions, although these are relatively small, and it is likely that these emissions have been underestimated. Long range atmospheric transport of air pollutants from the industrialised Highveld and biomass burning in southern and central Africa may influence ambient air quality over parts of the Northern Cape.

5.2 Topography

Site is located at elevations between 1 063 and 1 070 m above mean sea level (mamsl). The topography within the proposed mining area gently sloping from the east (at approximately 1 071 mamsl) towards the Gamagara River west of the proposed mining area (at approximately 1 063 mamsl). The topographical gradient ranges around 1:280.

The only distinct topographic features in the greater area are a small inselberg at Black Rock mine, the north-south trending Kuruman Hills toward the east and the Korannaberge to the west. With the exception of the existing opencast void and surface dumps in the south and east of the proposed THM, no significant landforms such as hills, valleys or outcrops could be discerned from available elevation and relief data, although surface mine dumps are present within the east and south of the proposed THM.

5.3 Geology

The proposed THM is located on the relatively young Kalahari Group within the Kalahari Manganese Basin, on the northern portion of the Kalahari Manganese Field (KMF). The KMF is an erosional basin spanning approximately 40 km in the North-South and 15 km in the East-West dimension. The regional strike in the study area is 330 degrees with a westward dip of around 7 degrees.

Locally, within the bounds of the MR area, only the Hotazel Formation and overlying Kalahari Group Sediments are preserved, with all three manganese units (UB, Middle Body and LB) present. The MR area is unique in that both ore types of the KMF (i.e., Wessels Type and Mamatwan Type) appear to be present. There are also numerous fractures and potential faults which have allowed for deleterious ferruginization (replacement of manganese by iron).

The major rock types that occur in the study area include dolomite, limestone and chert of the Ghaap Group, BIF within the Griquatown West Sequence and shales and schists of the Ecca Group of the Karoo Supergroup.

5.4 Soil, Land Capability and Agricultural Potential

The proposed THM consists red or yellow high base status soils and where the pedosystem is predominately located on a terrain with footslopes (gradient <1%). Soils in the area have limited pedological development and the texture of soil in this land type is dominated by sand with a low clay fraction (estimated as less than 10%). Deep Hutton and Clovelly soil forms (>1.2m) constitutes the largest portion of this land type. The land capability is classified as Class VII which has limitations that cannot be corrected, including severe erosion hazard, low water holding capacity and severe climate. These limitations make the land generally unsuited for cultivation and limit its use largely to non-arable, grazing, woodland or wildlife.

5.5 Palaeontology, Archaeology and Cultural Heritage

The South African Heritage Resources Information System (SAHRIS) Palaeontology (fossil) sensitivity map, the area is indicated the areas as having moderately sensitive (green), this applies to the Kalahari sands. The mining area lies on the aeolian sands of the Kalahari Group (Quaternary age) which do not preserve fossils. The rocks bearing iron and manganese also do not preserve fossils. No palaeopans or palaeosprings which may preserve fossils are in the area. Furthermore, there are no UNESCO World Heritage Sites in the vicinity of the proposed THM.

From a cultural perspective, known heritage sites are situated at a distance to the west of the proposed THM on the opposite side of the town of Hotazel and are therefore not threatened by the proposed development. No sites of cultural heritage importance were identified within the surveyed area.

5.6 Noise

A short-term noise sampling campaign was carried out by Airshed Planning Professionals (Pty) Ltd (March 2021), on the 1st and 2nd of December 2020 at six locations during which day- and night-time noise measurements were taken per the methods described in SANS 10103 (2008) the NEMA protocols published in GN 320. The daytime and night-time acoustic climate at the six sampling points was heavily influenced by local noise generating sources, with the R31 (regional main road) activities only audible at Site 1; and railway operations at Site 5. Noise sources at Sites 3, 4 and 5, which were located either in- or near to-Hotazel residential areas were mostly influenced by local sources such as community activity, vehicle traffic and domestic animals. The acoustic sources at Point 6, located close to what appeared to be an unused mine access road, included insects, birds, cows and community activity. Refer to Table 3 and Figure 3 below for the results and map showing the sensitive receptors and sampling locations.

Table 3: Noise measurement sites and levels

Site	Location and visual and acoustic observations	Continuous day-time noise levels ($L_{Req,d}$)	Continuous night-time noise levels ($L_{Req,n}$)
1	South of R31: *Shrubs, trees, uncultivated land, R31 road to the north and unoperational mine to the south. Noise sources included birds (day-time and evening), vehicle traffic from the R31 and insects (day and night).*	Typical of urban district with main roads	Typical of urban districts
2	North of HMM: *Shrubs, trees, uncultivated land, unoperational mine to the south. Noise sources included insects, birds (day and evening) and dogs (night).*	Typical of urban districts	Lower than rural districts
3	East of Hotazel near Dwarsstraat: *Uncultivated land, short grass, near residential properties and road. Noise sources included birds (day), insects (day and evening), dogs (evening and night), music (evening), community noise (evening) and vehicle traffic from the residential road.*	Lower than rural districts	Typical of suburban districts
4	Between Wessels Clinic and Hotazel Combined School in Hotazel: *Uncultivated land, near unused sports field. Noise sources included insects (day and evening), birds (night), dogs (evening and night), community noise (evening and night), and vehicle traffic (night).*	Typical of rural districts	Lower than rural districts
5	Residential area near railway line: *Uncultivated land within residential area and near railway line. Noise sources included birds (day and night), insects (evening), dogs, music (day), community noise (day and evening), vehicle traffic from the residential road (day and evening), and cows (day).*	Lower than rural districts	Typical of urban districts
6	North of proposed THM access road: *Uncultivated land, long grass and shrubs near mine access road. Noise sources included birds and insects.*	Typical of suburban districts	Typical of rural districts

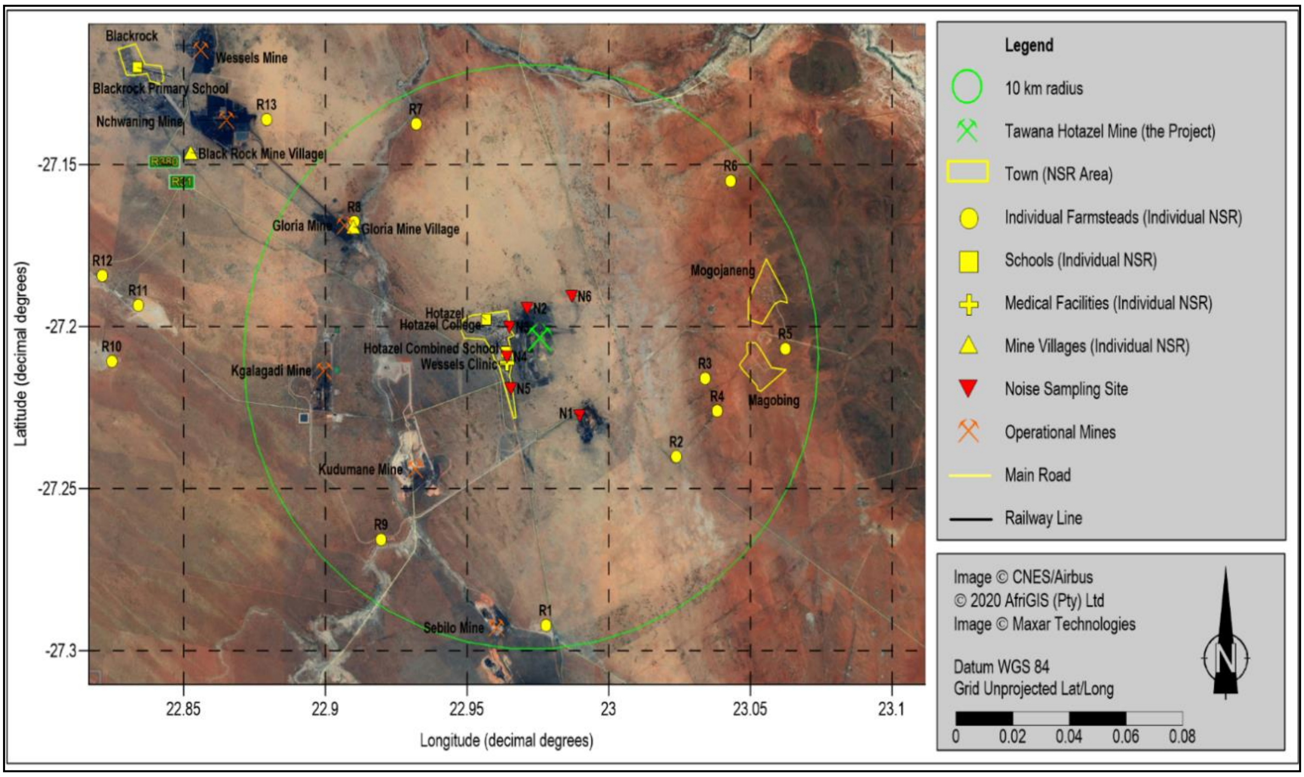

Figure 3: Noise sensitive receptors and noise sampling locations

5.7 Surface Water

The proposed THM is located within the newly revised Vaal Water Management Area (WMA) within Quaternary Catchment D41K between the Kuruman and the Gamagara Rivers within the Molopo River catchment. The proposed THM does not contain rivers or streams within the boundaries of the MR application area however, it drains generally to the west towards the Gamagara River (about 5 km west), which flows from south to north. Within the quaternary catchment, the Witleegte, Gamagara and Vlermuisleegte Rivers are present; these are, however, at a distance greater than 5 km from proposed THM. The Gamagara River confluences with the Kuruman River to the north of the proposed THM, which eventually joins the Molopo River further downstream to the west. The Gamagara River may be regarded as Largely Natural and non-perennial in nature, while the portion of the Kuruman River about 10 km directly north of THM may be regarded as Largely Natural and perennial due to its source, a natural spring known as the 'eye of Kuruman' further upstream. The Gamagara River is classified as Critically Endangered, and with the river signature not considered to be adequately protected, while the Kuruman River is classified as Critically Endangered with the river signature considered to be poorly protected.

The catchments are largely undeveloped, although significant iron ore and manganese deposits are being mined in the Gamagara River catchment. The Kuruman River catchment comprises mostly agricultural activities.

The proposed THM is not located within a surface water or groundwater Strategic Water Source Area (SWSA) WRC, 2018, with the closest SWSA being the Northern Ghaap Plateau groundwater SWSA, approximately 12 km east and the Sishen/ Kathu groundwater SWSA located approximately 11 km south (WRC, 2017).

The following likely downstream users were determined from aerial photography, literature surveys and observations made during a site visit of the catchment:

- Domestic users – limited drinking water, but farm labourers and local inhabitants may consume this river water and use it for laundry and cleaning when water is available.
- Recreational users – it is likely that farm labourers and local inhabitants may swim in the rivers when they are flowing and may use the water for washing.
- Industrial users – there are no water quality sensitive industrial users on the Gamagara and Kuruman rivers downstream of the study area.
- Aquatic users – the catchments are impacted by agriculture and mining and sensitive aquatic users are unlikely to be present. Some less sensitive aquatic species may still be present. Further considerations regarding baseline aquatic ecology are described in Section 5.11 below.
- Irrigation users – the river water may be used for opportunistic irrigation.
- Livestock watering – the river water may be used for opportunistic livestock watering.

The background water quality in the Kuruman River is good, with only elevated calcium, resulting in elevated TDS and electrical conductivity. This is considered naturally occurring calcium.

5.8 Groundwater

Three aquifers occur in the area. These three aquifers are associated with a) the primary sandy gravel material, b) the fractured rock and leached banded iron formation aquifer, and c) the dolomitic aquifers of the Griqualand West Sequence. The fractured rock aquifers are not high yielding, but the dolomitic karst aquifer is well known for its high potential (Van Dyk and Jones, 2006). The aquifers present in the area are classified as minor aquifers. The aquifers are of high importance to the local landowners outside of town as it is their only source of water for domestic, gardening, and agricultural purposes. The depth to groundwater level measured in the boreholes during the hydrocensus of November 2020 ranged between 20.3 and 32.00 m with an average of 26.76 m. The depth to groundwater level measured in the groundwater monitoring boreholes TMBH1, TMBH2 and TMBH3 during October 2021 ranged between 26.65 and 47.03 m.

Baseline groundwater samples were collected from:

- Three of the eleven hydrocensus points. Boreholes NG, JB40 and York were sampled;
- The water in the main existing opencast pit (sample HP); and
- Three of the newly drilled groundwater monitoring boreholes (TMBH4 was dry at the time and could not be sampled).

The sample from the church in town (sample NG) and that of monitoring borehole TMBH3 differ notably from the other five samples. None of the elements exceed the SANS241:2015 guideline values in samples NG and TMBH3, while chloride and nitrate exceed the SANS241:2015 guideline value in all five other samples. Sodium and manganese also exceed the guideline values in individual samples. Due to the high chloride and nitrate concentrations the total dissolved solids (TDS) and electrical conductivity (EC) also exceed the SANS241:2015 guideline values in samples HP, JB40, York, TMBH1 and TMBH2 (refer to Table 4).

Table 4: Groundwater chemical analysis results

Analysis	Units	SANS 241:2015 guideline value	HP	NG	JB40	York	TMBH1	TMBH2	TMBH3
pH		≥5 - ≤9.7	7.84	8.13	7.41	7.58	7.52	7.3	8.53
EC	mS/m	≤170	456	73.5	365	394	427	367	86.6
TDS	mg/L	≤1 200	4144	458	3036	3230	2858	2591	488
Total Alkalinity	mg/L $CaCO_3$	N/G	150	316	30	288	130	200	46.9
Total Hardness	mg/L $CaCO_3$	N/G	2080.8	404.1	1454.3	1992	1693	1695	137
Chloride (Cl)	mg/L	≤300	774.9	24	748.3	665.8	728	515	136
Sulphate (SO_4)	mg/L	≤500 (health)	199	23.6	117	35.7	103	121	88.1
Nitrate (NO_3-N)	mg/L	≤11	323.3	4.18	119.7	223.6	260	235	14.1
Nitrite (NO_2-N)	mg/L	≤0.9	0.365	<0.006	0.07	<0.006			
Ammonium (NH_4)	mg/L	N/G	<0.03	<0.03	1.65	<0.03	<0.008	<0.008	<0.008
Phosphate (PO_4)	mg/L	N/G	0.12	0.15	0.24	0.2	<0.005	<0.005	<0.005
Fluoride (F)	mg/L	≤1.5	<0.3	0.3	0.5	<0.3	<0.263	<0.263	<0.263
Bromide	mg/L	N/G	6.95	0.12	7.26	6.31			
Calcium (Ca)	mg/L	N/G	384.6	76.3	277.8	311.6	367	427	36.7
Magnesium (Mg)	mg/L	N/G	266.5	50.8	180.9	288.8	189	153	11
Sodium (Na)	mg/L	≤200	239.3	20.7	182.5	150.5	179	133	122
Potassium (K)	mg/L	N/G	5.4	2.2	3.9	4.4	9.54	7.07	2.26
Aluminium (Al)	mg/L	≤0.3	<0.02	<0.02	<0.02	<0.02	<0.002	<0.002	0.098
Arsenic	mg/L	≤0.01	<0.0025	<0.0025	<0.0025	<0.0025			
Cadmium (Cd)	mg/L	≤0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.002	<0.002
Chromium (Cr)	mg/L	≤0.05	0.002	<0.0015	0.0018	<0.0015	<0.003	<0.003	<0.003

Analysis	Units	SANS 241:2015 guideline value	HP	NG	JB40	York	TMBH1	TMBH2	TMBH3
Cobalt (Co)	mg/L	N/G	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.003
Copper (Cu)	mg/L	≤2	<0.007	<0.007	<0.007	<0.007	0.046	0.043	0.015
Iron (Fe)	mg/L	≤2 (health)	0.08	0.051	0.389	0.034	<0.004	<0.004	<0.004
Lead (Pb)	mg/L	≤0.01	<0.005	<0.005	0.037	<0.005	<0.004	<0.004	<0.004
Manganese (Mn)	mg/L	≤0.4 (health)	0.007	0.003	0.408	<0.002	<0.001	0.168	<0.001
Nickel (Ni)	mg/L	≤0.07	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002
Selenium	mg/L	≤0.04	<0.003	<0.003	<0.003	0.011			
Vanadium	mg/L	N/G	0.0082	0.0051	0.0015	0.0078			
Zinc (Zn)	mg/L	≤5	0.007	0.183	0.026	0.044	<0.002	0.02	<0.002

Exceed SANS241:2015 guideline value

mS/m = milliSiemens/metre

mg/L = milligram per litre

N/A = Not analysed

N/G = No SANS241:2015 guideline value

Analysis of the water character shows that, in terms of cations, the samples are magnesium dominant. Anion analysis shows that:

- In general, the groundwater is chloride dominant;
- Sample NG is bi-carbonate dominant.

The water from the area in general shows a high degree of ion exchange having taken place (implying that water has not been recently recharged). Only sample NG shows a recently recharged character. Sample TMBH3 indicates a sodium chloride dominant character.

5.9 Geochemistry

Samples analysed are representative of the material that will be mined, processed and stored on site. A summary of the samples is provided in Table 5.

Table 5: Geochemical sample description

Sample	Description
TH1	Calcrete composite sample (waste rock)
TH2	Banded ironstone composite sample (waste rock)
TH5	High grade Mn ore. Sampled at the old plant.
TH6	Low grade Mn ore. Sampled from historic waste rock.
TH7	Composite sample of surface waste rock. BIF, calcrete and quartzite.
TH8	Composite sample of fine material. Appears to have been screened or windblown. Occurs on the roads on the site. Comprised of BIF and manganese.

Acid base accounting tests

Results from the acid-base-accounting testing show that none of the material on site is likely to be acid forming. In addition, the samples have very low abundances of sulphur (<0.01%). Therefore, the samples have insufficient sulphide present that if oxidised, could sustain long term acid generation.

Metal and sulphate leach testing

Results from the SPLP 1:20 material to solution ratio testing show that copper in the low-grade ore sample (TH 6) narrowly exceeded the General Standard for Discharge and manganese in the composite fine sample (TH 8) exceeded the General Standard for Discharge and aesthetic SANS241 drinking water guideline. No other concentrations of the analysed metal and metalloid contaminants of concern have been released in concentrations which exceed water quality guidelines.

The waste rock (represented by TH 1, 2 and 7) and ore samples present a low risk in terms of metal leaching potential. The circum-neutral pH of the solutions resulting from the leach testing as well as the presence of oxyhydroxide iron and manganese minerals within the material inhibits the mobilisation of metal contaminants of concern. The fines material (TH 8) presents a higher risk due to manganese leaching at concentrations exceeding drinking water and discharge standards.

Leach testing was also done using a 1:4 material to solution ratio. Results show that boron exceeded the General Discharge Standard of 1 mg/L in the surface waste rock composite (TH 7). Boron was not leached in detectable concentration in the 1:20 SPLP leach test and was therefore diluted due to the high leaching ratio. The potential for boron leaching from the waste rock in concentrations exceeding guidelines is therefore dependent on the site-specific rock to water interaction ratio.

Manganese exceeded the General Discharge Standard and aesthetic drinking water standard in the fines composite (TH 8). The concentration of manganese observed in the 1:4 leach test and the 1:20 SPLP test are not markedly different. Given the high abundances of manganese oxide minerals noted in the mineralogy, the concentration of manganese in the solution is not governed by the amount of manganese-bearing mineral present or the water to rock leaching ratio but is more likely to be metered by mineral solubility controls.

5.10 Terrestrial Biodiversity

The proposed THM falls within the Savanna Biome, in the Eastern Kalahari Bushveld Bioregion, and the Kathu Bushveld vegetation type (a conservation status of Least Threatened (Mucina & Rutherford, 2006)). The greater area falls within the Griqualand West Centre of Endemism, however endemic and near-endemic species are unlikely to occur within the proposed THM. A limited portion of the existing haul roads and access roads is located within remaining extent of Kathu Bushveld [Threat Status: Least Concern (LC); Protection Level: Poorly Protected] in terms of the NBA: Terrestrial Remnant Vegetation (2018). According to the Northern Cape Conservation Plan (C-Plan; 2016) there are Other Natural Areas (ONAs) indicated to remain along existing haul roads within the opencast void and along the access road in the east (Figure 4).

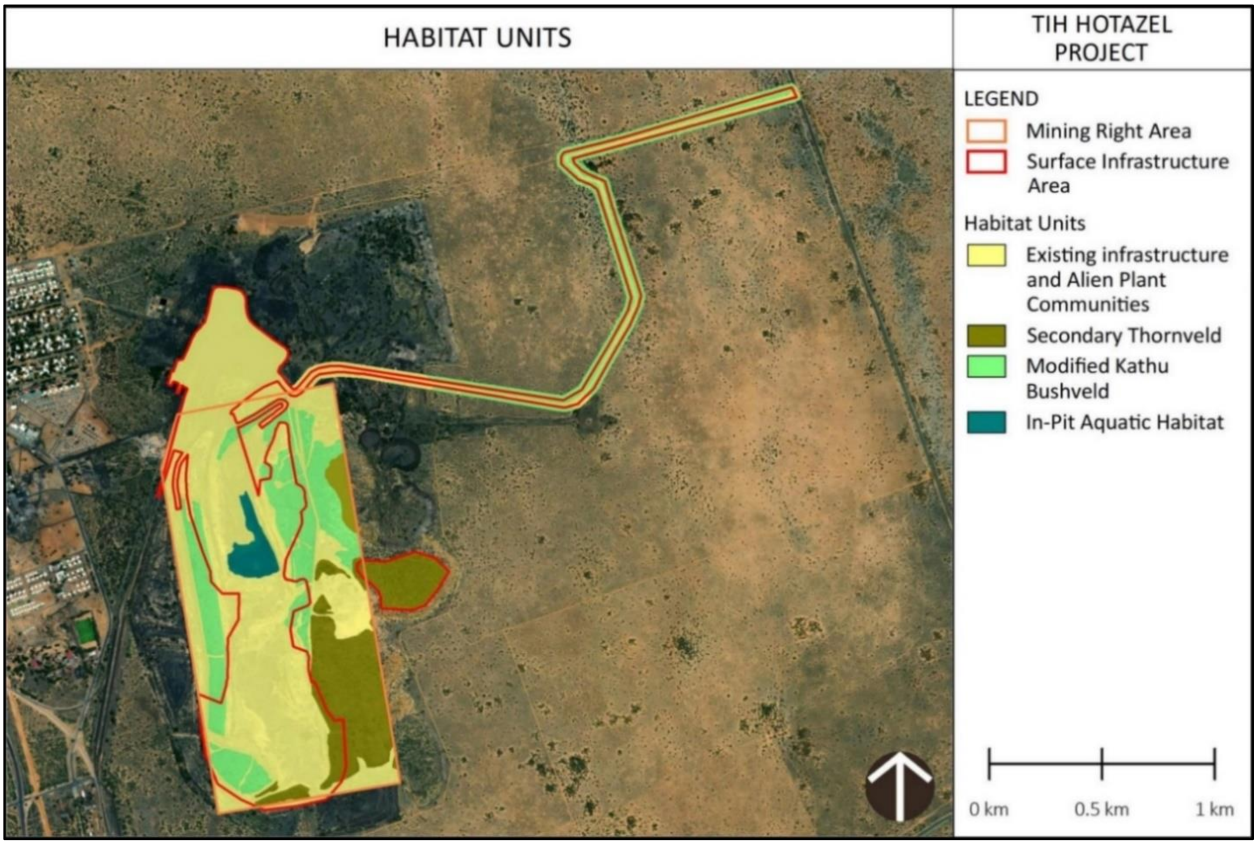

Figure 4: Habitat Units associated with the proposed THM

The SCC, Protected and TOPS-listed and Endemic Species occurring within the proposed THM are as follows:

<u>Existing Infrastructure and Alien Vegetation Communities</u>

- No floral SCC protected, or TOPS listed species were recorded within this habitat unit, and such species have a low probability of occurrence due to past disturbances within this habitat unit.
- No nationally protected or TOPS-listed faunal were recorded or are likely to permanently inhabit this habitat unit.
- One faunal SCC namely Verreaux's eagle (*Aquila verreauxii*) utilises this habitat unit for nesting, breeding and foraging purposes.

<u>In-Pit Aquatic habitat unit</u>

- Fish species, *Tilapia sparrmanii*, is listed as Protected under the NCNCA.
- No other floral or faunal SCC protected, or TOPS-listed species were recorded within this habitat unit, and such species have a low probability of occurring/ residing within this habitat unit.

<u>Modified Kathu Bushveld habitat unit</u>

- No floral SCC species were recorded or are likely to occur. One TOPS-listed floral species, namely *Harpagophytum procumbens* was recorded.
- Two nationally protected tree species in terms of the National Forests Act (Act No. 84 of 1998) occur, namely *Vachellia erioloba* in relatively low abundance and *V. haematoxylon* in high abundance.
- One provincially protected floral species in terms of Schedule 1 of the NCNCA, namely *H. procumbens*, and several floral species listed under Schedule 2 of this Act, namely *Plinthus sericeus, Ammocharis*

coranica, Boophone disticha, Crinum sp., Orthanthera jasminiflora, Albuca seineri (=Ornithoogalum seineri), Albuca setosa (=Ornithogalum setosum) were recorded.

- No faunal SCC were noted during the field assessment or are likely to occur based on the desktop investigation. Signs of TOPS-listed Aardvark (*Orycteropus afer*) were however noted during the field assessment in the vicinity of the access road. Other faunal TOPS-listed species that may occur are Bat-eared Fox (*Otocyon megalotis*) and Cape Fox (*Vulpes chama*).
- The arachnid species *Harpactira* spp. and *Pterinochilus* spp. are provincially protected under Schedule 1 of NCNCA (Act No. 9 of 2009) and may occur within this habitat unit.
- Based on distributional data, the South African Python (*Python natalensis*) is the only SCC whose distribution includes the proposed THM and historically would have occurred within wooded communities with rocky elements. Although regionally listed as Least Concern (LC), *P. natalensis* is a registered TOPS-listed species. Sundevall's Shovel-snout (*Prosymna sundevallii*) is a near-endemic reptile species with an overlapping distribution with the proposed THM and may occur in more intact Kathu Bushveld along the access road.

<u>Secondary Thornveld habitat unit</u>

- No floral or faunal SCC provincially protected, or TOPS-listed species were recorded within this habitat unit, and such species have a low probability of occurrence due to past disturbances within this habitat unit.
- *Vachellia haematoxylon*, a national protected tree species in terms of the National Forests Act (Act No. 84 of 1998) occurs scattered within this habitat unit.
- The arachnid species *Harpactira* spp. and *Pterinochilus* spp. are provincially protected under Schedule 1 of NCNCA (Act No. 9 of 2009) and may occur within this habitat unit.

Although a relatively low diversity of alien and invasive floral species is present within the proposed THM, a large proportion of the vegetation, particularly considering the Existing Infrastructure and Secondary Bushveld habitat, are alien or encroacher species, mostly attributed to *Prosopis glandulosa* var. *torreyana*. As a result, the overall floral and faunal species assemblages have an overall reduced biodiversity (based on historic habitat transformation and mining activities) when compared to intact natural habitat in the region and reference state Kathu Bushveld.

5.11 Wetlands and Aquatic Biodiversity

The closest aquatic systems to the proposed mining activities were determined to be the Gamagaraand Kuruman Rivers approximately 5 km and 9 km away, respectively. According to the NFEPA (2011), NBA Wetland Map 5 (2018) databases and from the site inspection, no natural aquatic or wetland systems were identified within the proposed project footprint areas or within the 500 m zone of regulation in accordance with Government Notice 509 as it relates to the NWA. The closest wetland features to the proposed THM, indicated to be depression (pan) wetlands, are shown to occur more than 4km to the east and west of the site.

The opencast pit void within the proposed THM, which is associated with the historical mine workings, is comprised of a moderately sized and relatively deep, artificial pit lake. The pit lake appeared to support both aquatic vegetation as well as fauna has established within the pit lake. The area associated with the proposed mining activities was confirmed to have a low sensitivity from the perspective of natural surface water features.

5.12 Socio Economic

5.12.1 Provincial context

The Northern Cape is the largest of the South African provinces, covering an area of 372 889 km^2. The province is also the least populous of the country's provinces, with a total population of only 1 193 780 (Community Survey, 2016). Only 2.1% of the country's total households reside in the Northern Cape.

Mining and agriculture are the primary economic sectors of the province. Mineral resources include alluvial diamonds, iron ore, copper, asbestos, manganese, fluorspar, semi-precious stones and marble. The province has fertile agricultural land in the Orange River Valley and the Vaalharts Irrigation Scheme near Warrenton.

The Northern Cape is subdivided into five district municipalities: Francis Baard, John Taolo Gaetsewe, Namakwa, Pixley Ka Seme and ZF Mgcawu. The THM is located in the John Taolo Gaetsewe District Municipality (JTGDM).

5.12.2 Regional context

The JTGDM (previously Kgalagadi) is located to the northeast of the province and borders Botswana. It is comprised of three local municipalities: Gamagara, Ga-Segonyana and Joe Morolong. Joe Morolong Local Municipality (JMLM) is the largest of these municipalities in terms of area.

The JTGDM comprises of 186 towns and settlements of which the majority (80%) are villages in the JMLM. The population of the JTGDM was 242 264 (Community Survey 2016), of which 63.3% were aged between 15 and 64 years and 31.9% of the population was under the age of 15. The official unemployment rate of the District Municipality is 29.7%, while the youth unemployment rate is 37.2%.

The district has an established rail network from Sishen South and between Black Rock and Dibeng. It is characterised by a mixture of land uses, of which agriculture and mining are dominant.

5.12.3 Local context and receiving environment

The primary labour sending areas for the THM are predicted to be the community of Hotazel and other surrounding farms and villages within the JMLM.

The THM is situated within the JMLM, Ward 4 (Figure 5). JMLM is the district's largest local municipality in terms of area size, covering an extent of 20 215 km^2. JMLM is mostly rural, with natural land surface comprising about 60% of the surface. Agriculture, mining and community services are the primary economic sectors. JMLM has three main nodes where relatively higher economic activity takes place, namely Vanzylsrus, Hotazel and Blackrock. Mining is the predominant economic activity in Hotazel and Blackrock. Vanzylsrus operates as service centre for the surrounding area.

The population of the JMLM was 84 201 (Community Survey 2016), of which 52 % were aged between 15 and 64 years and 38 % of the population was under the age of 15. There has been a major decline of about 25% in the population of JMLM in the 10-year period between 1996 and 2016; this is mainly due to the out-migration from the municipality to the Ga-Segonyana and Gamagara Local Municipalities.

The JMLM has the highest unemployment rate in the JTGDM of 40%. According to 2011 data, there are 7 828 employed, 4 912 unemployed, 6 200 discouraged work seekers and 29 569 other not economically active.

Setswana is the most prevalent language spoken in the community with 90% of people listing it as their first language. Afrikaans and English are the first languages of 4% and 2% of the population respectively.

Of the population aged 20 years and older, 5% have completed primary school, 28% have some secondary education, 13% have completed matric, 4% have some form of higher education and 23% have no form of schooling.

There are 168 schools, 4 police stations, 24 clinics and 3 community health centres located in JMLM. There is no hospital in JMLM. According to the IDP, there are 23 707 households with a population growth of -1%. The average household size is 3.4 persons per household.

JMLM does not own any land in its jurisdiction. Most of the land either belongs to the State or falls under the jurisdiction of the Traditional leaders.

As per the IDP, JMLM itself is not responsible for the implementation of electrification projects. The Municipality acts as a project coordinator for projects implemented by Eskom and the DMRE. Within JMLM, 86% of households have access to electricity. Electricity is used for cooking in 59% of households, while wood is used for cooking in 36% of households.

Groundwater is a major source of water and factors affecting the quality include agricultural activities and environmental issues. Currently, most of the communities within JMLM receive water for free. Of all households, only 7% have access to piped water either in their dwelling or in the yard. As per the 2011 Census, 72% sourced water from a water services provider (municipality or other), 16% used borehole water and 6% received water via a water truck. Vanzylsrus and Hotazel are the only areas that have piped water system in JMLM. According to the IDP, there are 24 villages that are without access to piped water. They receive water by means of truck delivery or through a windmill equipped with a tap. The IDP identified the following as challenges to the provision of water:

- Community disruptions;
- Vandalism of infrastructure equipment;
- Insufficient funding; and
- Illegal water connections.

Due to the shortage or lack of water supply, JMLM is unable to provide adequate sanitation to its communities. The majority of the population (81%) make use of pit latrines with or without ventilation, 7% of the population have no access to toilet facilities and 6% are connected to a sewerage system.

JMLM collects refuse in Hotazel and Vanzylsrus, serving 1 144 households in the two areas, with 3% of the population having access to such a service. While 84% of households rely on their own refuse dump.

JMLM conducts Environmental Awareness campaigns in all resident wards annually. The communities are given information on issues that need to be taken care of in their respective environmental areas. The most challenging issue of environmental management in JMLM is veld fires and to minimize that the municipality has entered into an agreement with Working on Fire through an Expanded Public Works Programme.

The town of Hotazel consists of approximately 1755 people and 600 households (Census 2011). The majority of the population in Hotazel reside in house or concrete block structures on a separate stand (82%). Hotazel has a large number of households that have access to flush toilets (97%) and piped water into their dwellings (89%). This may be attributed to the area being more urbanized having been developed and supported by surrounding mines in recent years.

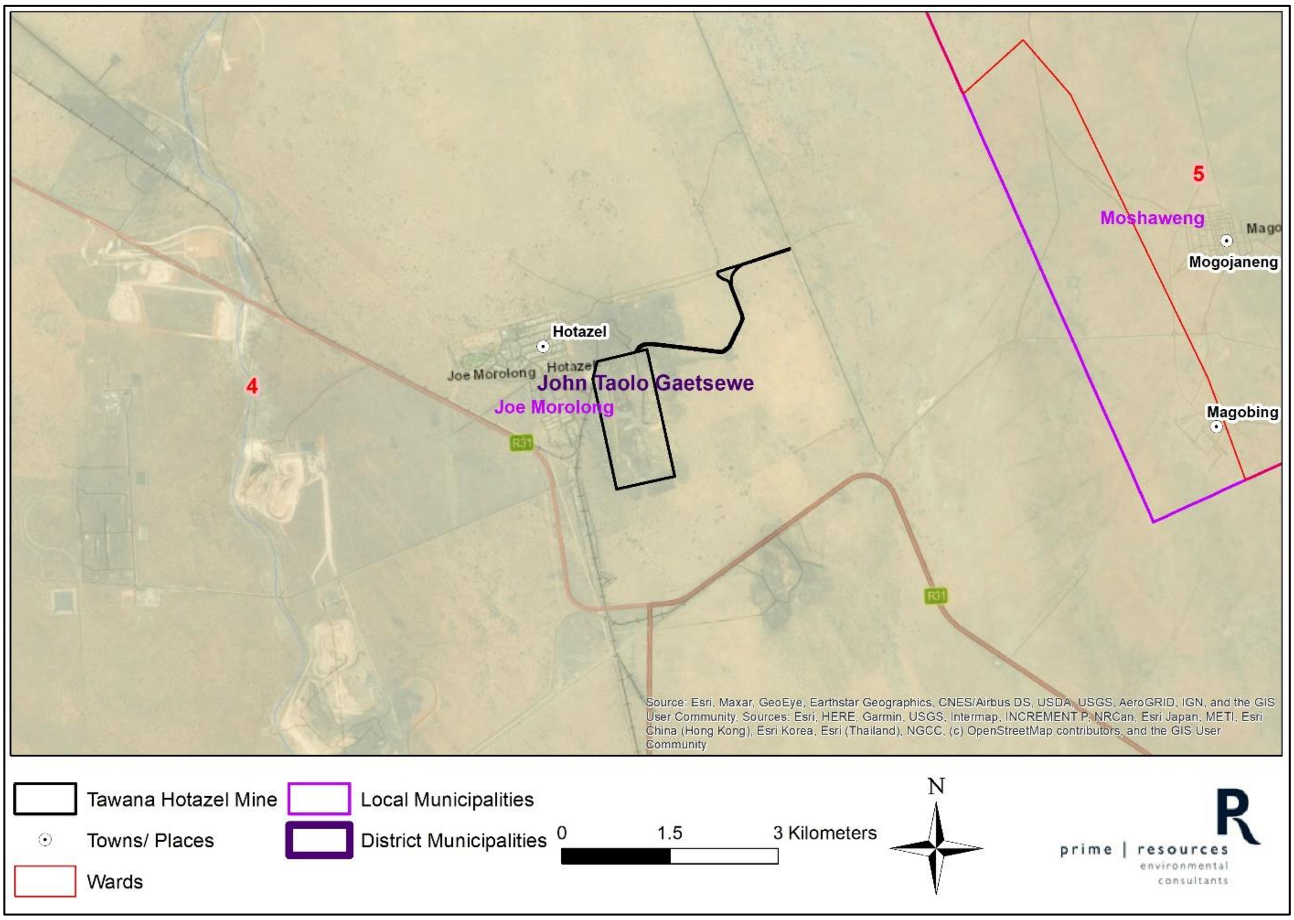

Figure 5: Surrounding settlements and wards

5.13 Visual Context/ Landscape

The visual character of the regional landscape is already considerably impacted on by mining. The following existing landscape features dominate the character of the project site and surrounds:

- Mining and associated infrastructure (including voids below natural ground-level and large residue deposits above ground-level);
- Overhead railway structures/ lines and power lines;
- Rural and residential land-use features.

The town of Hotazel is expected to be the main sensitive visual receptor. Historic mining, evidenced by the remaining void, adits, stockpiles of residue material and infrastructure can be seen within and around the proposed mining area (Figure 6). The historical residue deposits and berms can be seen from viewpoints within Hotazel town.

Through the desktop investigation and site confirmation, the existing historical mine infrastructure and residue deposits surrounding the proposed site results in a low visual sensitivity. Furthermore, the proposed

THM will have a comparably similar height and therefore, will minimally alter the visual landscape further. Backfilling/ rehabilitation will also commence immediately after the commencement of the mining operation, and this may improve the current visual landscape to a degree.

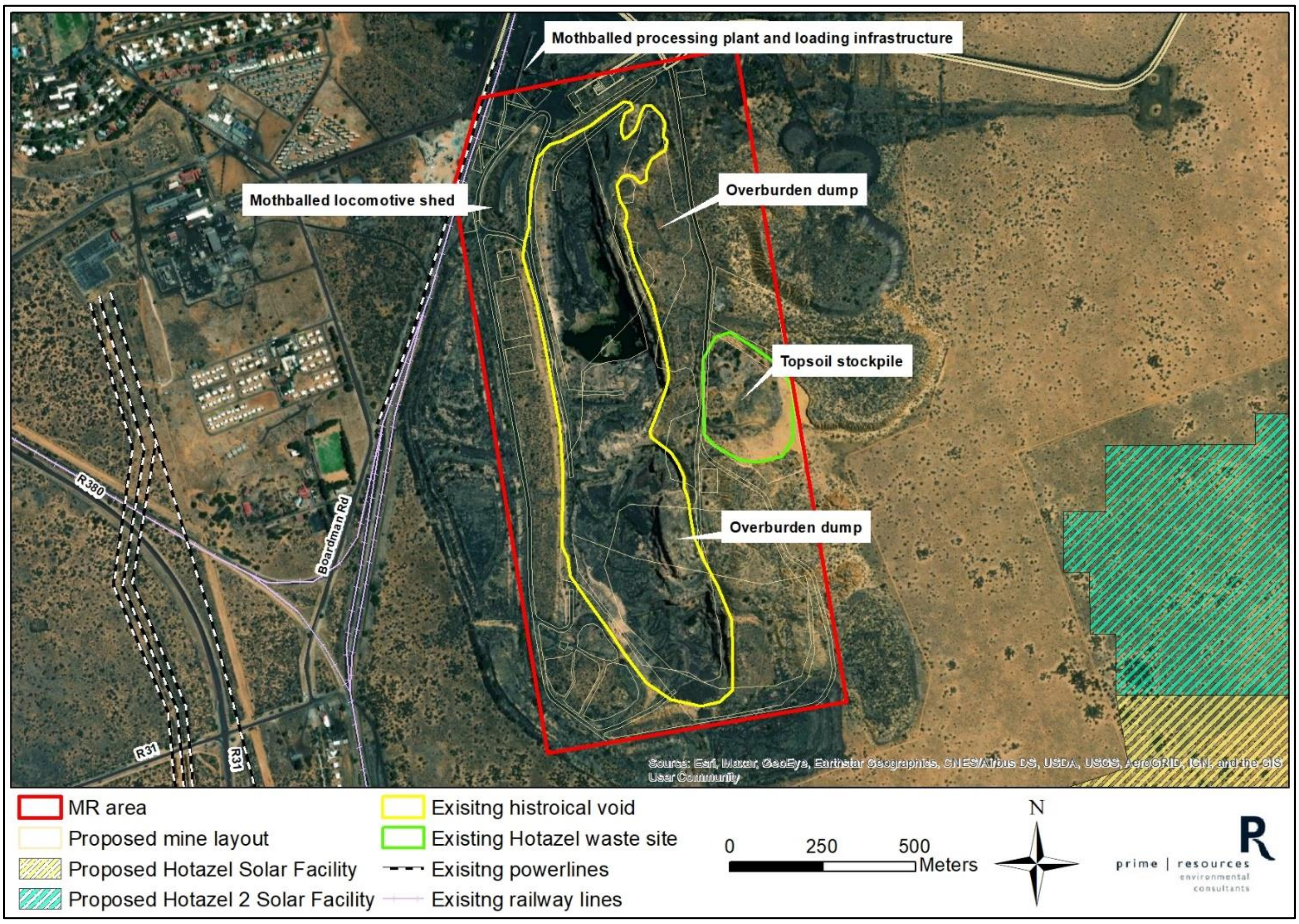

Figure 6: Land uses and existing landscape features including the location of proposed and historical mine infrastructure in relation to the THM

5.14 Roads and Traffic

Existing on-site roads will be utilised as access roads into the mine with two main access points. The main entrance to the mine will use the access road off Broadman road and will facilitate access for light vehicles and light delivery vehicles. The road network connecting the proposed THM to the surrounding towns and suburbs consists of the following:

- **N14**: The N14 is a Class 1 national road under the jurisdiction of SANRAL that cuts across the mining corridor in the Northern Cape linking Upington in the west and ultimately to Gauteng in the east. The road has a 2-lane single carriageway configuration and is located over 50km south-east of the development site. The overall pavement structure appears to be in fair condition, however, in the section near the R31 Intersection, the road has no shoulders and edge breaks were observed, indicating a worn road wearing surface.
- **R31:** The R31 is a provincial road that can be classified as a Class R2 Rural Major Arterial linking the towns of Hotazel, Kuruman and Kimberley. The road is surfaced and tends to carry significant HV traffic volumes. The pavement condition of the road is poor having severe edge breaks and surface

bleeding. Longitudinal cracks and potholes were also observed on the road. As a national road, the maintenance and rehabilitation of the R31 is the responsibility of the South African National Roads Agency SOC Ltd (SANRAL) and mitigation measures should be developed in conjunction with the road agency.

- **R380:** The R380 is a provincial road that can also be classified as a Class R2 Rural Major Arterial running north-south and linking Hotazel, Kathu and Postmasburg. The road is surfaced and has similar features as the R31 where the pavement condition of the road is poor; characterised by severe edge breaks. A section of the road is currently being rehabilitated by the Northern Cape Department of Roads and Public Works.
- **D3463:** Road D3463 is a provincial district road and can be classified as a Class R3 Rural Minor Arterial. The road is a low volume surfaced road providing access to mining activity in the north. The road is surfaced up to its intersection with a local road towards Tsineng, where after it continues as a gravel road. The pavement is in fair condition.
- **Broadman Road:** Broadman Road is a collector-distributor road running in the north-south direction in Hotazel town. The road intersects with the R31 and provides direct access into Hotazel and towards the development site. Broadman Road also comprises several at-grade rail intersections as well as non-motorized transport infrastructure such as sidewalks and raised pedestrian crossings.

6. CLOSURE RELATED ISSUES

In accordance with the requirements of GN982 and GN1147 this section details the public participation conducted for the THM as part of the EA and MR application process.

The Scoping phase public commenting period ran from 10 August 2021 to 9 September 2021. No stakeholder issues or comments relating specifically to closure of THM were raised during the Scoping Phase public participation process.

As per GN1147 the Draft Closure Plans form a component of the EMPr submitted in terms of Section 24N of the NEMA and EIA Regulations and are subject to stakeholder review and comment. The EIAR/ EMPr, and the Draft Closure Plans were made available during the EIA phase for comment between 10 January 2022 to 9 February 2022. Any additional stakeholder issues or comments relating to closure will be addressed in the Final EIAR/ EMPr and Closure Plans to be submitted to the DMRE.

6.1 Future Public Engagement

A stakeholder engagement plan (including a grievance mechanism), to provide a defined process for ongoing two-way communication between the community and THM must be compiled. The grievance mechanism must prescribe methods for community members to raise complaints (anonymously if they so choose). Complaints must be responded to and addressed effectively. Response methods and timeframes must be specified in the grievance mechanism. Interested and Affected Parties must be notified of the stakeholder engagement plan and grievance mechanism.

7. CLOSURE VISION, OBJECTIVES AND TARGETS

7.1 Measures to be implemented throughout the construction and operational phase

The construction and operational phase should be undertaken with closure in mind many of the decisions made during construction will affect the extent of the impacts that will have to be addressed during the subsequent life cycle phases of the mine. Therefore, THM will aim to:

- Implement and expand environmental monitoring to establish the extent of impacts that need to be corrected at final closure and address impacts identified;
- Implement the alien and invasive vegetation species eradication strategy mine wide;
- Ensure optimum placement of infrastructure and minimal clearing for construction to minimise impacts on sensitive receptors;
- Ensure that soil stockpile areas are clearly demarcated to prevent unnecessary disturbance;
- Concurrent backfilling of waste rock into the opencast pit void is recommended throughout the LoM. The proposed backfilling of the waste rock into the opencast pit requires that exemption from the provisions of Regulation 4 of GN 704 of 1999 Regulations on use of Water for Mining and Related Activities Aimed at the Protection of Water Resources is sought. The following motivates for this exemption:
    - Backfilling is considered an acceptable long term storage solution for the waste rock due to the low geochemical risk the waste rock presents. The waste rock is non-acid generating and very low concentrations of soluble anions, metals and metalloids are anticipated to arise in the long-term in neutral pH conditions.
    - Provision of a stable repository for waste rock – long-term slope stability of large waste rock dumps is not of concern when the material is backfilled. Stability aspects such as subsidence may, however, be of concern and the area is to be managed appropriately in terms of the mine closure and rehabilitation plan.
    - Reduction of exposed surface area – waste rock material stockpiled on surface has a greater surface area for rainwater interaction, leading to higher runoff volumes and a greater impact on surface water resources. Backfilling limits exposure of the slopes of both the pit and overburden stockpiles to atmospheric weathering and oxidation. Where residue material has been backfilled, only the upper surface is exposed to atmospheric conditions in the long term.
    - Avoidance of pit lakes –the backfilling of a pit eliminates the creation of a pit lake which in itself carries environmental and safety concerns, and therefore promotes a free-draining surface in the long-term.
    - Restoration of impacted land to beneficial use – areas that would host waste rock dumps can be rehabilitated to an acceptable end-use.
- Backfilled waste rock should be compacted to restrict rainwater infiltration and the resulting landform shaped to promote rainwater runoff;
- Revegetation trials must be conducted to establish procedures, accurate timeframes and costs for revegetating landforms and disturbed areas in the prevailing arid environment;

- Scrap and rubble to be removed during operations;
- THM, in conjunction with the community directors, will work to ensure that negative social ills do not proliferate and vocational training and technical skills promoted during operations phase to ensure post mining livelihoods;
- Strive to enhance long-term plans such as local or regional development plans;
- Ongoing implementation of the annual rehabilitation plan and concurrent/progressive rehabilitation throughout operations to reduce closure costs and liabilities; and
- Regularly update and audit the closure plan, closure costing and risk assessment.

7.2 Closure vision and objectives

The current vision for closure of the mine is to rehabilitate the areas disturbed by mining activities to an acceptable end land use that is resilient, self-sustaining and comparable to the surrounding areas and in agreement with commitments to stakeholders by ensuring that the following objectives are met:

- All statutory and other legal requirements are adhered to;
- Full awareness with landowner and other IAPs regarding the mine closure concept and timing thereof;
- The landowner is left with no residual liability for site rehabilitation and/or maintenance;
- Land use options for rehabilitation will be considered during the life of mine in accordance with changes in the mine's development;
- All surface infrastructure is removed;
- No stockpiles of ore material remain on the site post-closure;
- The final waste dumps are sloped, capped (depending on soil availability), and vegetated in order to reduce oxygenation and rainfall recharge into the facilities and to minimise erosion on the slopes;
- The extent of the final opencast void is limited due to the application of concurrent backfilling / rehabilitation during the operational phase;
- The final opencast void is rehabilitated by modifying the slopes of the perimeter walls to be stable and not susceptible to erosion. The sloped area is revegetated;
- The soil is considered uncontaminated according to applicable legislation (currently Part 8 of Chapter 4 of the National Environmental Management: Waste Act, No. 59 of 2008 {NEMWA});
- Dust generated from the waste dumps and denuded areas, prior to vegetation establishment, adheres to limits which apply at that time (currently the National Dust Control Regulations, GNR827 of 2013);
- Vegetation across the rehabilitated footprint is established and self-sustaining;
- The rehabilitated landform is free draining and adhere to applicable best practice in terms of water management for mine closure (currently the 2006 DWA Best Practice Guideline);
- The rehabilitated landform is inconspicuous / aesthetically compatible in relation to the surrounding landscape;
- Runoff and seepage from rehabilitated areas does not exceed applicable standards, including the WUL objectives;
- No impact on water quantity or quality available to private groundwater users;
- All haul roads and other on-site access roads are rehabilitated unless required for end land use by landowner; and

- The rehabilitated site is ultimately be rendered safe for the nearby communities and animals, for the foreseeable future, in compliance with relevant standards (currently the Occupational Health and Safety Act No. 85 of 1993 and relevant Regulations).

7.3 Sustainable end state/ final land use

The current land use associated with the proposed THM is historic mining evidenced by the remaining void, adits, stockpiles of residue material and infrastructure. The land use in the vicinity of the proposed THM comprises primarily mining, residential and grazing. The Hotazel landfill waste disposal site (G:S:B-, Permit No.: B33/2/441/20/P156, licence date 20 February 1995) is located within the MR area. Some of the topsoil stockpiles are being used to cover the waste. Apart from the town of Hotazel, the area immediately surrounding the proposed THM is unpopulated and undeveloped. The proposed Hotazel and Hotazel 2 Solar facilities are located to the south and south-east of THM.

When considering the climate (low rainfall, high temperatures, and evaporation) in combination with the sandy deep soils (low water holding capacity), the area is poorly suited to arable agriculture. The site also falls in a low grazing capacity of 13 hectares per large stock unit (ha/LSU).

Based on the above it is proposed that all reasonable efforts be taken to improve the greater majority of the mine affected land, post closure, to low intensity grazing or wilderness. Refer to Figure 7 for the infrastructure to remain post-closure and the high-level final end land use plan for the THM area.

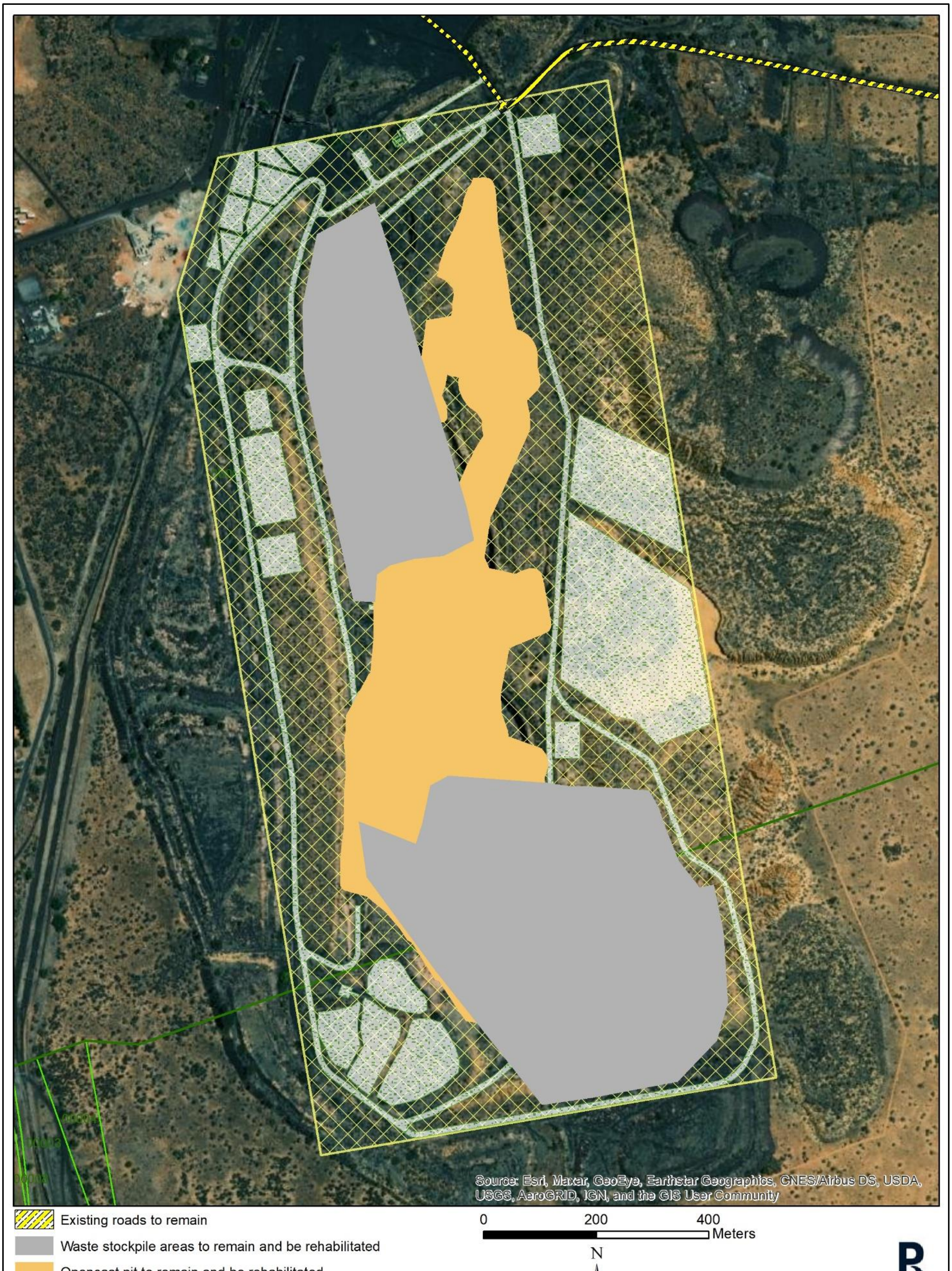

Figure 7: Infrastructure to remain post-closure and high-level final end land use plan for the THM area

7.4 Closure Alternatives

It is anticipated that the project may result in an improved environmental condition at closure if the recommended rehabilitation measures are implemented, as the proposed THM is currently considered significantly impacted by historical mining activities with vegetation not being representative of the natural indigenous vegetation. If the mine were to improve the environment through rehabilitation measures and the removal of invasive species it could potentially improve the functioning of the ecosystems and reinstate indigenous and healthy environments that would be of benefit to the surrounding communities from an ecosystem services and beneficial / suitable end land-use perspective.

The historical open-cast pit has filled up with water and created an aquatic environment (current pit lake). The water contained within the historical open pit and the island in the centre of the water-filled pit have created an ideal breeding habitat for various water dependent species i.e., herons, cormorants, ibis, grebes, moorhens and coots. The option is therefore available to fully backfill the currently open pit void, which would improve the safety of the area, for both livestock and people. Alternatively, the objective will be to limit the extent of the final opencast void with the application of concurrent backfilling / rehabilitation during the operational phase. The remaining void could be left to become a pit lake (as currently exists) which would provide a suitable breeding habitat for water dependent species.

At closure, THM will consider alternative uses for surface infrastructure e.g., containers or office buildings which can be converted to a clinic for use by the community. If improved closure options are identified, it will be necessary to amend this closure plan in future.

7.5 Implementation Schedule for Closure and Rehabilitation

It is anticipated that backfilling will commence immediately after the commencement of the mining operation and its advance will match the depletion rate of the open pit until the final void remains. The closure phase will commence once the opencast activities have ceased and decommissioning, and mine rehabilitation is being conducted. It is anticipated that this phase will take 1 year after mining ceases. The post closure phase will entail final rehabilitation and post closure monitoring and will cease when the relevant relinquishment criteria are met. Once relinquishment criteria are met the holder would typically apply for a closure certificate.

Table 6: Schedule for decommissioning and final rehabilitation and post closure monitoring

Rehabilitation action	Closure Phase: Decommissioning and mine rehabilitation 1 year	Post Closure Phase: Final Rehabilitation and post closure monitoring 3 - 5 years
Mining activities cease	■	
Topsoil inventory	■	
Preliminary soil fertility monitoring	■	
Removal of surplus hazardous material and all waste from the operational phase	■	
Demolition of surface infrastructure	■	
Removal of all salvageable material and demolition waste	■	
Contaminated land assessment and remediation	■	
Rehabilitation of disturbed footprint		■
Vegetation establishment		■

Rehabilitation action	Closure Phase: Decommissioning and mine rehabilitation 1 year	Post Closure Phase: Final Rehabilitation and post closure monitoring 3 - 5 years
Rehabilitation and post closure monitoring		
Submit an application for closure certificate		

8. ENVIRONMENTAL RISK ASSESSMENT

This risk assessment serves to identify potential risks which may manifest during- and after closure, with the aim of identifying the most appropriate closure actions required (Section 9) to be implemented by the mine to achieve the closure goals and objectives identified in Section 7.2.

8.1 Identification of receptors sensitive to closure

The receptors that are potentially sensitive to closure-related impacts, as identified per the EIAR/ EMPr are shown in Table 7 below.

Table 7: Potential closure-related risks and sensitive receptors

Sensitive Receptor	Negative Closure-Related Risks
All of the below	Insufficient financial provision for rehabilitation would have a negative impact on all of the below sensitive receptors as a result of closure actions that are insufficiently implemented or the abandonment of the site.
Soil, Land Capability and Visual	• Many of the soils have already been disturbed on the site however, the risk of the remaining soils not been stripped and stockpiled correctly during the LoM will negatively impact the land capability at closure as there may not be sufficient soil resources for capping. • Due to the arid environment, it will take longer for vegetation to establish on soils in disturbed denuded areas and soil stockpiles and rehabilitated areas, increasing the risk of soil erosion (from wind and stormwater) prior to vegetation re-establishment. Erosion will negatively impact the soil potential and subsequently the final land capability. Steep slopes are also susceptible to erosion and slopes should be designed to minimize erosion of capping or topsoil. • Backfilling/ rehabilitation of the currently disturbed area upon completion of mining may improve the visual and aesthetic features of the site while simultaneously transforming the area into a usable landform. • The waste dumps will remain permanent features of the landscape upon closure and will alter the landscape character of the surrounding area.
Socio-Economic	• At closure the unemployment rate in the area will increase as retrenchments will be required, such job-losses will have a negative effect on the local economy.
Surface water	• Surface water quality deterioration

Sensitive Receptor	Negative Closure-Related Risks
Groundwater	• The water level within the rehabilitated pit will continue to recover in the long term. After 40 to 50 years post closure the water level in the rehabilitated pit is expected to reach the elevation of the natural regional groundwater levels. The water level in the rehabilitated pit will then continue to slowly rise above the regional groundwater levels due to the higher recharge from rainfall into the rehabilitated pit than into the surrounding, undisturbed, aquifers. Once the water level in the rehabilitated pit rises above the regional groundwater level water will start to flow from the pit towards the surrounding area. It is expected that by 100 years post closure the groundwater level in the rehabilitated pit will have risen to around 10 m above the regional groundwater levels. It will not have reached decant elevation and no decant is expected by 100 years post closure. • During the initial years post closure, the contamination that has already entered the aquifers from the ROM pads, processing plant footprint, and product stockpile footprint will continue to migrate towards the pit where the water levels are expected to rise but remain beneath the regional groundwater levels up to 40 to 50 years post closure. Once the water level in the rehabilitated pit has reached the regional groundwater levels and started to rise above it due to continuing recharge from rainfall, contaminants can start to migrate away from the opencast pit area. At 50 years post closure the contamination will mostly be contained within the pit area. Over time the plume will start to migrate radially away from the pit area. The radial spread of the plume is due to the fact that the region has a flat topography and the water level within the rehabilitated pit will rise above the surrounding topographical elevations. By 100 years post closure it is expected that the plume will not have spread more than 200 m from the pit boundary. No surface water bodies, or privately owned boreholes fall within the expected zone of influence of the plume.
Air Quality	• Wind erosion from the waste dumps and denuded areas where infrastructure has been removed and from gravel roads may result in the fallout of nuisance dust. This may occur during before the establishment of vegetation cover and potentially in the long-term should rehabilitation not be successful.
Biodiversity	• If existing alien invasive species are not eradicated throughout the LoM and during closure and rehabilitation, these may proliferate. • The establishment of vegetation within the existing infrastructure areas that are currently devoid of vegetation may contribute towards improved habitat conditions in these areas. • Ineffective backfilling and rehabilitation may lead to exposed and impacted areas beyond the clearance footprint. • Ineffective backfilling, rehabilitation and vegetation reestablishment may leave exposed and impacted areas beyond the clearance footprint.

8.2 Methodology

The risk assessment aims to identify the risk associated with the above closure risks and the implementation of the intended closure actions listed in Section 9 below.

The following assessment model was used for determination of the significance of closure and post closure related risks:

Significance = (magnitude + duration + scale) x probability

The maximum potential value for significance of an impact is 100 points. Environmental impacts can therefore be rated as high, medium or low significance on the following basis:

High environmental significance	60 – 100
Medium environmental significance	30 – 59
Low environmental significance	0 – 29

Magnitude (M)	
Minor (2)	Change not measurable; or threshold never exceeded There is no need for people to adapt and will not notice changes to livelihoods and lifestyles
Low (4)	Low disturbance of degraded areas, which have little conservation value Minor change in species occurrence or variety Minor deterioration (nuisance or minor deterioration) or harm to receptors Change to receiving environment not measurable; or identified threshold never exceeded People are able to adapt and maintain pre-impact livelihoods and lifestyles
Moderate (6)	Moderate/measurable deterioration or harm to receptors Receiving environment moderately sensitive Identified threshold occasionally exceeded People are able to adapt with difficulty (with no resettlement). Pre-impact livelihoods and lifestyles can be maintained with difficulty or with support or intervention Disturbance of areas that have potential conservation value or are of use as resources Complete change in species occurrence or variety
High (8)	High, measurable deterioration or harm to receptors Receiving environment highly sensitive Identified threshold often exceeded Pre-impact livelihoods and lifestyles cannot be maintained, or resettlement is required
Very High / Unknown (10)	Loss of ecosystem function Loss of an irreplaceable natural resource (including cultural and heritage resources) Disturbance of pristine areas that have important conservation value Human health and or safety is compromised Receptors of impact are of conservation importance; or identified threshold (such as SANS limits, Resource Quality Objectives, etc.) consistently exceeded Unknown
Scale (S)	
Footprint (0)	Occurs only within the footprint of the activity
Site (1)	Occurs only within the site of the project
Local (2)	Occurs within approximately 2.5 km of the activity
Regional (3)	A regional scale as determined by administrative boundaries, habitat type/ecosystem or regional loss of a species population.
National (4)	Nationally important or macro-economic consequences
International (5)	Internationally important agreements and resources are affected such as areas protected by international conventions, international waters etc. Unknown
Duration (D)	
Immediate (1)	Completely reversible without management Impact is instantaneous and ceases imminently
Short (2)	Naturally reversible or reversible with minimal management Impact ceases when the activity ceases
Medium (3)	Impact can be reversed with sufficient management Impact ceases when project ends
Long (4)	Impact is potentially irreversible even with management
Permanent (5)	Impact remains after the life of the project The impact will continue indefinitely / ad infinitum Unknown
Probability (P)	
Improbable (1)	Improbable, almost impossible
Unlikely (2)	Low probability, unlikely to occur
Likely (3)	Medium probability, likely to occur
Expected (4)	High probability, expected to occur
Definite (5)	Definite (certain) or unknown

8.3 Risk Assessment

The EIAR provides a detailed description of the environmental impact/risk identification and assessment (including the methodology and findings) undertaken for the THM. Table 8 below lists the environmental impacts and risks identified and assessed in the EIAR, which relate to closure, decommissioning and post closure.

Table 8: Assessment of the potential closure and post closure related risks associated with THM

Environmental Attribute / Sensitive Receptor	Activity / Process	Potential impact	Magnitude	Scale	Duration	Probability	Significance	
							Rating	Value
Closure and Decommissioning Phase								
Surface water	Decommissioning, removal and rehabilitation	Surface water quality deterioration	3	2	2	3	Low	21
Greenhouse Gas Emissions and Climate Change	Establishment of vegetation	The previously cleared areas that form part of the project will be rehabilitated resulting in a carbon sink gain.	2	1	3	3	Low Positive	+9
Socio-economic	Downscaling and retrenchment Decommissioning and rehabilitation of the THM Establishment of vegetation within areas currently devoid of vegetation	Downscaling and retrenchment of employees.	4	3	2	4	Medium	36
		In-pit dumps will remain on site resulting in a permanent change to the visual character of the area.	2	2	3	5	Medium	35
		Improved habitat conditions in the rehabilitated areas	10	1	3	4	Medium Positive	+56
		Backfilling/ rehabilitation of the currently disturbed area upon completion of mining may improve the visual and aesthetic features of the site while simultaneously transforming the area into a usable landform. Improved safety of the area, for both livestock and people.	2	1	5	4	Medium Positive	+32
Biodiversity, soils, land capability, visual	Ineffective backfilling and rehabilitation	Soil compaction and erosion, exposed and impacted areas beyond the clearance footprint, unsafe voids, denuded areas, proliferation of invasive vegetation	6	2	3	3	Medium	33
Air quality		Emissions arising from the in-pit waste rock dumps and denuded areas during dry and windy conditions	6	2	3	3	Medium	33
Groundwater	Recovery of groundwater levels and decant potential	It is expected that by 100 years post closure the groundwater level in the rehabilitated pit will have risen to around 10 m above the regional groundwater levels.	6	2	5	5	High Positive	+65
	Migration of contamination plume due to poor quality seepage from the mining area and surface ROM pads and the product stockpiles	It is expected that by 100 years post closure the plume will not have spread more than 200 m from the pit boundary.	4	2	5	5	Medium	55

8.4 Assumptions and Uncertainties Relating to the Closure Strategies and financial provision

The main assumptions made in the compilation of this report and in calculating the financial provision are:

- The risk assessment is a quantitative process which needs to be informed by future specialist studies;
- As per standard practise, mine infrastructure asset salvage value has not been taken into account;
- Costs related to closure planning, feasibility studies and environmental authorisations are operational costs and thus no provision has been made for these aspects;
- The closure cost, as calculated, does not cover components such as staffing or workforce matters such as separation packages, re- training /reskilling required for the site after decommissioning and it does not cover infrastructure and support services required for the staff after decommissioning.
- Allowances for the initial monitoring, maintenance and aftercare for the mine have been included and allow for three years of post-closure monitoring, care and maintenance of rehabilitation only.
- It is assumed that the waste facilities will be sloped, capped, and vegetated in order to reduce oxygenation and rainfall recharge into the facilities. In the long term this will reduce the vertical seepage from the facilities towards the underlying sandy gravel and fractured rock aquifers.

Threats, opportunities and uncertainties associated with the proposed closure actions include:
Threats:

- Stakeholder agreement to proposed final land use.
- Social implication of closure.
- The arid environment will increase the risk of revegetation failure.
- Lack of current closure planning.
- Lack of topsoil available to fully achieve rehabilitation goals.
- Insufficient management commitment to effective rehabilitation.

Opportunities:

- There is the opportunity for the mine to rehabilitate the land and improve the current status of the site. If the mine were to improve the environment through rehabilitation measures and the removal of invasive species it could potentially improve the functioning of the ecosystems and reinstate indigenous and healthy environments that would be of benefit to the surrounding communities from an ecosystem services and beneficial / suitable end land-use perspective. The backfilling and rehabilitation of the currently open pit void would also improve the safety of the area, for both livestock and people.
- Annual reviews and updates of the closure plans will allow for the opportunity to assess the relevance plans going forward.

Uncertainties:

- Discussions will be undertaken with the landowner prior to closure to identify infrastructure and buildings that they/ the community can use after mine closure.
- Due to the fact that this project has not commenced there are certain criteria and parameters which are unknown which are crucial for accurate closure predictions and planning going forward.

- The groundwater model should be updated based on monitoring data and the assessment of available water management and treatment options (if required) should be reviewed and revised.
- Due to the lack of precipitation, revegetation may fail and take a number of growing seasons for vegetation to establish.

9. CLOSURE STRATEGY AND REHABILITATION ACTIONS

The following section details the current identified closure strategies and rehabilitation actions as contained within the EIAR/ EMPr and where gaps in the EMPr exist, technical solutions and actions have been added which need to be implemented to avoid, manage or otherwise mitigate the identified risks to ensure that closure objectives are met, and the realisation of the potential residual risks are avoided.

9.1 Removal of infrastructure

It is anticipated that all infrastructure, temporary and permanent equipment and facilities will be dismantled and removed at mine closure. The closure actions to be implemented, when the infrastructure is dismantled, demolished and removed from THM, are detailed in Table 9 below.

Table 9: Closure actions for the removal of infrastructure at THM

Aspect	Closure actions
Electrical, pipelines, water and other services	• All power and water services are to be disconnected and certified as safe prior to commencement of any demolition works. • Electrical, water and other services that are more than 700 mm below ground surface will remain, all others at a shallower depth must be excavated and disposed of. • Overhead power lines, which are not going to remain for use by the surrounding communities post-closure, should be dismantled and removed. • All aboveground electrical, water and other service infrastructure and equipment to be removed and disposed of as general waste or, if they are salvageable, be removed to a designated temporary salvage yard.
Infrastructure	Such as weighbridge facility, offices, stores, plant yard/ workshop, refuelling station: • Where practical, equipment and materials with salvage value must be sold and removed from the site. • All other equipment must be demolished and disposed of off-site. • Dismantle / demolish to ground level. • The water management infrastructure should be removed last (as per Section 9.4) once all potential sources of contaminants have been removed. • Associated foundations / hard-standing areas must be demolished by ripping and levelling of areas, extending to 1 m below the final surface in order to reduce compaction. • Any voids will be backfilled in a controlled manner with building rubble and waste rock, compacted, and rehabilitated (refer to Section 9.2).
Processing Plant	• All stockpiles of ore material must be removed from site. • Infrastructure must be cleaned and dismantled and removed from site.
Roads	• Removal of all signage, fencing, shade structures, traffic barriers, etc. from access and on site roads no longer required. • Imported road construction materials may hamper the regrowth of vegetation will be avoided as far as possible. • If material has to be imported, it will be removed and disposed of to an approved landfill during rehabilitation. • All concrete lined drainage channels and sumps to be broken up and removed. • All potentially contaminated soils are to be identified and demarcated for later remediation. • Roads must then be re-shaped according to the area contours, scarified, fertilized and re-vegetated with indigenous vegetation species (refer to Section 9.2).

Aspect	Closure actions
Fencing	• Fencing around decommissioning areas must be maintained in place until closure activities are complete to prevent trespassing and uncontrolled entry. • Dismantle and remove redundant fencing for salvage. • Where fencing is to be installed for post-closure safety, first use dismantled fencing. • Demolish all concrete fence foundations to 500 mm below original ground level, if used. • Rip all fence lines to a depth of 500 mm depth and rehabilitate the disturbed areas as per Section 9.2.
Contaminated Land	• A soil contamination investigation must be conducted on completion of the above demolition activities, in line with the applicable legislation, currently Part 8 of Chapter 4 of the NEMWA, particularly in excavations remaining open for a period of time during the LoM. The purpose of this is to identify areas of possible contamination and design and implement appropriate remedial measures to ensure that the soil potential is retained, and the end land use capabilities are achieved. • If the soil contamination investigation indicates that soil is contaminated, the first management priority is to treat the contamination by means of *in situ* bioremediation. The acceptability of this option must be verified by an appropriate soil specialist and by the Department of Water and Sanitation (DWS) on a case-by-case basis, before implementation. • If *in situ* treatment is not possible or acceptable then the contaminated soil must be assessed according to legislation (currently the Norms and Standards for the Assessment of Waste for Landfill Disposal, GNR635 of 2013) and disposed of at an appropriate licensed landfill facility.

9.2 Rehabilitation

Once the infrastructure has been removed, as per Section 9.1 above, the rehabilitation measures described in Table 10 below must be implemented.

Table 10: Closure actions for the rehabilitation of disturbed areas at THM

Aspect	Closure actions
Sites of Archaeological/ Palaeontological Importance	• Archaeological, paleontological, and heritage finds, if encountered during the decommissioning and closure phase, must be reported to the SAHRA and responsible Mine Manager who will decide, after consultation with authorities, company representatives and local communities whether work may go ahead. Special precautions may be instituted to enable the work to proceed.
Excavations, sumps and trenches	• All sumps and trenches will be backfilled, compacted and topsoil will be replaced. • Any remaining voids on the site at closure will be backfilled, in a controlled manner, with building rubble and inert waste rock, compacted and top dressed with sufficient material and the appropriate vegetation.
Compacted areas	• Deep ripping with a tine of at least 500 mm. • Where space allows, cross ripping to be undertaken, with the final rip to be parallel to contours.
Waste dumps	• Waste rock and overburden is to be used for backfilling the opencast pit. • The waste dumps must be sloped, capped, and vegetated in order to reduce oxygenation and rainfall recharge into the facilities. • The following describes the preliminary waste dump model to be further refined:

Aspect	Closure actions
	○ Outer batters will be formed on waste dumps at a lower angle than the natural angle of repose the dump to suit subsequent rehabilitation The batters and berms will be profiled to establish surface drainage. ○ The dump batter slope of the completed dump after rehabilitation sloping, shall be 20 degrees. ○ Berms will be 5 m in width, after battering of dump slope to 20 degrees. ○ Lifts will vary from 5- 15 m vertical height, with the majority being 15 m. ○ A toe bund will be constructed at the base of the waste dump. This will act as a sediment trap and dissipate energy from surface runoff flows down the batter. ○ Minor landscaping of the upper surface and side slopes of the dumps, to allow for a more natural appearance.
Soil	• During decommissioning, a soil survey should be undertaken to identify and quantify appropriate soil reserves for use in rehabilitation. Such a survey would include sampling and analysis of soils to determine parameters such as fertility and soil water characterisation curves that are important in determining soil suitability as a cover material. • Based on the analysis and with input from a soil specialist, the fertility remediation requirements need to be verified and fertilizers must be applied as necessary prior to re-vegetation. • Before rehabilitation remove all gravel and other rocky material and recycle as construction material or place in open voids. • Stockpiled soil must be redistributed in a manner that achieves an approximate uniform stable thickness consistent with the end land use (low intensity grazing or wilderness). • The areas to be planted will be levelled and engineered to a slope not greater than 1:5 where possible. The soils will then be ripped to a depth of 20 mm to loosen the soil, and all weeds will be removed. • All soils compacted as a result of decommissioning and rehabilitation activities must be ripped to a depth of 30 cm, scarified and stabilized. • Soil should be ameliorated and fertilized as required (if re-establishment of vegetation does not occur successfully or as per recommendations of a specialist).
Erosion control	• The land surface must be contoured to facilitate good drainage and be free draining. • Erosion control measures must be implemented to ensure that the soil is not washed away and that erosion gullies do not develop prior to vegetation establishment. • These may include contours; berms; energy dissipaters (such as gabions); and application of straw mulches or soil binders to exposed soils.
Revegetation	• Any disturbed and compacted areas must be ripped, reprofiled and self-succession of indigenous grass and forb species allowed. • Rehabilitated areas should be cordoned off to limit equipment, and human movement on the rehabilitated areas. • Vegetation establishment will be monitored, and remedial measures will be implemented where necessary. • Alien invasive vegetation species monitoring, and eradication must be conducted during decommissioning and rehabilitation and on-going thereafter. • Maintenance of rehabilitated areas, including any additional erosion control measures, will continue until the vegetation cover has been established and can be shown to be self-sustaining.

Aspect	Closure actions
	• Where self-succession does not occur over a period of one growing season, active revegetation by means of applying an indigenous veld grass mixture is recommended.

9.3 Opencast Pit

The closure actions to be implemented, when the opencast operations are decommissioned, for the infrastructure components and disturbed areas associated with the THM are detailed in Table 11 below.

Table 11: Closure actions for the opencast pit at THM

Aspect	Closure actions
Opencast pit – final void	• The final opencast void is to be rehabilitated by modifying the slopes of the perimeter walls to be stable and not susceptible to erosion. The sloped area is revegetated • If slopes are steeper than 18 degrees, then a suitably qualified person may be required to undertake erosion modelling to confirm the sustainability of the selected slope cover

9.4 Water Management

The measures to be applied to the components of the water management systems to be removed are described in Table 12 below.

Table 12: Closure actions components of the water management systems to be removed

Infrastructure component	Closure actions
The water management facilities must be the last mine components to be dismantled / demolished to ensure that any contaminated runoff from the decommissioning activities remains contained. Recommendations from a geohydrologist, hydrologist and/or engineer, relating to the requirements for any water management infrastructure, to remain *in situ* post closure for residual pollution control, must be adhered to.	
PCD and surface water management structures	• At closure, pipelines, plinths and associated infrastructure must be removed. • The PCD and stormwater ponds must be drained, and the water disposed of in accordance with the classification of the impounded water. • Sediment contained within the PCD, and stormwater ponds should be assessed, and disposed of at a licensed landfill facility as either general or hazardous waste according to the classified waste type. • Liner is to be removed and disposed of according to the class unless pre-classified in terms of the regulations. • The footprints of the PCD and stormwater ponds must be filled and profiled to prevent ponding and ripped to break compaction. • Rehabilitate the disturbed areas as per Section 9.2. • A contamination assessment (See Section 9.1) must be undertaken on the soil underlying the PCD and the soils must be assessed for salts. Where contamination occurs, soil must be removed to a depth of 500 mm and disposed of at a licensed landfill facility.
Disused surface pipes, pump stations and facilities and water storage tanks	Described in Section 9.1.

9.5 Socio-economic Measures

- Consultation with local communities, Competent Authority and other relevant parties. Local businesses that are reliant on the mine will also be consulted as part of this process.
- Capacity building focussed on empowering retrenched employees to set up their own businesses. Support and guidance will be provided during operations as well as at the time of retrenchment to encourage entrepreneurial initiatives through local business and with interested employees.
- Mentorship will be used during the operational phase in line with the needs of employees, empowered groups and local community structures. Ad hoc mentoring for entrepreneurs will be provided as required and based on specific projects.

  Skills development will be conducted with employees facing retrenchment, in addition to the skills development initiatives that takes place during the life of mine. This programme will be focussed on developing skills that can be transferred to other industries and which will promote employability. The skills development programme will build on skills that are recognised nationally as well as on the existing skills of employees. Skills gaps will be addressed to enable employees to manage their own careers and to provide business related training, where applicable.

10. RE-ASSESSMENT OF THE CLOSURE RISKS AFTER THE APPLICATION OF THE CLOSURE ACTIONS

The closure risks were re-assessed to determine whether, after the implementation of the conceptual closure strategy (as described in Section 8.4 above), the residual risk has been avoided and / or how it has resulted in avoidance, rehabilitation and management of impacts. Impacts that are classified as high-risk post-mitigation will be considered as latent environmental impacts and financial provision will be provided to remediate these specific impacts.

Table 13: Re-assessment of the potential closure related risks associated with the proposed THM after the application of the closure actions

Environmental Attribute / Sensitive Receptor	Risk	Significance Pre and Post Implementation of Closure Strategy		Comment
		Before	After	
Surface water	Surface water quality deterioration	**Low**	**Low**	By ensuring successful rehabilitation and if identified early through monitoring, these impacts are easily mitigated.
Socio-economic	Downscaling and retrenchment of employees.	**Medium**	**Medium**	This impact is difficult to mitigate but can be managed by establishing Future Forums, providing information and counselling for retrenched employees to promote their absorption into the labour market and by offering a post retrenchment programme designed to equip retrenchees with knowledge and skills.
Visual	In-pit dumps will remain on site resulting in a permanent change to the visual character of the area.	**Medium**	**Low**	This impact is difficult to mitigate but can be managed by shaping the dumps to achieve stabilisation and to blend in with the natural topography and by establishing vegetation on the dumps.
Biodiversity	Ineffective backfilling and rehabilitation: • Potential habitat destruction • Decrease in biodiversity • Increased erosion and subsequent negative impact on vegetation establishment	**Medium**	**Low**	Ensuring successful rehabilitation through monitoring will also reduce this risk. Should indigenous grass cover not establish successfully after one growing season, active reseeding will be required.
Biodiversity, soils, land capability, visual	Ineffective backfilling and rehabilitation - Soil compaction and erosion, exposed and impacted areas beyond the clearance footprint, unsafe voids, denuded areas, proliferation of invasive vegetation	**Medium**	**Low**	By ensuring soils are replaced in the correct layers, ripped and re-profiled post-closure, by shaping residual dumps that are elevated above surface level to achieve deposit stabilisation and to blend with the natural topography, and establishing vegetation on the crests of the dump, by implementing erosion protection on dump slopes, by undertaking post-closure monitoring, ensuring

				vegetation is restored adequately and ensuring topography is free draining this impact can be mitigated.
Groundwater	Recovery of groundwater levels and decant potential - No decant is expected by 100 years post closure.	**Low**	**Low**	By monitoring the groundwater quality for 5 years post closure the migration of contamination can be modelled.
	Migration of groundwater contamination plume due to poor quality seepage from the mining area and surface ROM pads and the product stockpiles - It is expected that by 100 years post closure the plume will not have spread more than 200 m from the pit boundary.	**Medium**	**Medium**	
Air Quality	Emissions arising from the in-pit waste rock dumps and denuded areas during dry and windy conditions	**Medium**	**Low**	By shaping dumps to achieve deposit stabilisation and establishing vegetation on the crests of the dumps this risk can be reduced. Ensuring successful rehabilitation through monitoring will also reduce this risk.

10.1 Outcomes

As indicated in Table 13 above, if the closure objectives are achieved by successfully implementing strategies (as detailed in Section 7), the overall significance of the closure-related risks identified can be suitably managed and thereby mitigated to an acceptable degree. The socio-economic impact of downscaling and retrenchment of employees during mine closure and the migration of the groundwater contamination plume will remain as medium impacts post closure.

11. ORGANISATIONAL CAPACITY

The organisational capacity that will be put in place to implement the closure plans is described below.

11.1 Responsibilities

Roles and responsibilities for the effective planning, implementation and monitoring of the closure processes and plans must be clearly defined and provided for. The closure and rehabilitation liability ultimately rests with the licence holder. Suitably qualified people must be appointed to the project to ensure that all commitments in the EMPr and closure plans are met. Closure and rehabilitation will be the duty of the Mine Manager under the guidance of a multidisciplinary team, with input from the various mine technical disciplines including engineering and mining, mine surveyor, Safety Health and Environment Quality (SHEQ), the social department and the finance section.

As the mine nears end-of-life, mine closure will be approached as a project with a dedicated team to ensure the implementation of the closure plan. The project team will be responsible for appointing and managing suitable subcontractors to implement the physical work where such skills and expertise are not available in-house.

Closure and rehabilitation actions must be carried out under the supervision of suitably qualified persons for the multiple discipline leads required. For example, demolition, engineering of the backfilled pit and waste dumps, waste removal, grassing and revegetation and monitoring.

A suitably qualified Environmental Control Officer (ECO) is required to ensure that the various closure and rehabilitation actions detailed herein are implemented and that the necessary internal monitoring and reporting is conducted. The ECO will also be responsible for employing the relevant suitably qualified external specialists to conduct closure related reviews and assessments, monitoring and independent audits as required.

11.2 Training

THM must implement a training-needs analysis to identify gaps in terms of training regarding closure to ensure that there is sufficient time to implement a training matrix to supplement training requirements where necessary for closure purposes. Training and capacity building of employees of the mine who may be able to assist in the facilitating the closure of the mine will be undertaken through the various training structures.

The ECO will also be responsible for training and supervising the staff to be utilized to undertake decommissioning and rehabilitation activities to ensure competence in appropriate closure and rehabilitation measures.

All contractors will be advised of the required health and safety standards prior to the commencement of decommissioning works. Induction training will be conducted for all staff and contractors involved with closure and rehabilitation activities by way of the environmental awareness plan to provide them with the necessary skills.

12. MONITORING AND REPORTING

12.1 Closure and Post- Closure Monitoring

A period of three years is assumed to account for closure, rehabilitation, maintenance and monitoring of the areas that would have been associated with the various project related structures and infrastructure. Monitoring, to be undertaken during this post closure period, will aid in evaluating whether the relinquishment criteria are met. If after this three-year period, it is determined that relinquishment criteria have not been met, an extended monitoring programme will be required. The duration of the extended monitoring programme will depend on the findings of ongoing monitoring and special assessments and a fixed commitment in this regard can only be made in the final detailed closure plan submitted for approval upon applying for closure.

The objective of the post-closure monitoring programme will be to track the recovery of the mining area towards the long-term post-closure land use goals, in accordance with the overall closure objectives.

The post-closure monitoring programme has been designed to collect information to demonstrate that the relinquishment criteria (refer to Table 15) have been achieved and the anticipated closure and post closure monitoring is addressed in Table 14 below.

Table 14: Closure and post closure monitoring

Monitoring aspect	Description	Scheduling
Soil quality monitoring	• A representative sample of the stockpiled soils must be analysed prior to rehabilitation to determine the nutrient status and chemistry of the utilisable materials. • Appropriate soil ameliorants are to be applied to assist rehabilitation	Prior to rehabilitation activities commencing.
	Contaminated land survey	During decommissioning, prior to rehabilitation
Erosion monitoring	Develop a representative reference site and undertake visual and topographic assessments to determine erosion rate, using standard erosion monitoring techniques.	All areas susceptible to erosion must be monitored bi-annually, and repair, maintenance and prevention measures implemented (if erosion is noted) for a period of 2 years post-closure.
Groundwater monitoring	Groundwater quality and level monitoring as required by the WUL.	Quarterly groundwater quality and level monitoring must be undertaken for a five-year post-closure period. Based on these results remediation requirements can be identified and a remediation plan put in place.
Biodiversity monitoring	• Alien and invasive plant species monitoring and eradication. • Monitor all rehabilitated areas for erosion. • Monitor reestablishment success of relocated species. • Monitor areas that have been revegetated (either through succession or reseeding) to ensure that adequate vegetation cover has been achieved.	Invasive species monitoring, and eradication biannually (every six months) for a period of two years. Reestablishment success of relocated species monitoring every six months (biannually) for a period of two years after relocation. Monitor areas that have been revegetated biannually for a period of two years once rehabilitation has been completed.

Monitoring aspect	Description	Scheduling
	• Where large bare areas are noted, reseeding must take place at the beginning of the following rainy season and where tree mortalities are noted, these must be replaced. • Ensure that the post-mining landscape is self-sustaining, and in line with future land use of the project area.	
Air Quality	To determine whether dust emitted from the waste rock dumps and denuded areas, prior to vegetation establishment, is within the applicable limits (currently the National Dust Control Regulations, GNR827 of 2013) at surrounding sensitive receptors.	Monthly dustfall monitoring, as per the operational air quality monitoring programme to continue during decommissioning and rehabilitation, for three years.
Photographic records	Maintained together with findings, follow up actions and close out records.	As per each monitoring occasion described above.

12.1.1 Reporting

The following external reporting requirements apply to the monitoring programme and reports must be submitted to head of the closure task team:

- Water monitoring reports must be prepared (including recommendations) by the relevant specialist for each monitoring survey.
- Erosion monitoring reports must be prepared (including recommendations) by the relevant specialist for each monitoring survey.
- Soil reports containing the results of the soil fertility monitoring must be prepared to inform the remediation and amelioration efforts required during rehabilitation to ensure that closure objectives are met.
- Vegetation monitoring reports (including photographs of the species identified as well as appropriate eradication measures for any alien invasive vegetation species) must be prepared by a botanist.
- Photographic records should be maintained together with findings, follow up actions and close out records.

12.1.2 Internal

- A record of all rehabilitation and closure requirements and actions should be kept by the ECO. If monitoring records indicate that closure risks are being realized, the appropriate specialist should be consulted, and the recommended management measures implemented.
- A closure report must be prepared by the ECO, including all of the monitoring data recorded. This must be submitted to the DMRE. Closure reporting by the ECO must include whether the relinquishment criteria have been achieved. Refer to Table 15 below for the relinquishment criteria and indicators. Recommendations for additional actions to be taken, where relinquishment criteria have not been achieved, must also be included in the report.

12.2 Maintenance plan

Should rehabilitation of an area be unsuccessful or poorly implemented, maintenance measures may be required. Maintenance measures should primarily be passive in nature with minimal long-term maintenance and operating costs. Maintenance which may be required until intervention achieves the necessary relinquishment criteria includes:

- Dust suppression methods should be implemented (as per the recommendations of a specialist) if dust monitoring indicates that dust fallout is exceeding limits at surrounding sensitive receptors.
- Fertilizing rehabilitated areas as per the findings of soil fertility monitoring, should a botanist indicate that vegetation establishment has not be successful.
- Eradication of alien invasive vegetation, as per the eradication plan to be compiled by a botanist as per the outcomes of the alien and invasive vegetation monitoring.
- Erosion repair and, where required, the implementation of additional erosion protection measures (e.g., contours, berms, energy dissipaters such as gabions and application of straw mulches or soil binders to exposed soils) based on the findings of erosion monitoring.

12.3 Relinquishment criteria

Relinquishment can be defined as the formal approval by the relevant regulating authority indicating that the completion criteria for the activity have been met through post-rehabilitation monitoring, management, and evaluation to the satisfaction of the authority. In this regard the relinquishment criteria are driven by the objectives of closure and consequently the indicators applicable to each impact associated with closure and decommissioning. The proposed relinquishment criteria for THM are described in Table 15 below.

Table 15: Relinquishment criteria for the closure of THM

Environmental Attribute	Relinquishment Criteria	Indicators	Reporting Requirements
Aesthetic Quality and Safety	• The landscape is inconspicuous / aesthetically compatible in relation to the surrounding landscape • Acceptable end-state (land use) achieved	• All surface infrastructure is dismantled and removed from site • The open pit is sloped to resemble the surrounding land configuration/landscape and rehabilitated with indigenous vegetation • Voids on the site backfilled, with building rubble and inert waste rock, compacted and top dressed with sufficient material and the appropriate vegetation • Waste rock and overburden material remaining after backfilling terraced and vegetated • Rehabilitated waste dumps and open pit do not pose a threat human and animal health/ safety • All ore stockpiles removed • All access roads are to be rehabilitated unless required for end land use by landowner • On-site access and haul roads are removed and re-shaped according to the area contours, scarified, fertilized and re-vegetated with indigenous vegetation species	• The process of removing buildings, structures and other objects will be in consultation with the Regional Manager in terms of Section 44 of the MPRDA, 2002 • Photographic evidence of backfilling and rehabilitation activities and close-out reports • Photographic evidence of removal of all surface infrastructure • Audit of roads and infrastructure no longer required after closure to confirm decommissioning and rehabilitation to acceptable standards
Air Quality	Closure objectives for air quality and dust fallout are achieved	Dust fallout and emissions from rehabilitated areas compliant with the standards as per the National Environmental Management: Air Quality (Act 39 of 2004 as amended)	• Records of air quality measurements particulate matter and dust fallout • Dust / air quality monitoring reports compiled by a qualified air quality specialist
Soil, Land Capability and Biodiversity	Vegetation is resilient, self-sustaining and comparable to the surrounding area	• Contaminated land assessment undertaken • Surface and soil areas where structures were, are scarified and levelled according to the prevailing contours • Compacted soils are ripped and profiled • Topsoil layer re-applied to required thickness • Fertilisation, applied where necessary • Area revegetated • Alien and invasive vegetation is controlled	• Evidence of soil sampling undertaken prior to rehabilitation (including nutrient status, chemistry of the utilisable soil materials and fertiliser requirements) • Photographic evidence of land returned to planned end land use and no erosion taking place
Ground and Surface Water	• Ground- and surface water quality monitoring results showing no indication of contamination	• Compliance with the WUL conditions • Potential post-closure seepage from mining infrastructure is prevented as far as possible	Groundwater and surface water monitoring reports compiled by a qualified specialist as per the WUL and monitoring programmes

Environmental Attribute	Relinquishment Criteria	Indicators	Reporting Requirements
	• Updated mine water management plan for residual and latent impacts • Updated and secured financial provision for residual and latent impacts	• Receptors in the zone of influence not impacted by contamination • Groundwater monitoring post-closure demonstrates there is no change from the baseline in terms of quality and quantity and a specialist groundwater study shows that recharge rates are as per the predictions undertaken during the operational phase	
	• All backfilled and landscaped voids are free draining (no evidence of pooling of stormwater) • Land surface after rehabilitation follows the natural contours of the surrounding land	• No pooling is occurring within the rehabilitated site • No erosion taking place; area has the capacity to withstand long-term wind and water erosion	Photographic evidence taken after large rainfall events to indicate that no pooling or erosion is occurring
Waste Material	No waste material remaining on site	All waste material removed from site in a controlled manner to registered land fill sites or for recycling	Safe waste disposal certificates kept on record
Socio-Economic	Full awareness with landowner and other IAPs regarding the mine closure concept and timing thereof	Stakeholder engagement	Records show ongoing consultation and engagement in closure planning process.
	The rehabilitated site does not pose a hazard to humans or animals	The area is stable; all surface infrastructure is dismantled and removed from site; no waste remains on site and there are no steep slopes or other voids / excavations.	• Photographic evidence of the rehabilitated site • Safe waste disposal certificates
	The landowner is left with no residual liability for site rehabilitation and/or maintenance	All of the above	Competent Authority approval of Final Closure Report, which demonstrates achievement of all completion criteria

12.4 Liability Assessment

As per Section 24(P)(3) of NEMA, THM must annually assess their environmental liability and, if circumstances so require, must adjust their financial provision to the satisfaction of the Minister responsible for Mineral Resources. The process for annual review of financial provision is outlined in the NEMA Financial Provisioning Regulations (GN1147 of 2015 as amended).

The annual review and assessment must be undertaken by a specialist with a view to re-assessing the environmental impacts, closure objectives and sustainable and state of land to determine the appropriateness of the mitigation and rehabilitation measures, the acceptability of the risks and the adequacy of the financial provision.

On completion of the above actions the financial provision must be confirmed or adjusted and within 30 days of receipt of the findings of the specialists regarding the review and re-assessment, the holder must set aside the adjusted financial provision and submit the findings including the following to the Minister for approval:

- reviewed and amended annual rehabilitation plan
- confirmation of the adequacy of the financial provision or the adjusted financial provision
- reviewed and amended final rehabilitation, decommissioning and mine closure plan
- reviewed and amended environmental risk assessment report
- proof of payment of the adjusted financial provision or the amended guarantee

The holder must ensure that the results of the reviews, confirmations or adjustments of the adequacy of the financial provision must be audited by an independent auditor, included in the form of an auditor's report and submitted for approval to the Minister.

This plan is to be audited annually and updated when necessary (i.e., progressive rehabilitation takes place, changes in the mine layout or description occur, additional potential risks arise, additional closure actions are required and/ or adjustments are made to the financial provision).

12.5 Additional Legislative Requirements

In terms of Regulation 43 of the MPRDA, within 180 days of:

- the lapsing, abandonment or cancellation of the right,
- cessation of the prospecting or mining operation,
- the relinquishment of any portion of the prospecting of the land to which a right, permit or permission relate, or
- completion of the prescribed closing plan to which the right relates

an application for a closure certificate, in terms of Regulation 57 of the MPRDA, must be completed and submitted to the DMRE. This application must be competed in Form P in Annexure II and must be accompanied by the required information, programmes, plans and reports prescribed in terms of the MPRDA and NEMA including the closure plan, an environmental risk report contemplated, a final performance assessment report contemplated in the EIA Regulations and a completed application form to transfer environmental liabilities and responsibilities, if the transfer of such liabilities has been applied for.

The Environmental Authorisation associated EIAR/ EMPr, and Closure Plan is required to be audited, the frequency of which will be stipulated in the Environmental Authorisation. The holder of a prospecting right or mining right must implement and ensure compliance with the relevant procedures and requirements on mine closure, especially as they relate to compliance with the conditions of an Environmental Authorisation.

No closure certificate may be issued unless each government department charged with the administration of any law which relates to any matter affecting the environment have confirmed in writing that the provisions pertaining to health and safety and management pollution to water resources, the pumping and treatment of extraneous water and compliance to the conditions of the Environmental Authorisation have been addressed. Notwithstanding the issue of a closure certificate, liability for the environmental degradation on the site remains the responsibility of the holder of the right.

13. ANNUAL REHABILIATION PLAN

This Final Rehabilitation, Decommissioning and Closure Plan and associated Annual Rehabilitation Plan forms part of the EIAR/EMPr submission to the DMRE for consideration in the Environmental Authorisation. Mining will only commence, and the mine plan will be implemented once all of the relevant approvals and permissions are received. It is anticipated that backfilling will commence immediately after the commencement of the mining operation and its advance will match the depletion rate of the open pit until the final void remains.

13.1 Identification of risks for rehabilitation and remediation

Since the mine has not yet been constructed, monitoring has not yet commenced. The preliminary risks identified as part of the Final Rehabilitation, Decommissioning and Closure Plan are shown in Table 7 above. Once mining commences the Final Rehabilitation, Decommissioning and Closure Plan must be used to identify potential risks and inform the planned annual rehabilitation and remediation activities, with the aim of ultimately reducing the identified impacts at closure. During the annual review and assessment of the closure plans, the accumulated monitoring data must be consulted.

13.2 Review of prior rehabilitation and remediation and shortcomings experienced

Since the mine has not yet been constructed and construction is only planned to commence in 2022, no rehabilitation / remediation activities have been implemented for the preceding 12 months as such there are no shortcomings to report on for the previous year.

13.3 Planned annual rehabilitation and reclamation activities

Since the mine has not yet been constructed, no rehabilitation / remediation activities have been implemented for the preceding 12 months, nor will any rehabilitation or remediation activities be implemented in the forthcoming 12 months.

When the construction phase commences the annual rehabilitation plan must be updated accordingly to consider the detailed mine plan at the time and provide for the schedule and budget for rehabilitation for the forthcoming 12-month period.

14. QUANTUM FOR CLOSURE-RELATED FINANCIAL PROVISION

In accordance with the requirements of GN1147 (Appendix 4, Section 3.k) the financial provision for 2021 and the methodology used to calculate the financial provision for the proposed THM is described below.

As per GNR1147 of 2015 a holder of a right in terms of the MPRDA must determine and make financial provision for the rehabilitation and management of negative environmental impacts from mining operations to the satisfaction of the Minister responsible for Mineral Resources. According to Regulation 5 a holder must make financial provision for rehabilitation and remediation; decommissioning and closure activities at the end of prospecting, exploration, mining or production operations; and remediation and management of latent or residual environmental impacts which may become known in future, including the pumping and treatment of polluted or extraneous water. Regulation 6 makes provision for the method of determining the costs of the financial provision and states that a holder must determine the financial provision through a detailed itemisation of all activities and costs, calculated based on the actual costs of implementation of the measures required for the above.

The 2005 Guideline for Evaluation of the Quantum for Closure-Related Financial Provision compiled by the then DME describes the recommended procedure for determining the quantum for financial provision in Section B thereof, entitled "Working Manual for the Determination of the Quantum"*.* The recommended procedure was therefore followed for the purposes of this 2021 evaluation of the quantum for the THM as follows:

STEP NO.	DESCRIPTION	FINDING
1.	Determine mineral mined and saleable by-products	Manganese, a base- / transition metal is the primary mineral mined
2A.	Determine primary risk class	**Class C** • mineral mined: manganese (oxide-type ore) • producing >10 000 tpm • mining and mine waste handled on site • processing involves dry screening using a fixed- and mobile plant • no plant waste is generated or processed on-site - all material is sold
2B.	Revised primary risk class based on saleable by-products	Not applicable, no saleable by-products are produced
3.	Environmental sensitivity of the mining area	**Low** • Area largely disturbed from natural state due to historic mining activities
4.1	Level of information available	Limited

4.2	Identification of closure components	Proposed mine infrastructure includes the following:
		1. Mobile crushing and screening plant. Powerlines will be underground.
		2. The following facilities were identified which are considered as steel (2A) or reinforced concrete buildings or structures (2B):
		  ○ Refuel Bay
		  ○ Vehicle yard, workshop and washbay
		  ○ Weighbridge
		3. Access road and internal graded haul roads.
		4. <u>No</u> electrified (4A) or non-electrified (4B) railway lines are present on-site.
		5. Office Block and stores buildings and weighbridge office

STEP NO.	DESCRIPTION	FINDING
		6. Opencast mining is the primary activity proposed to be undertaken on-site. 7. Adits were previously developed into the underground workings during historical mining. 8. Overburden material will be stockpiled on-site for use in backfilling of the opencast workings. There will also be 3 in-pit waste stockpile areas. There will be no processing waste (8B or 8C). 9. No subsided areas are envisaged. 10. General surface rehabilitation over the disturbed areas. 11. No river diversions will be constructed. 12. The THM will be surrounded by a wire fence. 13. Water management will be required. 14. Maintenance and aftercare for a period of 3 years will be required. 15. See 4.6 below.
4.3	Unit rates for closure components	The unit rates as published by the DMRE have been escalated by inflation on a year-on-year basis. The unit rates for closure components utilised for this evaluation applied escalation as published by StatsSA for 2020 at 3.3%. The unit rates utilised are indicated in Table 16.
4.4	Weighting factors	Weighting Factor 1, Nature of the terrain where the mine is located: • The natural terrain at the Hotazel Project is flat, therefore the assigned weighting factor is 1. Weighting Factor 2, Proximity to urban area: • The Hotazel Project is located in a peri-urban setting, with Hotazel situated approximately 1 km from the site, and Kuruman 72 km. This weighting factor is therefore 1.05.
4.5	Areas of Disturbance	Survey imagery and Google Earth Satellite Imagery (base-dated October 2021), were utilised to identify the areas of disturbance interpreted in accordance with the proposed site layout.
4.6	Identify closure costs from specialist studies	Still to be confirmed • Provisional costs for specialist studies have been included.
4.7	Calculate Closure Costs	Closure costs have been determined for final rehabilitation, decommissioning and mine closure activities as well as for the residual environmental impacts. Refer to Table 17, Table 18 and Table 19 below.
5.	Independent review by competent person	This assessment represents an independent review by a competent person.

Table 16: Unit rates utilised for evaluation of the quantum (2021)

RATE COMPONENT S1.2	CLOSURE COMPONENT	UNIT	RATE 2021
1	Dismantling of processing plant and related structures (including overland conveyors and powerlines)	m^3	R 17
2A	Demolition of steel buildings and structures	m^2	R 236
2B	Demolition of reinforced concrete buildings and structures	m^2	R 347
3	Rehabilitation of access roads	m^2	R 42
4A	Demolition and rehabilitation of electrified railway lines	m	R 409
4B	Demolition and rehabilitation of non-electrified railway lines	m	R 223
5	Demolition of housing and facilities	m^2	R 471
6	Opencast rehabilitation including final voids and ramps	ha	R 247,098
7	Sealing of shafts, adits and inclines	m^3	R 127
8A	Rehabilitation of overburden and spoils	ha	R 164,732
8B	Rehabilitation of processing waste deposits and evaporation ponds ((basic, salt-producing waste - non-polluting potential)	ha	R 205,170
8C	Rehabilitation of processing waste deposits and evaporation ponds (acidic, metal-rich waste - polluting potential)	ha	R 595,912
9	Rehabilitation of subsided areas	ha	R 137,938
10	General surface rehabilitation	ha	R 130,495

RATE COMPONENT S1.2	CLOSURE COMPONENT	UNIT	RATE 2021
11	River diversions	ha	R 130,495
12	Fencing	m	R 149
13	Water management (Separating clean and dirty water, managing polluted water and managing the impact on groundwater, including treatment, when required)	ha	R 49,618
14	2 to 3 years of maintenance and aftercare	ha	R 17,366

Since the proposed THM mine has not yet been constructed, no rehabilitation / remediation activities have been implemented for the preceding 12 months, nor will any rehabilitation or remediation activities be implemented in the forthcoming 12 months. The current financial provision for the annual rehabilitation and remediation at the THM is therefore R 0.

Total 1, the financial provision for the final rehabilitation, decommissioning and mine closure activities at THM, has been calculated to be **R 35 947 195** (incl. P&Gs + contingencies) (Table 17).

Total 2, the financial provision for the residual environmental impacts at THM, has been calculated **R 5 959 845** (incl. P&Gs + contingencies) (Table 18).

The total financial provision (Total 1 + Total 2 + VAT) for the THM, is therefore **R 48 193 096** (Table 19).

Table 17: Quantum for the Final Rehabilitation, Decommissioning and Mine Closure activities at THM

Closure Component No.	Closure Component	Comment	Unit	Base Rate 2021	Quantity	Total
1	Dismantling of processing plant and related structures (including overland conveyors and powerlines)	Removal of Processing plant	m^2	R 17	480	R 113,130
2A	Demolition of steel buildings and structures	Vehicle yard & Workshop and Weighbridge	m^2	R 236	12305	R 2,900,137
2B	Demolition of reinforced concrete buildings and structures	Concrete hardstands at refuel bay, office block and stores, weighbridge office and vehicle yard & workshop	m^3	R 347	8148	R 2,829,840
3	Rehabilitation of access roads	On site roads	m^2	R 42	73424	R 3,096,699
5	Demolition of housing and facilities	Office Block and stores and weighbridge office	m^2	R 471	1954	R 921,067
6	Opencast rehabilitation including final voids and ramps	Estimate of the extent of final cut remaining	ha	R 247,098	20	R 4,941,954
8A	Rehabilitation of overburden and spoils	Final Waste Dump extents, envisaged at the end of LoM	ha	R 164,732	39	R 6,408,067
10	General surface rehabilitation	Refuel bay, Product Stockpile Area, Office Block and stores, Vehicle yard & Workshop, RoM pads, Processing plant, PCD, Stormwater ponds, Weighbridge and office, Topsoil stockpile and Sand stockpile area	ha	R 130,495	18	R 2,411,059
12	Fencing		m	R 149	5155	R 767,368
13	Water management (Separating clean and dirty water, managing polluted water and managing the impact on groundwater, including treatment, when required)	Allowance for engineering of in-pit water management for void remaining and in pit dumps	ha	R 49,618	59	R 2,922,501
15	Specialist Studies		no	R 750 000	1	R 750 000
					SUM OF CLOSURE COMPONENT COSTS	**R 28 061 823**
					SUB-TOTAL 1 = Sum of closure components x weighting factor (location)	**R29 464 914**
					Preliminary and General Management = 12% OF SUB-TOTAL 1 (< R 100,000,000.00)	R3 535 790
					Contingencies = 10% OF SUBTOTAL 1	R2 946 491
					Subtotal 1. FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE	**R 35 947 195**

Table 18: Quantum for the Residual Environmental Impacts which may occur in the future at THM

Closure Component No.	Main Description	Description		Unit	Base Rate 2021	Quantity	Total
14	2-3 years of maintenance and aftercare	Care and maintenance		ha/yr.	R 17,366	177	R 3,068,626
		Reclamation monitoring		ha/yr.	R 4,184	177	R 739,282
		Biodiversity	Alien invasive species monitoring and eradication, vegetation rehabilitation	yr.	R 40 000	3	R 120 000
		Erosion	Annual erosion monitoring	yr.	R 11 500	3	R 34 500
		Groundwater	4 monitoring points, quarterly sampling	yr.	R 138 017	5	R 690 086
						SUM OF CLOSURE COMPONENT COSTS	**R 4 652 494**
						SUB-TOTAL 1 = Sum of closure components x weighting factor (location)	**R4 885 119**
						Preliminary and General Management = 12% OF SUB-TOTAL 1 (< R 100,000,000.00)	R586 214
						Contingencies = 10% OF SUBTOTAL 1	R488 512
						Subtotal 2. RESIDUAL ENVIRONMENTAL IMPACTS WHICH WILL OCCUR IN THE FUTURE	**R 5 959 845**

Table 19: Total Financial Provision 2021

SUM Subtotal 1. FINAL REHABILITATION, DECOMMISSIONING AND CLOSURE + Subtotal 2. RESIDUAL ENVIRONMENTAL IMPACTS WHICH WILL OCCUR IN THE FUTURE	R 41 907 040
ADD VAT (15%)	**R 6 286 056**
Total Financial Provision	**R 48 193 096**

15. GAPS AND ACTION PLAN

The current gaps contained within this draft closure plan and the proposed actions required to address these gaps are detailed in Table 20 below.

Table 20: Existing gaps within this closure plan and proposed action plan

Gaps	Action Plan to Address Knowledge Gaps	Timelines
Actual and predicted environmental impacts and risks	Revise and update the environmental risk assessment to ensure that the Closure Plan remains applicable to the actual and predicted environmental impacts and risks.	Every year
Geochemical assessment	Update of the geochemical assessment - The material sampled for the geochemical assessment has been exposed on surface since the previous mining activities stopped in 1989. It is possible that oxidation and leaching of elements by rainfall has impacted the test results. It is recommended that the geochemical assessment be updated.	Once the mine is operational and fresh material is available.
Understanding of groundwater impacts post closure	Development of a conceptual waste dump model to contextualise physical and geochemical characteristics and conduct detailed hydrological and infiltration modelling to develop detailed water balances for the dumps. Update of the numerical groundwater flow and contaminant transport models based on time series groundwater level and quality data as obtained from the groundwater monitoring program as well as climatic aspects such as rainfall and evaporation. Re-calibrating the models based on time series data will increase the confidence level of the predictions. Any changes in the mine design, progression plan and surface layouts can also be included, and the impact simulations updated.	Every 2 years
Lack of understanding of the social impact of closure	• Compile a closure-focussed Stakeholder Engagement Plan. • Undertake an investigation into the social-related closure requirements of the mine. • THM to consider the LED strategy for the area, and investigate which useful infrastructure (i.e., roads, power lines and sewage treatment plants) are to remain in place post-closure for use by the surrounding communities.	5 years prior to known closure
End use of the remaining opencast void	Best practice dictates that THM should maximise backfill to the pit especially given the volumes of waste rock on surface.	5 years prior to known closure
Lack of detail around scheduling of actions required for the implementation of mine closure and post closure land use	• More detailed spatial plans and post-closure land use maps should be developed. • The rehabilitation actions can be quantified by conducting a first order volumetric assessment based on the electronic mining plan, pit shell, post mining landform modelling and specialist study inputs.	5 years prior to known closure

APPENDIX 23

LAND CLAIMS

COMMISSION ON RESTITUTION OF
LAND RIGHTS

Enquiries: Ryan Oliver

Prime Resources Environmental Consultants
70 – 7th Avenue
Parktown North
Johannesburg
2193

Dear Sir/ Madam

LAND CLAIMS ENQUIRY

1. **(Re) Portion of portion 1 of the Farm York A No. 279, Joe Morolong Local Municipality, Northern Cape Province.**

2. **(Re) (Portion of RE) of Farm Hotazel No. 280, Joe Morolong Local Municipality, Northern Cape Province.**

We refer to your email receive 12/04/2021

We confirm that as at the date of this letter land claims appear on our database in respect of the property mentioned under point 2. There are no land claims appearing on the remaining property description. This includes the database for claims lodged by 31 December 1998; and those lodged between 1 July 2014 and 27 July 2016 in terms of the Restitution of Land Rights Amendment Act, 2014.

Whilst the Commission takes reasonable care to ensure the accuracy of the information it provides, there are various factors that are beyond the Commission's control, particularly relating to claims that have lodged but not yet been gazetted such as:

1. Some Claimants referred to properties they claim dispossession of rights in land against using historical property descriptions which may not match the current property description; and
2. Some Claimants provided the geographic descriptions of the land they claim without mentioning the particular actual property description they claim dispossession of rights in land against.

The Commission therefore does not accept any liability whatsoever if through the process of further investigation of claims it is found that there is in fact a land claim in respect of the above property.

If you are aware of any change in the description of the above property after 19 June 1913 kindly supply us with such description so as to enable us to do a further search.

Yours faithfully

PP [signature]

Ms. M. Du Toit
Chief Director: Land Restitution Support-Northern Cape
Date: 19.04.2021