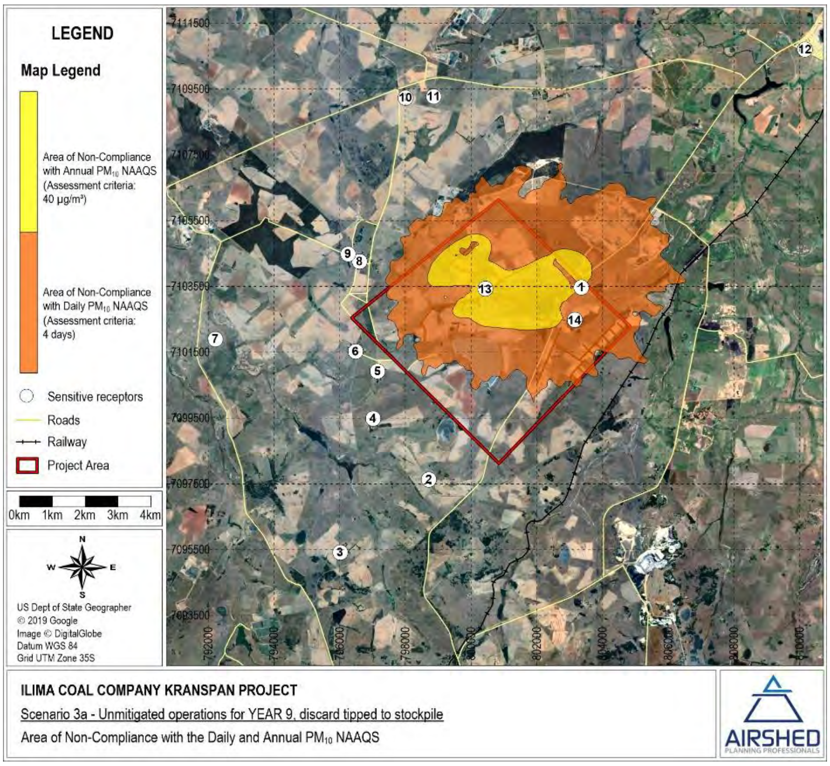

Figure 24: Scenario 3a – Area of non-compliance of daily and annual PM_{10} NAAQS for unmitigated YEAR 9 operations, discard tipped to stockpile

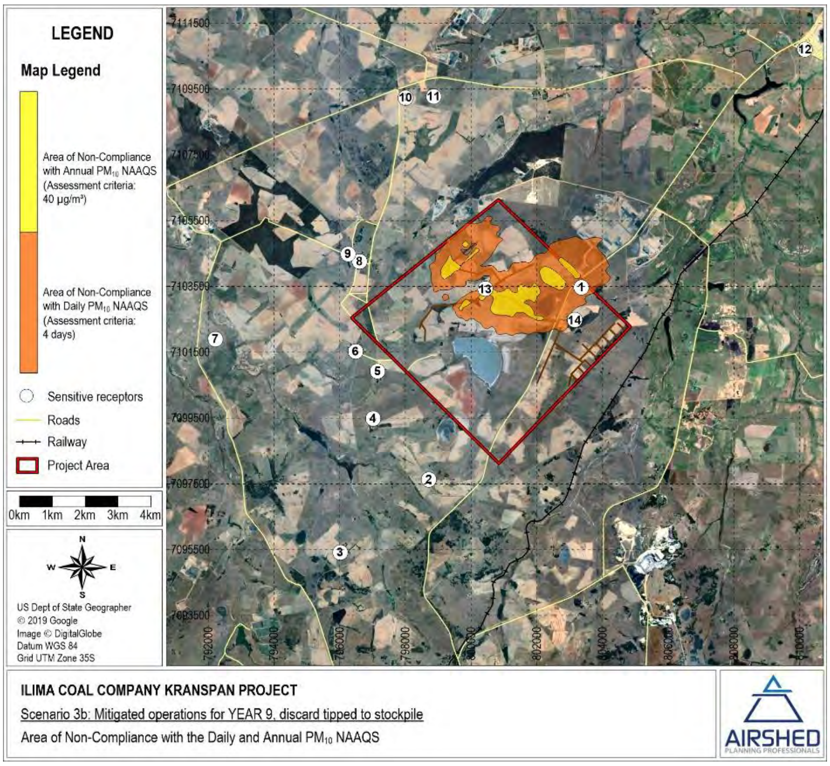

Figure 25: Scenario 3b – Area of non-compliance of daily and annual PM_{10} NAAQS for mitigated YEAR 9 operations, discard tipped to stockpile

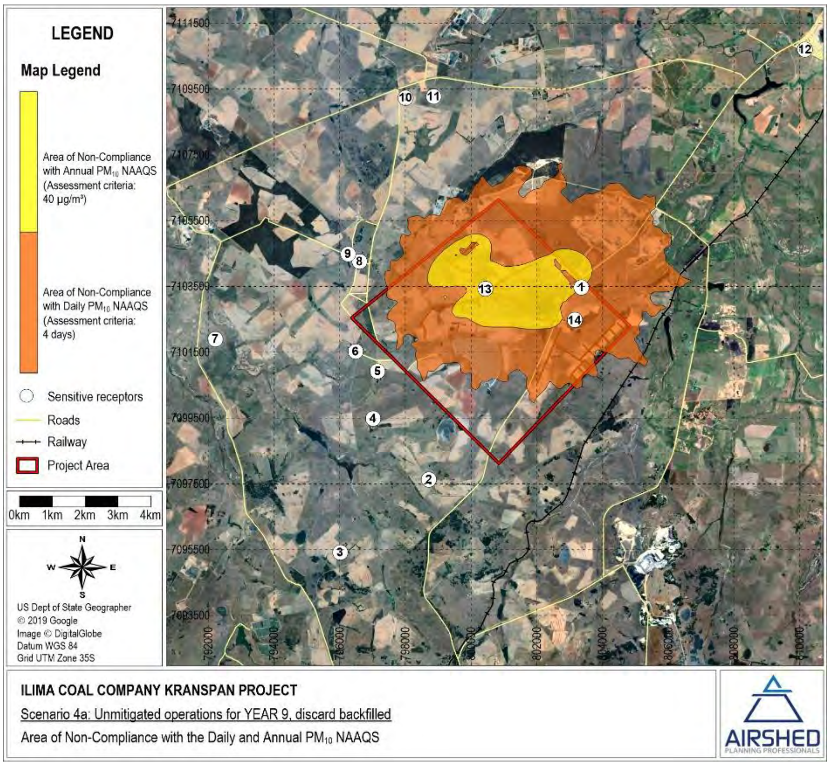

Figure 26: Scenario 4a – Area of non-compliance of daily and annual PM_{10} NAAQS for unmitigated YEAR 9 operations, discard backfilled

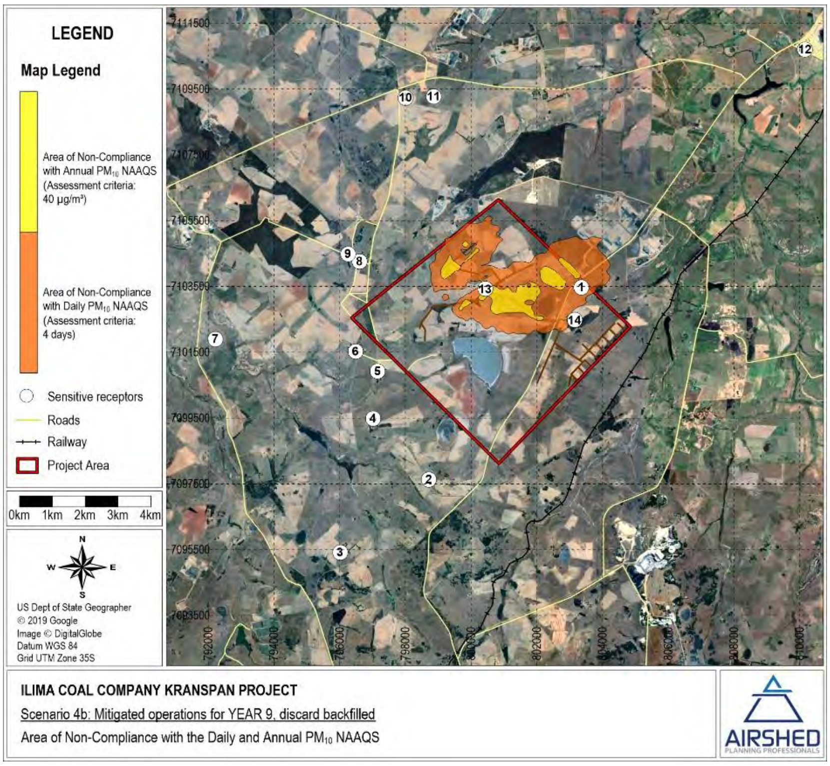

Figure 27: Scenario 4b – Area of non-compliance of daily and annual PM_{10} NAAQS for mitigated YEAR 9 operations, discard backfilled

Table 15: Simulated AQSR PM_{10} concentrations (in µg/m³) due to unmitigated and mitigated YEAR 9 operations, for the two discard disposal options (Scenario 3 and 4)

AQ SR	PM_{10} GLCs (µg/m³) – Discard tipped to stockpile								PM_{10} GLCs (µg/m³) – Discard backfilled							
	Scenario 3a				Scenario 3b				Scenario 4a				Scenario 4b			
	Highest Daily	Annual	No of Exceed ances	Within Complianc e (Yes/No)	Highest Daily	Annual	No of Exceed ances	Within Complianc e (Yes/No)	Highest Daily	Annual	No of Exceed ances	Within Complianc e (Yes/No)	Highest Daily	Annual	No of Exceed ances	Within Complianc e (Yes/No)
1	493.2	40.7	77	No	183.7	16.4	21	No	495.7	41.1	78	No	184.4	16.5	21	No
2	38.5	2.6	0	Yes	14.6	1.0	0	Yes	44.3	2.7	0	Yes	14.9	1.0	0	Yes
3	37.8	1.8	0	Yes	14.9	0.7	0	Yes	38.0	1.8	0	Yes	14.9	0.7	0	Yes
4	58.4	5.2	0	Yes	23.1	2.0	0	Yes	58.9	5.4	0	Yes	23.2	2.0	0	Yes
5	86.5	7.8	3	Yes	34.5	3.0	0	Yes	86.3	8.0	3	Yes	34.5	3.0	0	Yes
6	84.7	7.6	1	Yes	34.6	2.9	0	Yes	86.5	7.9	1	Yes	35.1	2.9	0	Yes
7	36.8	2.2	0	Yes	14.1	0.8	0	Yes	38.7	2.3	0	Yes	14.1	0.9	0	Yes
8	92.1	5.5	2	Yes	31.1	2.1	0	Yes	93.6	5.6	2	Yes	31.5	2.1	0	Yes
9	79.5	4.5	2	Yes	29.1	1.7	0	Yes	80.6	4.6	2	Yes	29.4	1.7	0	Yes
10	42.0	1.5	0	Yes	15.4	0.6	0	Yes	44.4	1.5	0	Yes	16.0	0.6	0	Yes
11	49.3	1.5	0	Yes	18.4	0.6	0	Yes	49.3	1.6	0	Yes	18.4	0.6	0	Yes
12	27.9	1.7	0	Yes	11.2	0.7	0	Yes	28.2	1.7	0	Yes	11.3	0.7	0	Yes
13	484.2	61.7	111	No	164.2	22.6	14	No	633.8	76.4	138	No	198.6	26.1	19	No
14	253.0	19.1	33	No	102.2	6.9	3	Yes	251.8	19.3	33	No	102.1	7.0	3	Yes

Notes:

(a) Scenario 3 (Year 9 operations, discard tipped to stockpile) – unmitigated scenario.

(b) Scenario 3 (Year 9 operations, discard tipped to stockpile) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

(c) Scenario 4 (Year 9 operations, discard backfilled) – unmitigated scenario.

(d) Scenario 4 (Year 9 operations, discard backfilled) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

4.3.2 $PM_{2.5}$

The simulated highest daily and annual average $PM_{2.5}$ concentrations (screened for compliance against current and future $PM_{2.5}$ NAAQS's) for Scenarios 1a and 1b, and Scenarios 2a and 2b (operational Year 5) are provided in Figure 28 to Figure 35 respectively, with the GLCs at each of the AQSRs provided in Table 16. The simulated highest daily and annual average $PM_{2.5}$ concentrations for Scenarios 3a and 3b, and Scenarios 4a and 4b (operational Year 9) are provided in Figure 36 to Figure 43 respectively, with the GLCs at each of the AQSRs provided in Table 17.

The main findings are:

- Scenario 1a: YEAR 5 – unmitigated, discard tipped at discard stockpile. *$PM_{2.5}$* daily GLCs, with no mitigation in place, are likely to be in non-compliance with the current NAAQS for distances up to 650 m from the south-western border (Figure 28). Unmitigated $PM_{2.5}$ daily GLCs are likely to be in non-compliance with the future NAAQS for distances up to 1.4 km from the northern border, and up to 1.1 km from the eastern border of the project site (Figure 29) From Table 16 exceedances of the future $PM_{2.5}$ NAAQS are expected at five (5) AQSRs, viz. #1, 5, 6, 13 and 14. Over an annual average the GLCs are within the future $PM_{2.5}$ NAAQS at all receptors except AQSR#13 (Figure 30 and Table 16).
- Scenario 1b: YEAR 5 – mitigated, discard tipped at discard stockpile. With mitigation in place, exceedances of the future $PM_{2.5}$ daily NAAQS is largely confined to the site (Figure 31 and Table 16) and exceedances are expected at two (2) AQSRs, viz. #5 and 13 (Table 16). Over an annual average the GLCs are low and well within the standard (Figure 30 and Figure 31, and Table 16).
- Scenario 2a: YEAR 5 – unmitigated, discard backfilled. *$PM_{2.5}$* daily GLCs, with no mitigation in place, show similar impacting areas as with Scenario 1a, but with a smaller footprint area of potential exceedances of the current NAAQS to the east of the border (Figure 32). The footprint area of potential exceedances of the future daily NAAQS (Figure 34) is very similar to the corresponding impact area of Scenario 1. Potential non-compliance with the future NAAQS for daily averages is shown at three (3) of the AQSRs (AQSR#5, 13 and 14) (Table 16). Over an annual average the GLCs exceed the future $PM_{2.5}$ NAAQS at AQSR#13 (Figure 34 and Table 16).
- Scenario 2b: YEAR 5 – mitigated, discard backfilled. With mitigation in place, potential exceedances of the $PM_{2.5}$ daily NAAQS (current and future NAAQS) are largely confined to the site (Figure 33 and Figure 35) with exceedances expected at two (2) AQSRs, viz. #5 and 13 (Table 16). Over an annual average the GLCs are low and well within the standard (Figure 33, Figure 35 and Table 16).
- Scenario 3a: YEAR 9 – unmitigated, discard tipped at discard stockpile. *$PM_{2.5}$* daily GLCs, with no mitigation in place, are likely to be in non-compliance with the current and future NAAQS for distances up to 1.2 km and 2.2 km from the north-eastern border respectively (Figure 36 and Figure 37). From Table 17 exceedances of the future daily $PM_{2.5}$ NAAQS are expected at three (3) AQSRs, viz. #1, 13 and 14. Over an annual average the GLCs are within the future $PM_{2.5}$ NAAQS.
- Scenario 3b: YEAR 9 – mitigated, discard tipped at discard stockpile. With mitigation in place, exceedances of the $PM_{2.5}$ current and future daily NAAQS extend for a distance of up to 300 m and 1 km from the north-eastern site border respectively (Figure 38 and Figure 39) and exceedances are still

expected at AQSR #1 and 13 (Table 17). Over an annual average the GLCs are within the standard (Table 17).

- Scenario 4a: YEAR 9 – unmitigated, discard backfilled. *$PM_{2.5}$* daily GLCs, with no mitigation in place, show similar impacting areas as with Scenario 3a with exceedances of the current and future daily $PM_{2.5}$ NAAQS's expected at three (3) AQSRs, viz. #1, 13 and 14 (Figure 40, Figure 41 and Table 17). Over an annual average the GLCs are within the standard except at AQSR#13 (Table 17).
- Scenario 4b: YEAR 9 – mitigated, discard backfilled. With mitigation in place, the footprint of exceedance of the current and future $PM_{2.5}$ daily NAAQS (Figure 42 and Figure 43) is similar as for Scenario 3b with exceedances expected at AQSRs #1 and 13 (Table 17). Over an annual average the GLCs are low and well within the standard (Table 17).

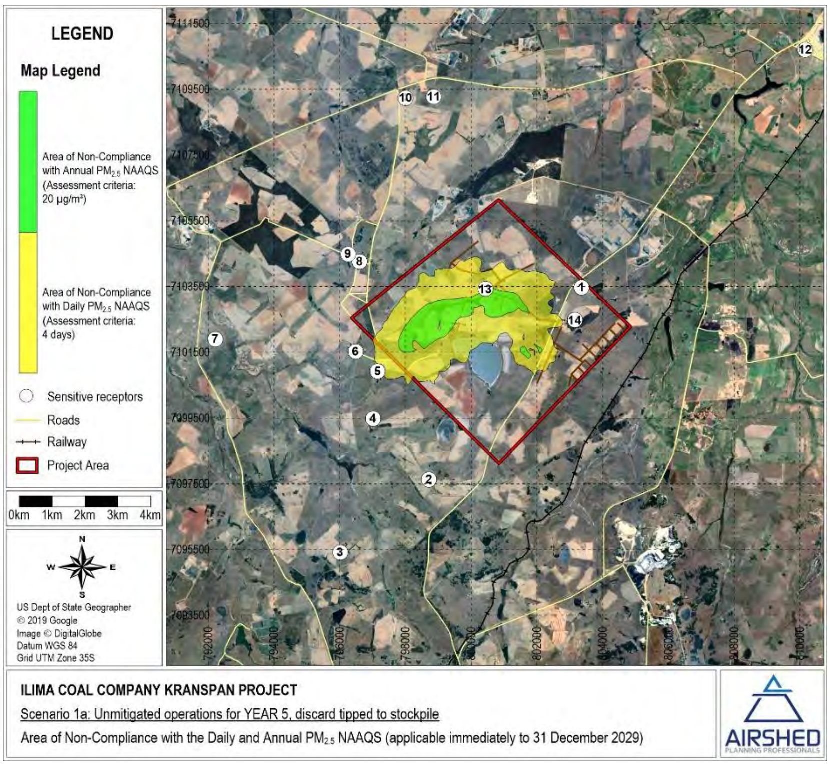

Figure 28: Scenario 1a – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for unmitigated YEAR 5 operations, discard tipped to stockpile

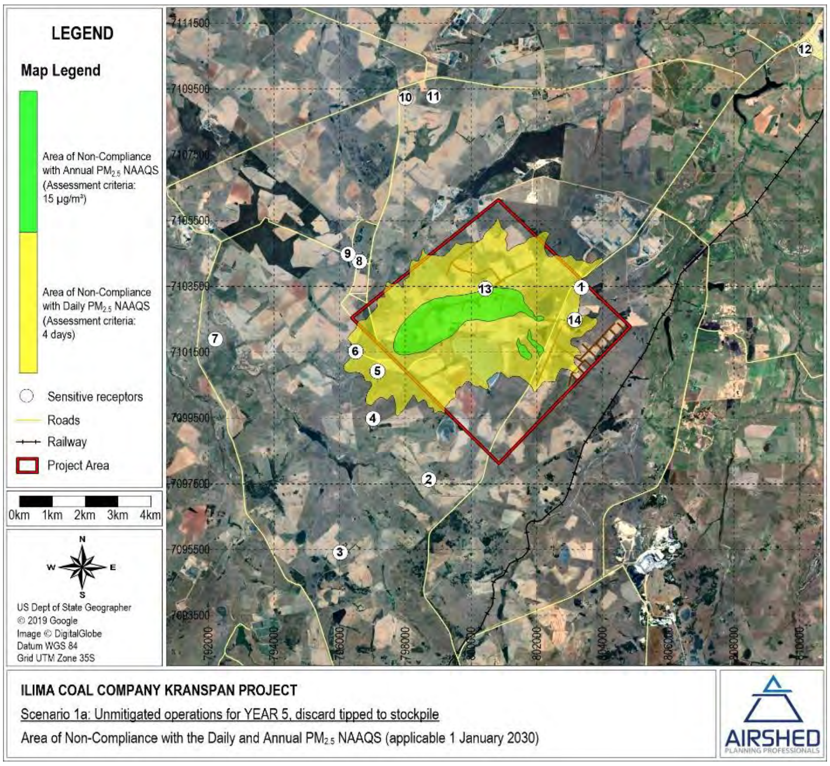

Figure 29: Scenario 1a – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for unmitigated YEAR 5 operations, discard tipped to stockpile

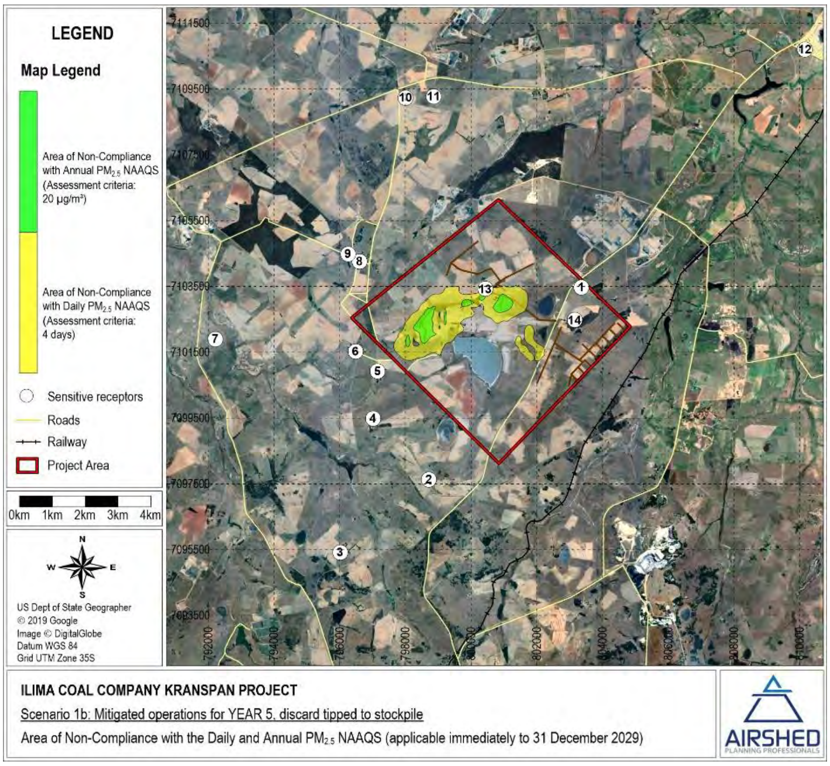

Figure 30: Scenario 1b – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for mitigated YEAR 5 operations, discard tipped to stockpile

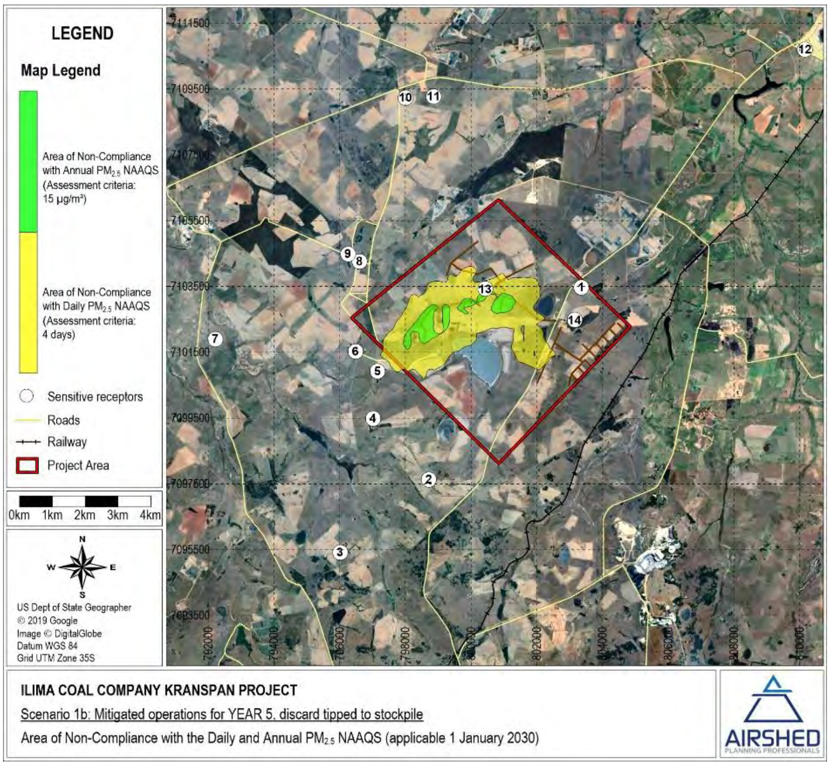

Figure 31: Scenario 1b – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for mitigated YEAR 5 operations, discard tipped to stockpile

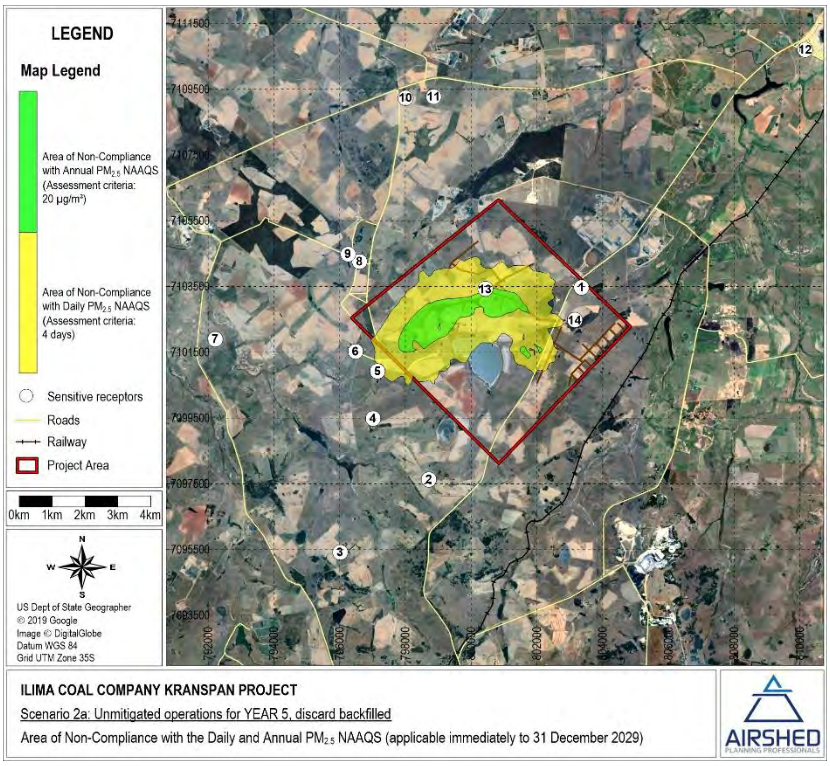

Figure 32: Scenario 2a – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for unmitigated YEAR 5 operations, discard backfilled

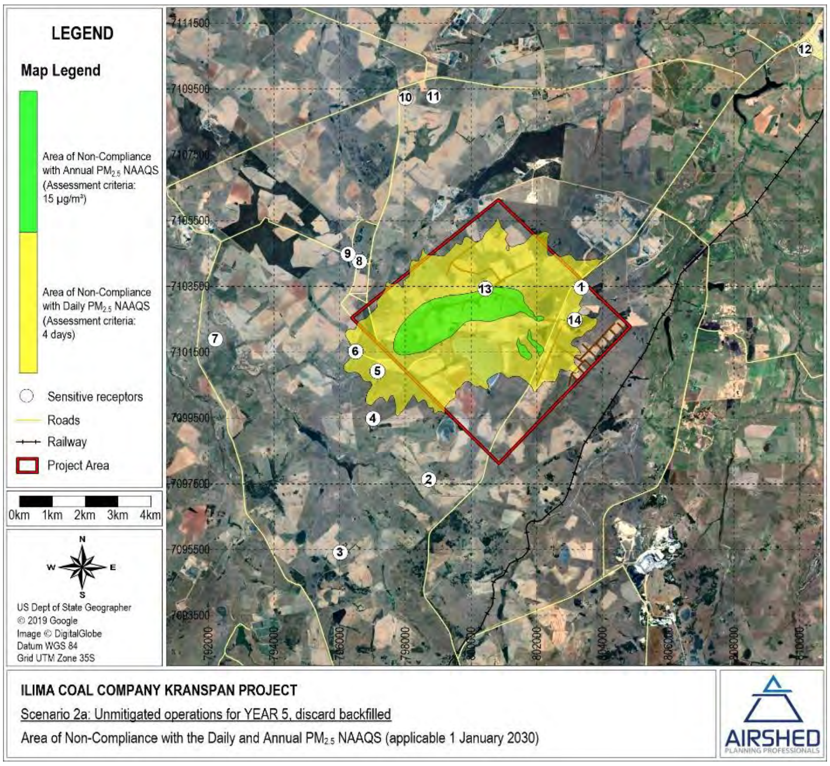

Figure 33: Scenario 2a – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for unmitigated YEAR 5 operations, discard backfilled

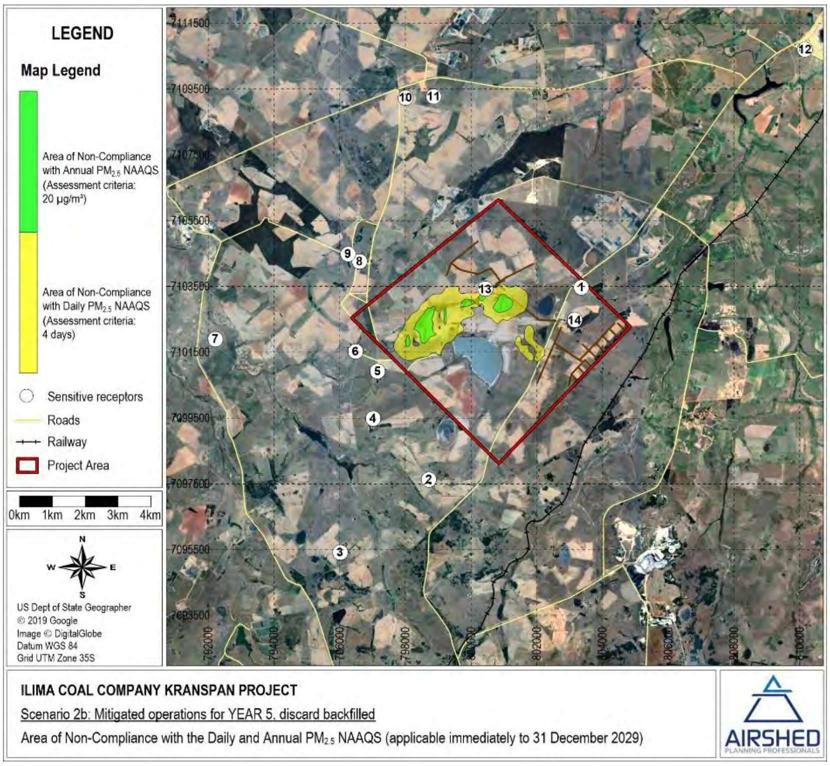

Figure 34: Scenario 2b – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for mitigated YEAR 5 operations, discard backfilled

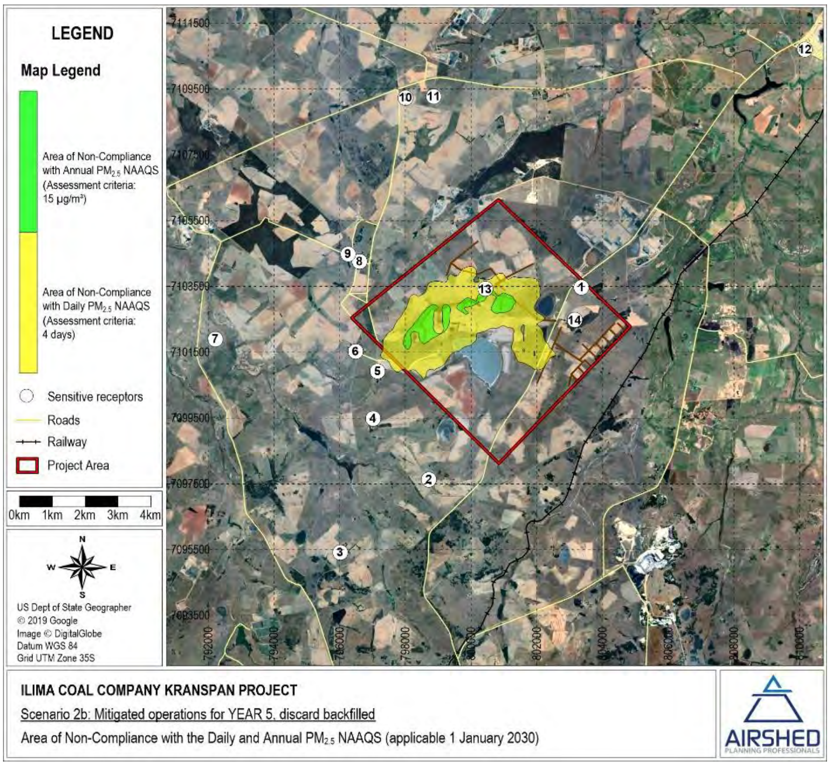

Figure 35: Scenario 2b – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for mitigated YEAR 5 operations, discard backfilled

Table 16: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) due to unmitigated and mitigated YEAR 5 operations, for the two discard disposal options (Scenario 1 and 2)

AQ SR	$PM_{2.5}$ GLCs (µg/m³) – Discard tipped to stockpile								$PM_{2.5}$ GLCs (µg/m³) – Discard backfilled							
	Scenario 1a[(a)]				Scenario 1b[(b)]				Scenario 2a[(c)]				Scenario 2b[(d)]			
	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]
1	34.2	2.9	6	No	14.9	1.4	0	Yes	35.8	3.0	0	Yes	15.3	1.4	0	Yes
2	18.6	0.8	0	Yes	8.4	0.4	0	Yes	18.6	0.8	0	Yes	8.4	0.4	0	Yes
3	11.5	0.5	0	Yes	5.8	0.3	0	Yes	11.6	0.5	0	Yes	5.9	0.3	0	Yes
4	29.3	2.0	2	Yes	14.2	1.0	0	Yes	29.4	2.0	0	Yes	14.3	1.0	0	Yes
5	76.7	6.0	16	No	38.1	3.0	9	No	77.0	6.1	6	No	38.2	3.0	6	No
6	54.7	4.2	6	No	26.8	2.0	4	Yes	54.9	4.3	1	Yes	26.9	2.0	1	Yes
7	10.6	0.6	0	Yes	5.1	0.3	0	Yes	10.9	0.6	0	Yes	5.1	0.3	0	Yes
8	23.8	1.2	0	Yes	11.9	0.6	0	Yes	23.9	1.2	0	Yes	12.0	0.6	0	Yes
9	20.6	1.0	0	Yes	10.4	0.5	0	Yes	20.6	1.0	0	Yes	10.4	0.5	0	Yes
10	15.1	0.3	0	Yes	7.4	0.1	0	Yes	15.2	0.3	0	Yes	7.4	0.1	0	Yes
11	10.4	0.3	0	Yes	5.2	0.2	0	Yes	10.4	0.3	0	Yes	5.3	0.2	0	Yes
12	9.0	0.3	0	Yes	4.4	0.2	0	Yes	9.2	0.3	0	Yes	4.4	0.2	0	Yes
13	119.9	15.2	79	No	51.5	6.6	14	No	131.6	16.4	88	No	54.5	6.9	17	No
14	35.7	3.5	7	No	16.5	1.7	0	Yes	36.0	3.6	7	No	16.6	1.7	0	Yes

Notes:

(a) Scenario 1 (Year 5 operations, discard tipped to stockpile) – unmitigated scenario.

(b) Scenario 1 (Year 5 operations, discard tipped to stockpile) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

(c) Scenario 2 (Year 5 operations, discard backfilled) – unmitigated scenario.

(d) Scenario 2 (Year 5 operations, discard backfilled) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

(e) Compliance evaluation against 1 January 2030 NAAQS

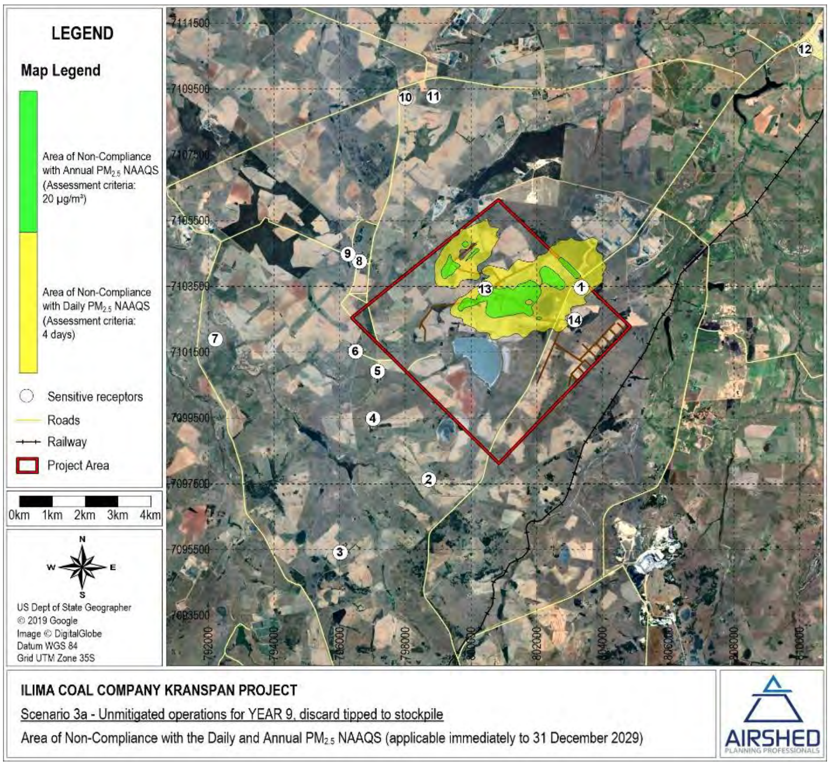

Figure 36: Scenario 3a – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for unmitigated YEAR 9 operations, discard tipped to stockpile

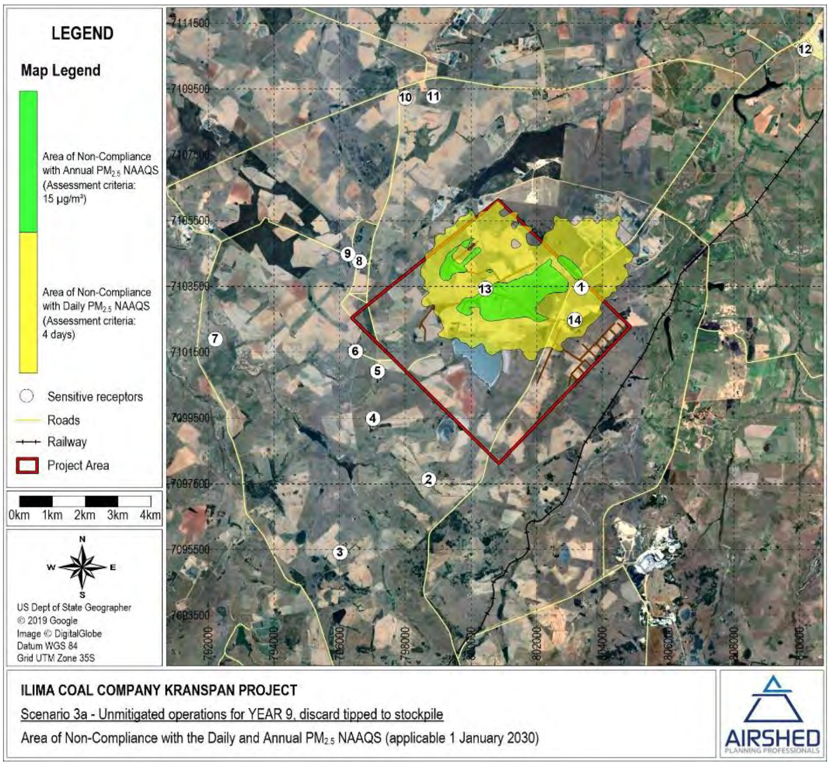

Figure 37: Scenario 3a – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for unmitigated YEAR 9 operations, discard tipped to stockpile

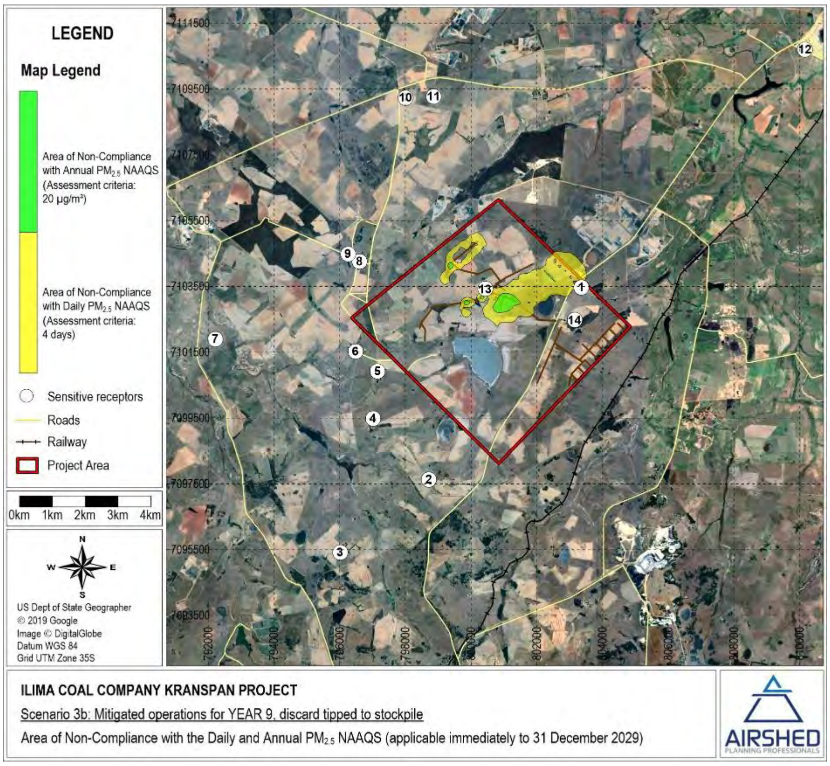

Figure 38: Scenario 3b – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for mitigated YEAR 9 operations, discard tipped to stockpile

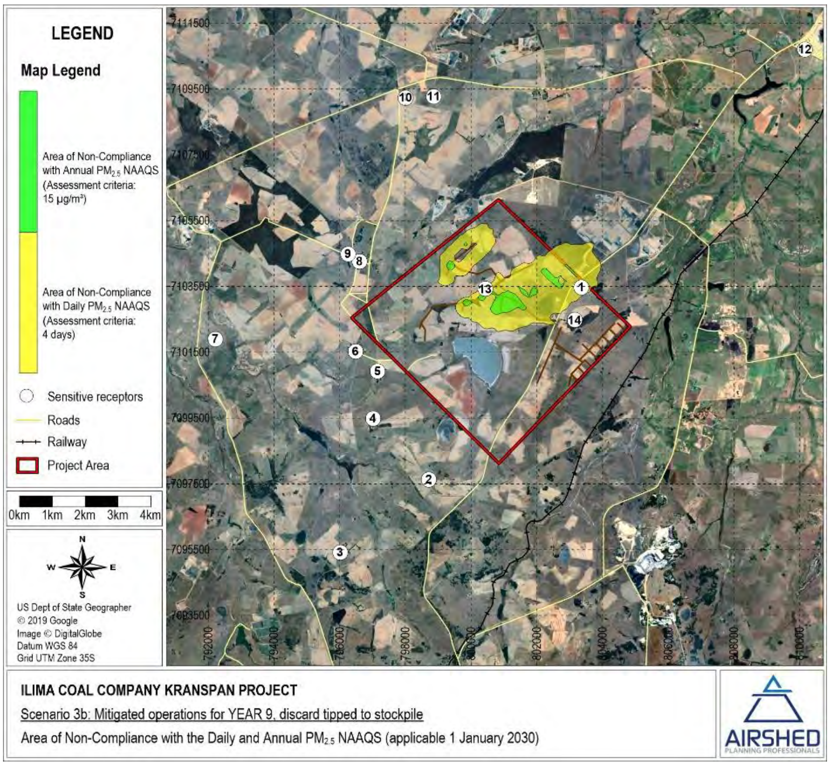

Figure 39: Scenario 3b – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for mitigated YEAR 9 operations, discard tipped to stockpile

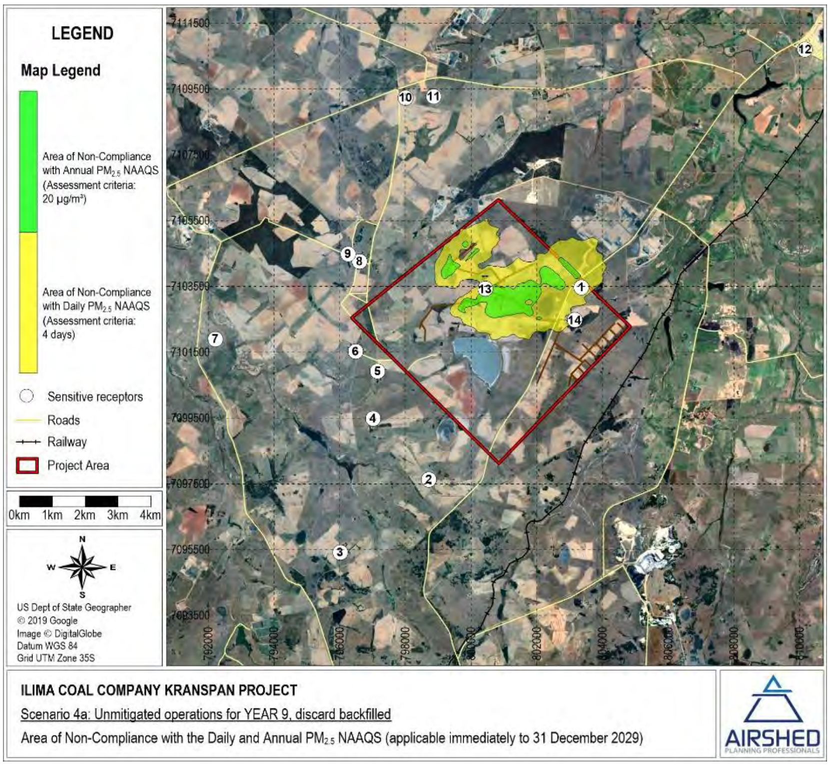

Figure 40: Scenario 4a – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for unmitigated YEAR 9 operations, discard backfilled

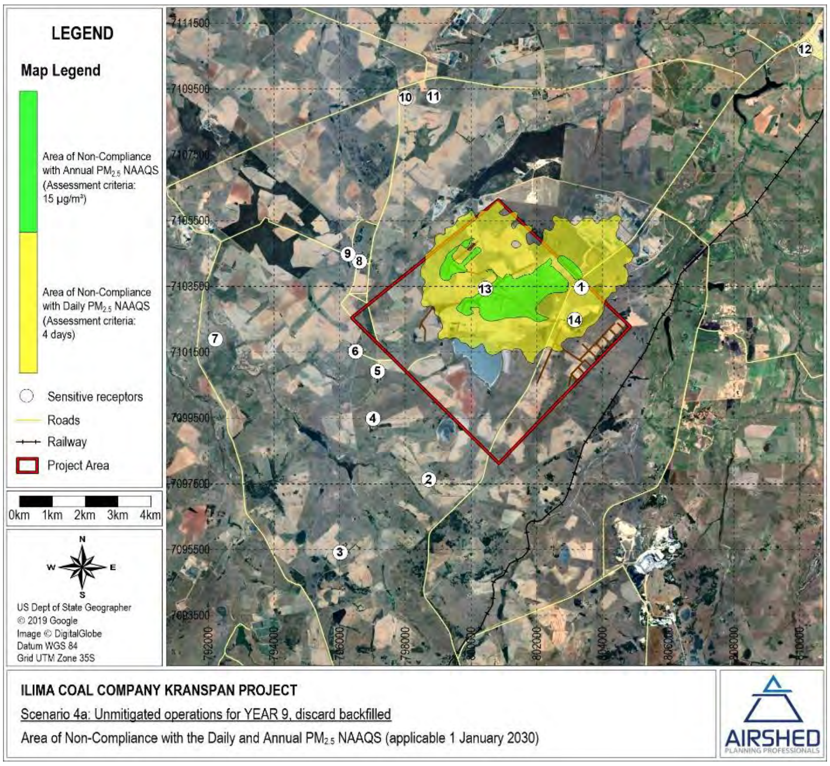

Figure 41: Scenario 4a – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for unmitigated YEAR 9 operations, discard backfilled

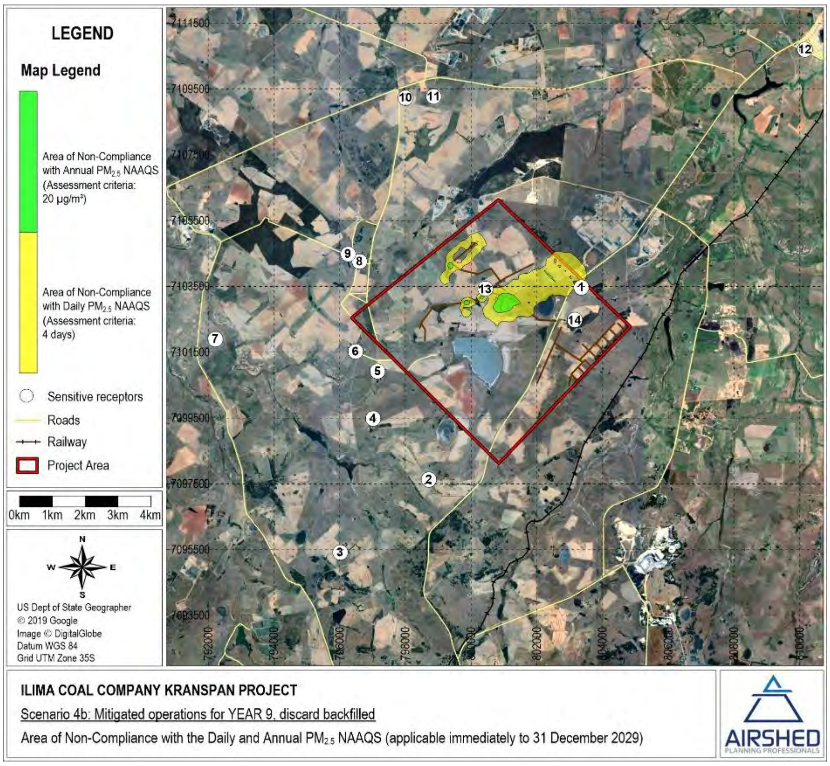

Figure 42: Scenario 4b – Area of non-compliance of daily and annual $PM_{2.5}$ current NAAQS for mitigated YEAR 9 operations, discard backfilled

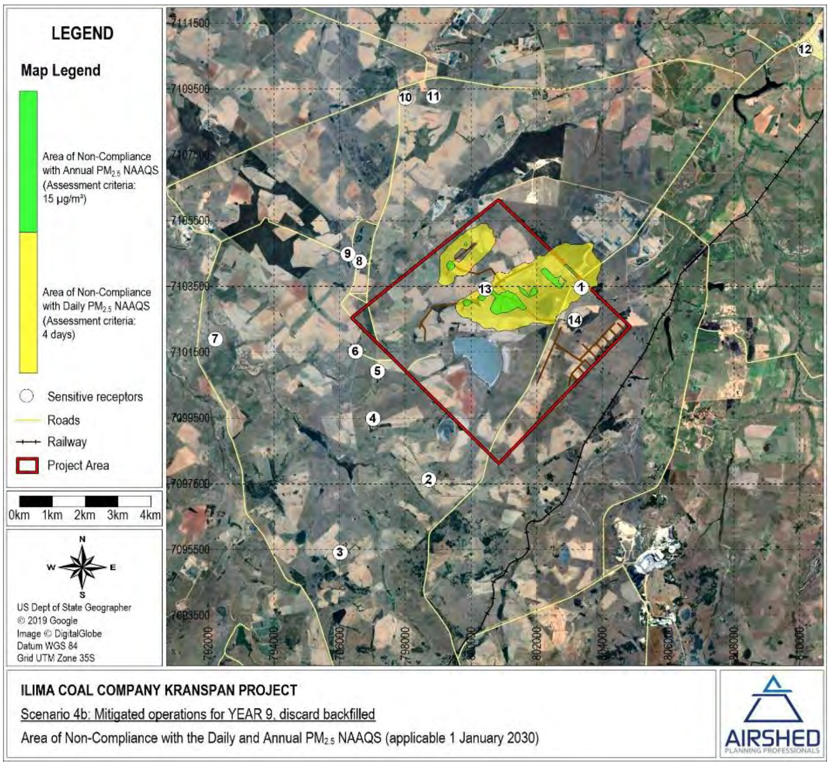

Figure 43: Scenario 4b – Area of non-compliance of daily and annual $PM_{2.5}$ future NAAQS for mitigated YEAR 9 operations, discard backfilled

Table 17: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) due to unmitigated and mitigated YEAR 9 operations, for the two discard disposal options (Scenario 3 and 4)

AQ SR	$PM_{2.5}$ GLCs (µg/m³) – Discard tipped to stockpile								$PM_{2.5}$ GLCs (µg/m³) – Discard backfilled							
	Scenario 3a[(a)]				Scenario 3b[(b)]				Scenario 4a[(c)]				Scenario 4b[(d)]			
	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]	Max Daily	Annual	No of Exceedances	Within Compliance (Yes/No) [(e)]
1	92.2	8.1	43	No	50.0	4.5	15	No	92.5	8.2	43	No	50.1	4.5	15	No
2	8.5	0.5	0	Yes	3.8	0.3	0	Yes	8.7	0.5	0	Yes	4.0	0.3	0	Yes
3	7.2	0.4	0	Yes	4.0	0.2	0	Yes	7.2	0.4	0	Yes	4.0	0.2	0	Yes
4	11.9	1.1	0	Yes	6.5	0.6	0	Yes	11.9	1.1	0	Yes	6.5	0.6	0	Yes
5	17.9	1.7	0	Yes	8.7	0.8	0	Yes	18.5	1.7	0	Yes	8.9	0.8	0	Yes
6	20.5	1.5	0	Yes	10.7	0.8	0	Yes	20.6	1.6	0	Yes	10.8	0.8	0	Yes
7	7.0	0.5	0	Yes	3.9	0.2	0	Yes	7.0	0.5	0	Yes	4.0	0.2	0	Yes
8	13.8	1.1	0	Yes	7.5	0.5	0	Yes	14.0	1.1	0	Yes	7.6	0.5	0	Yes
9	13.0	0.9	0	Yes	7.5	0.4	0	Yes	13.1	0.9	0	Yes	7.5	0.4	0	Yes
10	7.6	0.3	0	Yes	4.1	0.1	0	Yes	7.8	0.3	0	Yes	4.1	0.2	0	Yes
11	8.7	0.3	0	Yes	4.7	0.2	0	Yes	8.7	0.3	0	Yes	4.7	0.2	0	Yes
12	5.5	0.4	0	Yes	3.1	0.2	0	Yes	5.5	0.4	0	Yes	3.1	0.2	0	Yes
13	112.0	13.8	64	No	53.4	6.5	13	No	123.7	15.3	71	No	55.4	6.9	15	No
14	49.8	3.5	8	No	27.3	1.7	2	Yes	50.5	3.6	8	No	27.5	1.7	2	Yes

Notes:

(a) Scenario 3 (Year 9 operations, discard tipped to stockpile) – unmitigated scenario.

(b) Scenario 3 (Year 9 operations, discard tipped to stockpile) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

(c) Scenario 4 (Year 9 operations, discard backfilled) – unmitigated scenario.

(d) Scenario 4 (Year 9 operations, discard backfilled) – mitigated scenario. See Table 10 for estimated control factors for various mining operations.

(e) Compliance evaluation against 1 January 2030 NAAQS

4.3.3 Dust Fallout

The simulated maximum daily dustfall rates for Scenarios 1a and 1b, and Scenarios 2a and 2b (operational Year 5) are provided in Figure 44 to Figure 45 respectively, with the values at each of the AQSRs provided in Table 18. The simulated maximum daily dustfall rates for Scenarios 3a and 3b, and Scenarios 4a and 4b (operational Year 9) are provided in Figure 46 to Figure 47 respectively, with the values at each of the AQSRs provided in Table 19.

The main findings are:

- Scenario 1: YEAR 5 – discard tipped at discard stockpile. Maximum daily *dustfall rates*, for both unmitigated and design mitigated operations, are likely to be in compliance with the NDCR residential limit (600 mg/m²/day) (Figure 44 and Table 18). From Table 18 no exceedances are expected at any of the AQSRs.
- Scenario 2: YEAR 5 – discard backfilled. Maximum daily *dustfall rates* for unmitigated operations are likely to be in non-compliance with the NDCR residential limit at one AQSR, viz. AQSR #13 (Figure 45 and Table 18). For mitigated operations, simulated maximum daily dustfall rates are in compliance at all AQSRs (Table 18).
- Scenario 3: YEAR 9 – discard tipped at discard stockpile. Maximum daily *dustfall rates*, for both unmitigated and design mitigated operations, are likely to be in compliance with the NDCR residential limit (Figure 46 and Table 19). From Table 19 no exceedances are expected at any of the AQSRs.
- Scenario 4: YEAR 9 – discard backfilled. Maximum daily *dustfall rates* for unmitigated operations are likely to be in non-compliance with the NDCR residential limit at one AQSR, viz. AQSR #13 (Figure 47 and Table 19). For mitigated operations compliance with the NDCR residential limit are shown at all the AQSRs (Table 19).

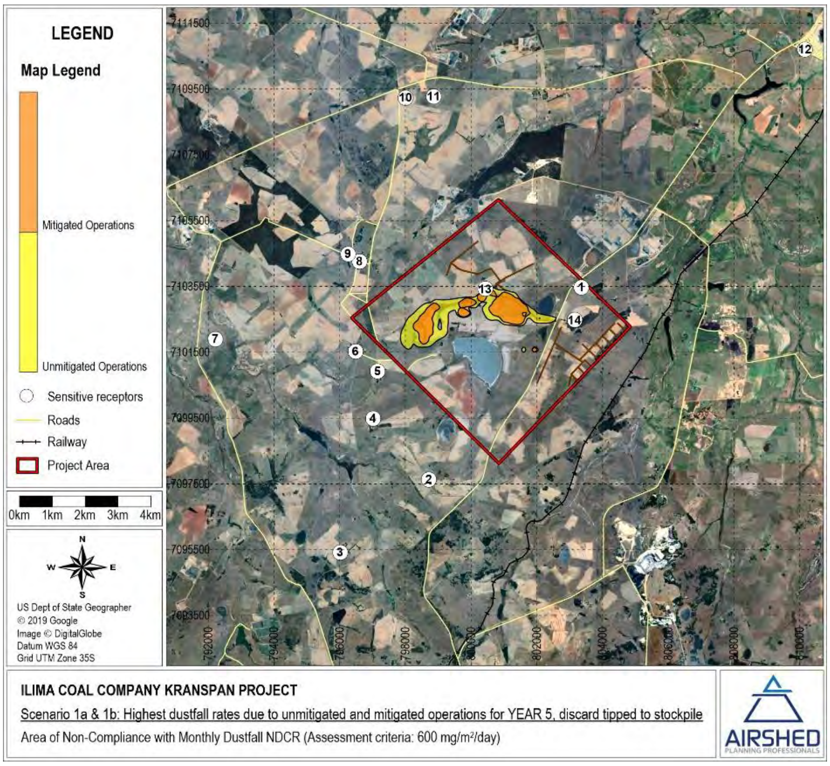

Figure 44: Scenario 1 – Simulated dustfall deposition rates due to unmitigated and mitigated operations for YEAR 5, discard tipped to stockpile

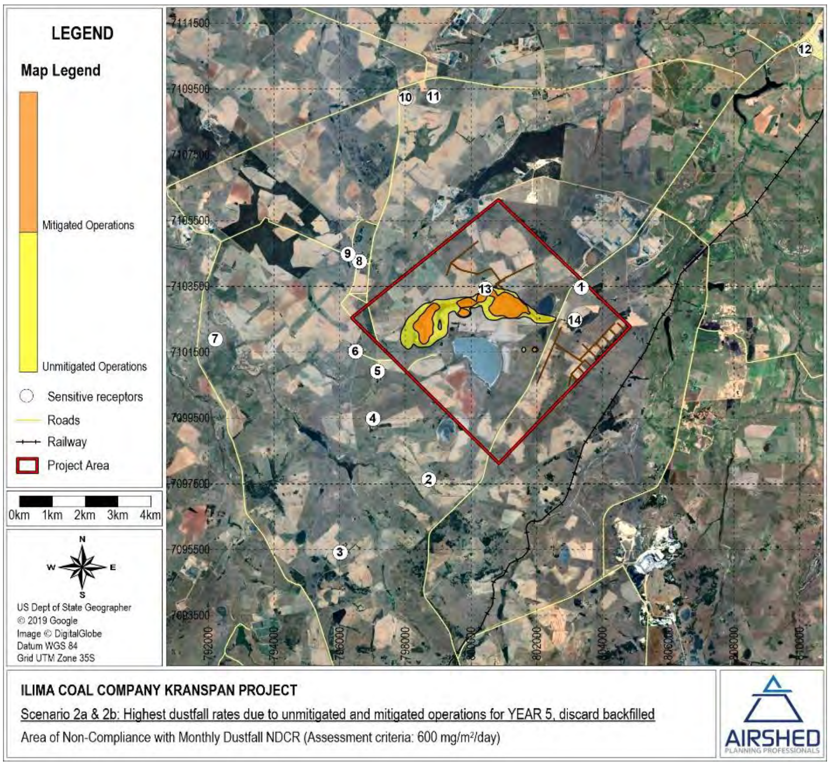

Figure 45: Scenario 2 – Simulated dustfall deposition rates due to unmitigated and mitigated operations for YEAR 5, discard backfilled

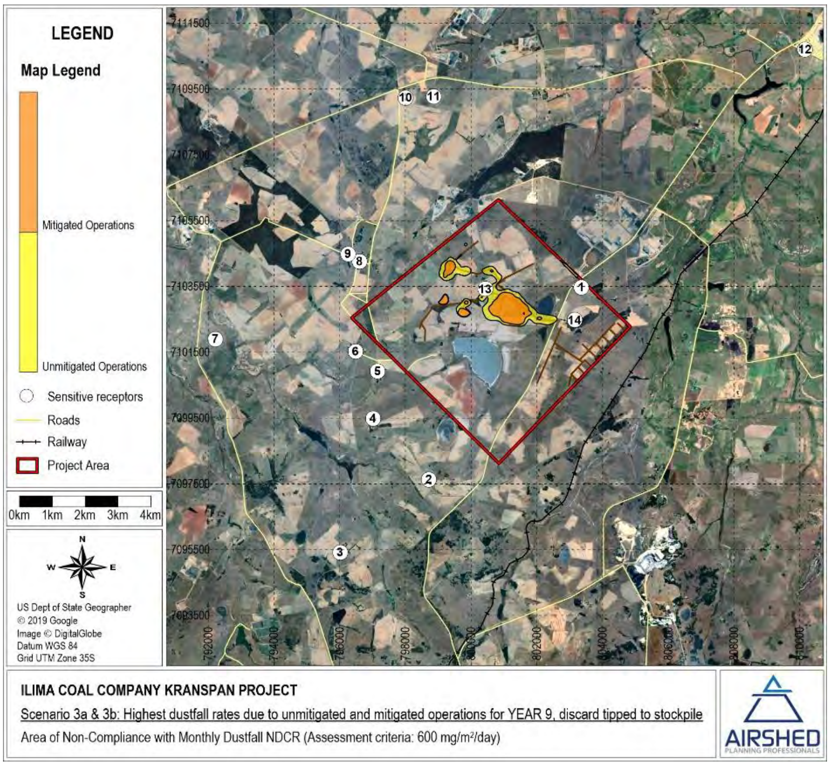

Figure 46: Scenario 3 – Simulated dustfall deposition rates due to unmitigated and mitigated operations for YEAR 9, discard tipped to stockpile

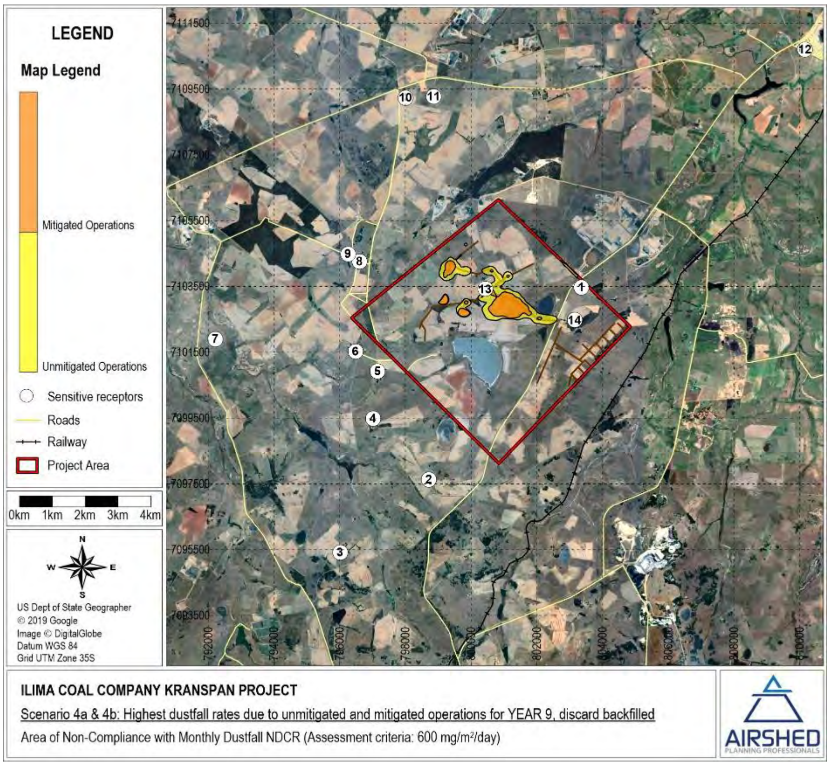

Figure 47: Scenario 4 – Simulated dustfall deposition rates due to unmitigated and mitigated operations for YEAR 9, discard backfilled

Table 18: Simulated AQSR total dustfall rates (in mg/m²/day) for Scenario 1a, Scenario 1b, Scenario 2a and Scenario 2b

AQSR	Scenario 1a- unmitigated	Scenario 1b- mitigated	Scenario 2a- unmitigated	Scenario 2b- mitigated
	Highest 30-day avg	Highest 30-day avg	Highest 30-day avg	Highest 30-day avg
1	29	12	29	11
2	10	4	10	4
3	7	3	7	3
4	33	14	33	13
5	115	43	116	43
6	88	31	89	32
7	12	4	12	4
8	34	12	34	12
9	28	10	28	10
10	3	1	3	1
11	3	1	3	1
12	2	1	2	1
13	520	194	613	217
14	65	29	65	28

Note: Screened against the residential dustfall limit of 600 mg/m²/day

Table 19: Simulated AQSR total dustfall rates (in mg/m²/day) for Scenario 3a, Scenario 3b, Scenario 4a and Scenario 4b

AQSR	Scenario 3a- unmitigated	Scenario 3b- mitigated	Scenario 4a- unmitigated	Scenario 4b- mitigated
	Highest 30-day avg	Highest 30-day avg	Highest 30-day avg	Highest 30-day avg
1	167	71	167	71
2	7	3	7	3
3	4	2	4	2
4	17	8	17	8
5	27	14	28	14
6	25	10	26	10
7	7	3	8	3
8	18	7	18	7
9	14	6	14	6
10	2	1	2	1
11	2	1	2	1
12	2	1	2	1
13	463	188	602	217
14	72	38	73	37

Note: Screened against the residential dustfall limit of 600 mg/m²/day

5 Impact Significance Rating

The significance of air quality impacts was assessed according to an impact significance rating methodology provided by ABS Africa. Refer to Appendix B of this report for the methodology.

5.1 Air Quality Impacts

The significance of air quality impacts due to operational[9] activities were found to be:

- Scenario 1 operations *Medium to high* (Table 20) for unmitigated activities and *Low to medium* for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low to medium for both unmitigated and mitigated activities.
- Scenario 2 operations *Medium to high* (Table 21) for unmitigated activities and *Low to medium* for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low to medium for both unmitigated and mitigated activities.
- Scenario 3 operations *Medium to high* (Table 22) for unmitigated activities and *Low to medium* for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low to medium for both unmitigated and mitigated activities.
- Scenario 4 operations *Medium to high* (Table 23) for unmitigated activities and *Low to medium* for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low to medium for both unmitigated and mitigated activities.

Table 20: Significance rating for air quality impacts due to proposed Project activities (Scenario 1)

Project Activity	Air Quality		Consequence			Likelihood		Significance
Scenario 1a								
Elevated PM_{10} and $PM_{2.5}$ [10] concentrations as a result of unmitigated activities	Phase of Project	Operational Phase	Duration[11]	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	4	3	4	5	90
Dustfall due to unmitigated activities	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	3	2	4	5	72
Scenario 1b								

[9] Impacts due to the construction and closure phases would be lower than those that were assessed for the operational phase, therefore this section is concentrated on impacts from the operational phase.
[10] Impact rating assessed based on $PM_{2.5}$ future limits.
[11] Scenario 1 (Year 5 operations, discard tipped to stockpile) is representative of opencast operations concentrated to the west and further away from the plant. The duration of impact is therefore estimated as one year to ten years.

Project Activity	Air Quality		Consequence			Likelihood		Significance
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of design-mitigated activities	Phase of Project	Operational Phase	Duration	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	3	3	4	4	72
Dustfall due to design-mitigated activities	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	2	2	4	4	56

Table 21: Significance rating for air quality impacts due to proposed Project activities (Scenario 2)

Project Activity	Air Quality		Consequence			Likelihood		Significance
Scenario 2a								
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of unmitigated activities	Phase of Project	Operational Phase	Duration[12]	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	4	3	4	5	90
Dustfall due to unmitigated activities	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	3	2	4	5	72
Scenario 2b								
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of design-mitigated activities	Phase of Project	Operational Phase	Duration	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	3	3	4	4	72
Dustfall due to design-mitigated activities	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	2	2	4	4	56

Table 22: Significance rating for air quality impacts due to proposed Project activities (Scenario 3)

Project Activity	Air Quality		Consequence			Likelihood		Significance
Scenario 3a								

[12] Scenario 2 (Year 5 operations, discard backfilled) is representative of opencast operations concentrated to the west and further away from the plant. The duration of impact is therefore estimated as one year to ten years.

Project Activity	Air Quality		Consequence			Likelihood		Significance
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of unmitigated activities	Phase of Project	Operational Phase	Duration[13]	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	4	3	4	5	90
Dustfall due to unmitigated activities	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	3	2	4	5	72
Scenario 3b								
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of design-mitigated activities	Phase of Project	Operational Phase	Duration	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	3	3	4	4	72
Dustfall due to design-mitigated activities	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	2	2	4	4	56

Table 23: Significance rating for air quality impacts due to proposed Project activities (Scenario 4)

Project Activity	Air Quality		Consequence			Likelihood		Significance
Scenario 4a								
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of unmitigated activities	Phase of Project	Operational Phase	Duration[14]	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating
	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	4	3	4	5	90
Dustfall due to unmitigated activities	Impact Classification	Direct Impact	Significance (Unmitigated)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	3	2	4	5	72
Scenario 4b								
Elevated PM_{10} and $PM_{2.5}$	Phase of Project	Operational Phase	Duration	Severity	Spatial Scope	Frequency of activity	Frequency of impact	Significance rating

[13] Scenario 3 (Year 9 operations, discard tipped to stockpile) is representative of opencast operations concentrated more to the east and closer to the plant. The duration of impact is therefore estimated as one year to ten years.
[14] Scenario 4 (Year 9 operations, discard backfilled) is representative of opencast operations concentrated more to the east and closer to the plant. The duration of impact is therefore estimated as one year to ten years.

Project Activity	Air Quality		Consequence			Likelihood		Significance
concentrations as a result of design-mitigated activities	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated PM_{10} and $PM_{2.5}$ Concentrations	3	3	3	4	4	72
Dustfall due to design-mitigated activities	Impact Classification	Direct Impact	Significance (Design Mitigation)					
	Resulting Impact from Activity	Elevated Dust Fall Levels	3	2	2	4	4	56

6 Air Quality Management Measures

In the light of the potential exceedances of the air quality limits around the mining operations, it is recommended that the project proponent commit to adequate air quality management planning throughout the life of the proposed project. The air quality management plan provides options on the control of dust particles at the main sources, while the monitoring network is designed to track the effectiveness of the mitigation measures.

Based on the findings of the impact assessment, the following mitigation, management and monitoring recommendations are proposed.

6.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations (specifically $PM_{2.5}$ and PM_{10}) and dustfall rates that are within the relevant ambient air quality standards and regulations outside the mining area and at the relevant AQSRs. In order to define site specific management objectives, the main sources of pollution need to be identified. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

6.1.1 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations (Section 4.1); and
- Impacts ranking; based on the simulated pollutant GLCs.

Ranking of sources based on emissions, are as follows:

- Scenario 1 – YEAR 5, discard tipped at discard stockpile: The main sources of emissions for $PM_{2.5}$ are in-pit operations (50%), whereas the main source of emissions for PM_{10} and TSP are vehicle entrained dust on unpaved haul roads (56% and 65%) respectively.
- Scenario 2 – YEAR 5, discard backfilled: The ranking of sources for Scenario 2 stays the same as for Scenario 1.
- Scenario 3 – YEAR 9, discard tipped at discard stockpile: The main sources of emissions for $PM_{2.5}$ and PM_{10} are in-pit operations (63% and 56% respectively), whereas the main source of emissions for TSP is vehicle entrained dust on unpaved haul roads (41%).
- Scenario 4 – YEAR 9, discard backfilled: The ranking of sources for Scenario 4 stays the same as for Scenario 3.

Ranking of sources based on impacts, are as follows:

- Construction: Likely activities to result in dust impacts during construction are:
    - metal and concrete works for the establishment of new plant and mine infrastructure;
    - scraping of topsoil and land clearing;
    - material loading and stockpiling; and
    - vehicle entrainment on unpaved road surfaces during construction.
- Scenario 1a: YEAR 5 – unmitigated, discard tipped at discard stockpile. The primary and secondary sources of impact at AQSRs during Scenario 1a (unmitigated activities) are: roads (ranging between 52% and 60%) and in-pit operations (ranging between 29% and 41%) for PM_{10}; in-pit operations (ranging between 37% and 58%) and roads (ranging between 28% and 37%) for $PM_{2.5}$; and roads (ranging between 46% and 63%) followed by in-pit operations (ranging between 16% and 31%) for daily dustfall rates.
- Scenario 1b: YEAR 5 – mitigated, discard tipped at discard stockpile. The primary and secondary sources of impact at AQSRs during Scenario 1b (design mitigated activities) are: in-pit operations (ranging between 40% and 56%) and roads (ranging between 36% and 44%) for PM_{10}; in-pit operations (ranging between 47% and 70%) and crushing (ranging between 6% and 26%) for $PM_{2.5}$; and roads (ranging between 27% and 46%) followed by in-pit operations (ranging between 20% and 39%) for daily dustfall rates.
- Scenario 2a: YEAR 5 – unmitigated, discard backfilled. The primary and secondary sources of impact at AQSRs during Scenario 2a (unmitigated activities) are: roads (ranging between 53% and 61%) and in-pit operations (ranging between 28% and 41%) for PM_{10}; in-pit operations (ranging between 37% and 58%) and roads (ranging between 29% and 37%) for $PM_{2.5}$; and roads (ranging between 48% and 63%) followed by in-pit operations (ranging between 15% and 30%) for daily dustfall rates.
- Scenario 2b: YEAR 5 – mitigated, discard backfilled. The primary and secondary sources of impact at AQSRs during Scenario 2b (design mitigated activities) are: in-pit operations (ranging between 48% and 78%) and roads (ranging between 37% and 45%) for PM_{10}; in-pit operations (ranging between 46% and 69%) and crushing (ranging between 6% and 26%) for $PM_{2.5}$; and roads (ranging between 29% and 46%) followed by in-pit operations (ranging between 21% and 39%) for daily dustfall rates.
- Scenario 3a: YEAR 9 – unmitigated, discard tipped at discard stockpile. The primary and secondary sources of impact at AQSRs during Scenario 1a (unmitigated activities) are: in-pit operations (ranging between 72% and 81%) and roads (ranging between 17% and 37%) for PM_{10}; in-pit operations (ranging between 48% and 79%) and crushing (ranging between 9% and 26%) for $PM_{2.5}$; and in-pit operations (ranging between 23% and 84%) followed by roads (ranging between 9% and 38%) for daily dustfall rates.
- Scenario 3b: YEAR 9 – mitigated, discard tipped at discard stockpile. The primary and secondary sources of impact at AQSRs during Scenario 1b (design mitigated activities) are: in-pit operations (ranging between 54% and 83%) and roads (ranging between 10% and 25%) for PM_{10}; in-pit operations (ranging between 52% and 83%) and crushing (ranging between 8% and 24%) for $PM_{2.5}$; and in-pit operations (ranging between 20% and 84%) followed by crushing (ranging between 6% and 37%) for daily dustfall rates.

- Scenario 4a: YEAR 9 – unmitigated, discard backfilled. The primary and secondary sources of impact at AQSRs during Scenario 2a (unmitigated activities) are: in-pit operations (ranging between 46% and 77%) and roads (ranging between 18% and 39%) for PM_{10}; in-pit operations (ranging between 48% and 79%) and crushing (ranging between 9% and 25%) for $PM_{2.5}$; and in-pit operations (ranging between 23% and 84%) followed by roads (ranging between 9% and 39%) for daily dustfall rates.
- Scenario 4b: YEAR 9 – mitigated, discard backfilled. The primary and secondary sources of impact at AQSRs during Scenario 2b (design mitigated activities) are: in-pit operations (ranging between 54% and 82%) and roads (ranging between 11% and 26%) for PM_{10}; in-pit operations (ranging between 52% and 83%) and crushing (ranging between 8% and 24%) for $PM_{2.5}$; and in-pit operations (ranging between 20% and 84%) followed by crushing (ranging between 6% and 37%) for daily dustfall rates.
- Closure and Post-closure: Likely activities to result in dust impacts during closure are:
    - infrastructure removal/demolition;
    - topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings; and
    - vehicle entrainment on unpaved road surfaces during rehabilitation – once that is done, vehicle activity associated with the operations should cease.

6.2 Proposed Mitigation and Management Measures

6.2.1 Proposed Mitigation Measures and/or Target Control Efficiencies

From the above discussion it is recommended that the project include the following measures:

- Construction and closure phases:
    - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on unpaved roads; and to apply water sprays on regularly travelled, unpaved sections.
    - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
    - The access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.
- Operational phase – the recommended mitigation measures for the proposed operations are shown in Table 24.

Table 24: Air Quality Management Plan – Operation Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Regular water sprays on unpaved roads to ensure at least 75% control efficiency. • Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces.	Environmental Manager	On-going during operational phase
Drilling & Blasting	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Controlled blasting techniques to be used to ensure minimal dust generation. • Blasting only to be conducted on cloudless days, if possible. • Addition of chemical surfactants to water sprays to lower water surface tension and increase binding properties. • Drilling to be controlled through water sprays or vacuum packs	Mine Production Engineer Drill Rig Operator Environmental Officer	On-going during operational phase
Materials Handling	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Increase in-pit material moisture content. • Drop height from excavator into haul trucks to be kept at a minimum for ore and waste rock. • Tipping onto ROM storage piles to be controlled through water sprays, should significant amounts of dust be generated. • Keep material handled by dozers and wheeled loaders moist to achieve a control efficiency of 50%, especially during dry periods. • Regular clean-up at loading areas.	Mine Production Engineer Environmental Officer	On-going during operational phase
Wind Erosion	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at ROM stockpile can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles. • Revegetation of overburden stockpile is recommended.	Mining Engineer Environmental Officer	On-going during operational phase
Crushing	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at the crushers to achieve at least 50% control efficiency.	Mining Engineer Environmental Officer	On-going during operational phase

6.3 Performance Indicators

Key performance indicators against which progress of implemented mitigation and management measures may be assessed, form the basis for all effective environmental management practices. In the definition of key performance indicators careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the source of the emission directly (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). Ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels, at the identified AQSRs, to below 600 mg/m^2-day represents an impact- or receptor-based performance indicator.

Except for vehicle/equipment emission testing, source monitoring at operational activities can be challenging due to the fugitive and wind-dependent nature of particulate emissions. The focus is therefore rather on receptor-based performance indicators i.e. compliance with ambient air quality standards and dustfall regulations.

6.3.1 Ambient Air Quality Monitoring

Ambient air quality monitoring can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal and spatial trend analysis;
- Source quantification; and,
- Tracking progress made by control measures.

To ensure that mitigation is effective, it is recommended that the newly installed dustfall monitoring network at the mine be expanded. It is recommended that continuous dustfall monitoring at one (1) additional location be conducted as part of the Project's air quality management plan (Figure 48). This should be undertaken throughout the Project duration to provide air quality trends. It is also recommended that PM_{10} and $PM_{2.5}$ monitors at the school and informal community be installed from year 3 onwards, to start an investigation into the impacts on these receptors well before nearby opencast mining occurs from Year 5 through Year 12. Should exceedances of the daily PM_{10} and/or $PM_{2.5}$ NAAQS occur, the relocation of the school and/or informal community must be considered.

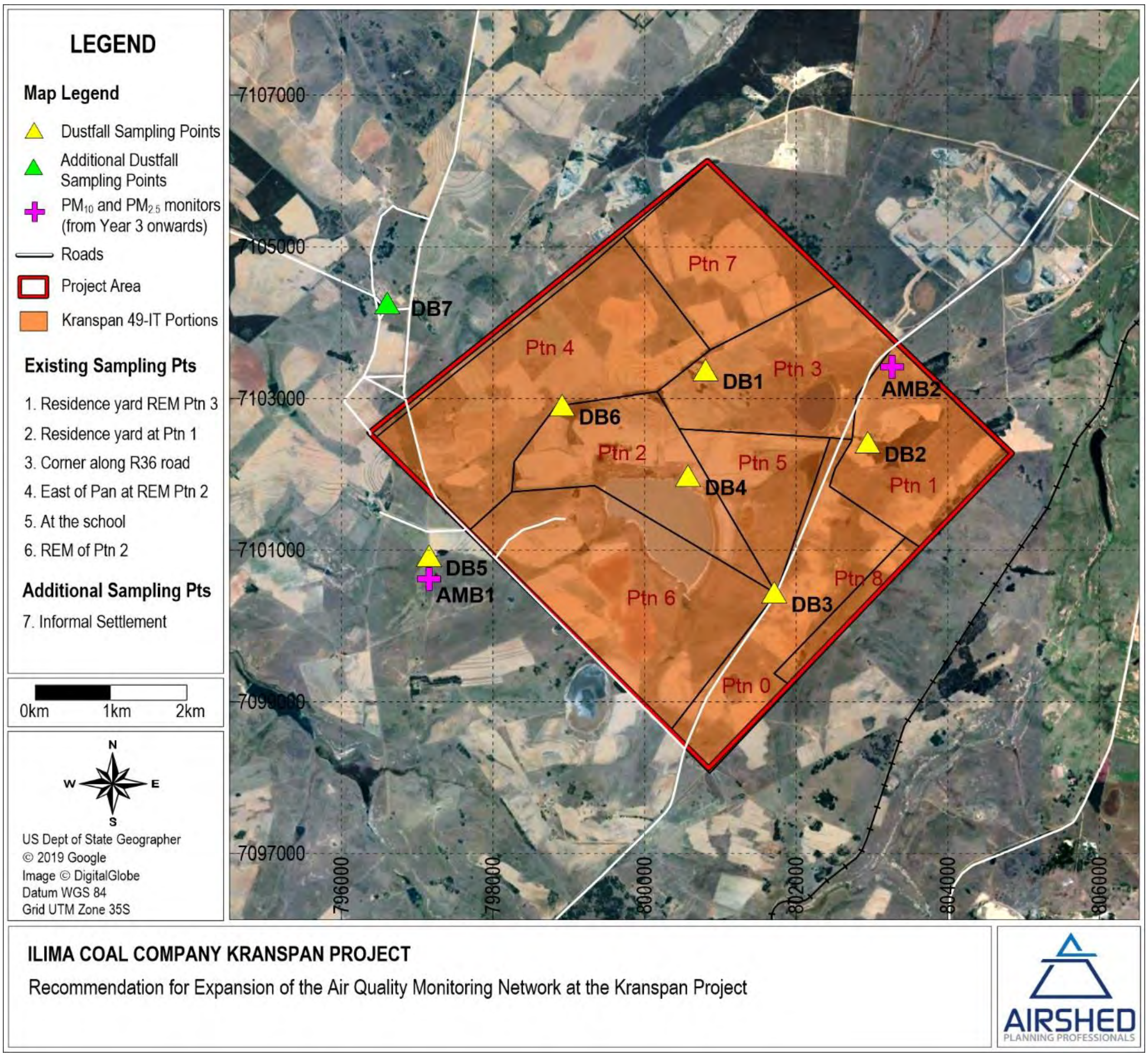

Figure 48: Recommended additions to the current air quality monitoring network at the Kranspan Project

6.4 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.5 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. Given the close proximity of the study site to the nearby farmsteads, it is recommended that such meetings be scheduled and held at least on an annual basis. A complaints register must be kept at all times.

6.6 Financial Provision

The budget should provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and I&APs liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures. The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

7 Greenhouse Gas Emission Statement

7.1 Introduction

7.1.1 The greenhouse effect

Greenhouse gases are "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle. Anthropogenic carbon dioxide (CO_2) emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

7.2 The Project's Operational Phase Carbon Footprint

7.2.1 GHG Emissions Estimation

7.2.1.1 Scope 1 Emissions due to Fuel Usage

The fuel usage per annum was calculated as 6 454 656 litres per annum from the Mine Working Plan, dated September 2018 (see Table 25). The Intergovernmental Panel on Climate Change (IPCC) provides default emission factors for diesoline in kg CO_2/unit energy content, while the density and calorific values are available from a number of standard engineering databases. Using the values in Table 26, the CO_2 emission factor can be calculated per litre of fuel used, which allows calculation of the total emissions directly from fuel records. The methane (CH_4) and nitrous oxide (N_2O) emission factors are given in Table 27.

Table 25: Equipment and activities impacting on opencast and underground fuel cost

Equipment	Quantity	Litres per hour	Total litres per hour
OPENCAST MINING			
D9 Dozer	64	2	128
D6 Dozer	22	2	44
Hydraulic 20t Excavator	36	1	36
Hydraulic 70t excavator	47	4	188
ADT 35t	18	16	288
Grader	16	2	32
Water bowser	18	2	36
Diesel Bowser	18	1	18
Percussion rig	15	2	30
Service truck	18	1	18
TLB	6	1	6
TOTAL LITRES PER HOUR (OPENCAST MINING)			824
UNDERGROUND MINING			
Multi-purpose vehicles	3.5	3	10.5
Load haul dumper	3.5	1	3.5
Stone duster	1.5	1	1.5
Grader	3	1	3
Man carriers	3	3	9
Light Delivery vehicle	3	3	9
Diesel maintenance vehicle	1.5	1	1.5
TOTAL LITRES PER HOUR (UNDERGROUND MINING)			38
LITRES PER ANNUM, ASSUMING 7488 HOURS OF OPERATION PER YEAR			6 454 656

Table 26: Calculation of liquid fuel-related CO_2 emission factors (for vehicles)

Type of fuel	CO_2 emission factor kg/TJ	Density kg/m^3	Calorific value kJ/kg	Emission factor kg CO_2/litre fuel
Diesoline	74100	840	43 400	2.701

Table 27: Vehicles - liquid fuel-related methane and nitrous oxide emission factors (EPA, 2018)

Type of fuel	Density kg/m^3	Emission factor g CH_4/gallon	Emission factor g N_2O/gallon
Diesoline	840	0.57	0.26

7.2.1.2 Fugitive Methane Emissions due to Underground Mining

The liberation of CH_4 during the coal mining at Kranspan Colliery for both opencast and underground operations is calculated in Table 28. The basis for the emission rates is given in Table 29.

Table 28: Fugitive Emissions due to Opencast and Underground Kranspan Operations

Emission Source	Description	Quantity	Units	Emission Factor	Emission Rate (tCH_4)	Emission Rate (tCO_2eq)
Coal mining	CH_4 liberated from the opencast mining of coal (determined per ton coal mined)	1 286 318	tonne/a	1.2 m^3 CH_4/tonne coal mined (804 g CH_4/tonne coal mined)	1034.2	25 855
	CH_4 liberated from the underground mining of coal (determined per ton coal mined)	970 522	tonne/a	0.77 m^3 CH_4/tonne coal mined (515.9 g CH_4/tonne coal mined)	500.7	12 517
Total					1 535	38 372

Table 29: Basis for Emission Rates

Emission Source	Description	Basis for Emissions Rate
Coal mining	CH_4 liberated from the opencast mining of coal (determined per ton coal mined)	IPCC 2006 guidelines – average tier 1 value (IPCC, 2006) A GWP of 23 was used for methane (Department of Environmental Affairs, 2013) A density for CH_4 of 670 g/m^3 was assumed (IPCC, 2006)
	CH_4 liberated from the underground mining of coal (determined per ton coal mined)	IPCC approved factor for SA – average tier 2 value (Department of Environmental Affairs, 2013)

7.2.1.3 Scope 2 Emissions

These emissions are related to purchased energy, heat or steam, and can be calculated from the average South African emission factor published annually by Eskom in its annual report (more recently its integrated sustainability report). The numbers for the last four years are given in Table 30. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The estimated project's electricity usage per month during the operational phase is 5 110 MWh (assuming 8760 hours of operation) (electricity usage obtained from the Mine Working Plan).

Table 30: Eskom electricity emission factors

Year	Emission Factor kg CO_2/kWh	Source
2007/2008	1.00	Eskom 2009 Annual Report
2008/2009	1.03	Eskom 2009 Annual Report
2009/2010	1.03	Eskom 2010 Integrated Report
2010/2011	0.99	Eskom 2011 Integrated Report

7.2.1.4 Summary

A summary of the greenhouse gas emissions due to the operational phase is provided in Table 31. For CH_4 and N_2O, the CO_2 equivalents were used, given as 25 times for CH_4 and 298 times for N_2O (http://www.climatechangeconnection.org/emissions/CO2_equivalents.htm).

Table 31: Summary of estimated greenhouse gas emissions for the proposed mining operations (cumulative scenario)

Source group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e
	t/a	t/a	t/a	t/a
Vehicle exhaust (scope 1)	17 434	24	132	17 590
Opencast coal mining (scope 1)	–	25 855	–	25 855
Underground coal mining (scope 1)	–	12 517	–	12 517
Electricity (scope 2)	62 087	124	241	62 452
Total (scope 1)	17 434	38 396	132	55 962
Total (scope 1 and scope 2)	79 521	38 520	373	118 414

The total CO_2 (equivalent) emissions of approximately 118 414 tpa for the operational phase, should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 544.31 million metric tonnes CO_2-e.

The calculated CO_2-e emissions due to the proposed Kranspan operations contribute 0.02% to the total of South Africa's GHG emissions, and 0.29% to the total "manufacturing industry and construction" sector. As indicated in Section 2.5.3, GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution of the future operational period is below 100 000 tons (Table 31). Based on this, a Pollution Prevention Plan is not required for the proposed Project.

7.2.2 The Project's GHG Impact

7.2.2.1 Magnitude

The GHG emissions due to the Project's mining operations are low and will not likely result in a noteworthy contribution to climate change on its own.

7.2.2.2 Impact on the sector

The GHG emissions from mining operations form 0.29% of the "manufacturing industry and construction" sector's total annual CO_2-e emissions and will therefore not make a significant contribution towards the sector's GHG impact.

7.2.2.3 Impact on the National Inventory

The GHG emissions from the proposed mining operations form 0.02% of the national inventory's total annual CO_2-e emissions, which is very low.

7.2.2.4 Alignment with national policy

As from the next NAEIS reporting period (January 2020 to December 2020), Kranspan will have to start reporting on Scope 1 GHG emissions.

7.3 Potential Effect of Climate Change on the Project

The most significant of the discussed climate change impacts on the project would be as a result of:

- Temperature increase[15],
- Possible reduction in rainfall[16].

With the increase in temperature there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both of these have the potential to negatively affect staff performance and productivity. There is also the increased risk of overheating of equipment/machinery with effects on production, and a possible increase in demand for energy to satisfy an increased cooling need (in buildings). The potential exists for higher evaporation rates and thus the need for increased watering of the roads. Higher temperatures also increase the risk of veld fires and spontaneous combustion of coal stockpiles.

[15] Under a no intervention scenario, temperatures are projected to rise over the Project region, by 2.5°C to 3°C over the South African interior in the near-future and even higher in the far-future.

[16] The region is projected to become systematically drier, with considerably more dry years than wet years. The drastically higher temperatures may have a negative impact on water availability from local dams due to enhanced evaporation.

A decrease in rainfall may result in severe water shortages, which may interrupt mining activities and increase working costs, thereby potentially making the project unprofitable. Lower rainfall will also have a negative impact on food security, possibly resulting in food shortages which may negatively affect staff performance.

7.4 Potential Effect of Climate Change on the Community

Of the discussed climate change impacts, all would likely have an effect on the surrounding communities, similar to the ones discussed in Section 7.3.

7.5 Adaptation and Management Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

7.5.1 Project adaptation and mitigation measures

7.5.1.1 General

Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible.

7.5.1.1.1 Scope 1 (technology/sector-specific)

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use, this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation and to ensure that as much as possible revegetation occurs and possibly even the addition of vegetation surrounding the project area. Technologies for capturing coal mine methane (CMM) emissions are discussed on the website https://www.epa.gov/cmop/mitigating-cmm-emissions.

7.6 Conclusions and recommendations

- Calculation of the Scope 1 GHG emissions from the proposed operations is at this stage an uncomplicated procedure involving (i) the use of liquid fuel consumption figures from estimated amounts based on fleet and power supply requirements; and (ii) the use of estimated opencast and underground coal mining throughputs, and multiplying by simple emission factors as given in tables above. The total CO_2-e emissions for Kranspan mining operations is not likely to be more than 118 414 tpa. The calculated CO_2-e emissions from the proposed mining operations contribute less than 0.02% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.29% to the national inventory's "manufacturing industry and construction" sector GHG emissions.

- GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution due to the proposed mining operations is below 100 000 tons. Based on this, a Pollution Prevention Plan is not required for the proposed Project.
- The GHG emissions from the proposed Kranspan Project are not likely to result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less than the community due to the short time operations are planned to occur for.
- The following is recommended to reduce the impacts of climate change on the project:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
- The following is recommended to reduce the GHG emissions from the project:
    - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

8 Conclusions and Recommendations

8.1 Main Findings

The proposed Kranspan Project is located approximately 13 km south-west of the town of Carolina in Albert Luthuli Local Municipality, Mpumalanga Province. Ilima Coal Company is the holder of a Prospecting Right for the project area and is now applying for a Mining Right for the planned surface and underground mining operations. The proposed mine will include associated infrastructure (haul roads, discard stockpile, other stockpiles, etc.) and a beneficiation plant. A quantitative air quality impact assessment was conducted for the proposed operational phase activities for the Project. Construction, closure and post-closure activities were assessed qualitatively. The assessment included an estimation of atmospheric emissions, the simulation of pollutant levels and determination of the significance of impacts.

8.1.1 Baseline Assessment

The findings from the baseline assessment can be summarised as follows:

- The prevailing wind field in the area consists of west-north-westerly and north-easterly winds, with infrequent winds from the north and south. During the day, winds occurred more frequently from the north-westerly sector, with 4.75% calm conditions. Night-time airflow showed increased wind speeds which occurred most frequently from the north-easterly sector. Wind speeds higher than 6 m/s occurred approximately 16% of the time.
- The climate of the area may be described as warm and temperate with an average annual rainfall of 613 mm.
- The Project is located outside the Highveld Priority Area.
- Power generation, mining activities, farming and residential land-uses occur in the region. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources.
- AQSRs around the project site include two schools, Silobela residential area, informal settlements, and surrounding farmsteads.
- Dust fallout data for one month was made available to the study. The dust fallout network was established to determine baseline dust fallout levels. Both off-site and on-site values were very low and did not exceed the residential or non-residential limits of 600 mg/m^2/day and 1200 mg/m^2/day respectively.
- Monitoring data from the DEA Hendrina site (approximately 24 km west of the project site) for a 1-year period of 1 February 2018 to 31 January 2019 was analysed. The daily 99th percentiles for PM_{10} exceeded the limit value (75 µg/m^3) at Hendrina station, with non-compliance occurring 6% of the time. The daily 99th percentiles for $PM_{2.5}$ exceeded the limit value (40 µg/m^3) for 3% of the time.
- Time variation plots (mean with 95% confidence interval) of ambient particulate matter (PM_{10} and $PM_{2.5}$) concentrations measured at Hendrina station were created to show the variation of these pollutants over

a daily, weekly and annual cycle. Monthly variation of particulate matter shows elevated concentrations during winter months due to the larger contribution from domestic fuel burning, dust from uncovered soil and the lack of the settling influence of rainfall.

8.1.2 Impact Assessment

The impacts as a result of operations during Year 5 (Scenario 1 and 2) and Year 9 (Scenario 3 and 4) were assessed, with Year 5 opencast areas located to the west and further away from the plant, and Year 9 opencast areas concentrated more to the east and closer to the plant. The impact of the proposed Project can be summarized as follows:

Construction phase:

- Likely activities to result in dust impacts during construction are: Topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, as well as metal and concrete works for the establishment of infrastructure.
- Construction: the impacts are expected to be Low to Medium.

Operational phase (Scenario 1):

- The primary and secondary sources of impact at AQSRs during Scenario 1a (unmitigated activities) are: for PM_{10}, roads followed by in-pit operations; in-pit operations and roads are the main sources for $PM_{2.5}$; and roads is the main source followed by in-pit operations for daily dustfall rates.
- The primary and secondary sources of impact at AQSRs during Scenario 1b (design mitigated activities) are: for PM_{10}, in-pit operations followed by roads; for $PM_{2.5}$, in-pit operations followed by crushing; and for daily dustfall rates, roads followed by in-pit operations.
- Simulated PM_{10} daily GLCs for Scenario 1, with no mitigation in place, are likely to be in non-compliance with the NAAQS for distances of between 1.8 km and 4 km from the project site border. Eight (8) exceedances of the daily PM_{10} NAAQS are expected at AQSR #1, 4 to 6, 8 to 9 and 13 to 14. With mitigation in place, exceedances of the PM_{10} daily NAAQS is largely confined to the site and exceedance of the daily PM_{10} NAAQS is expected at two (2) AQSRs, viz. #5 (nearby school) and #13 (on-site farmstead). Over an annual average the GLCs for unmitigated operations exceed the standard at AQSR#13, but for mitigated operations the GLCs are low and well within the standard.
- Simulated $PM_{2.5}$ daily GLCs for Scenario 1, with no mitigation in place, are likely to be in non-compliance with the NAAQS for distances up to 650 m and 1.4 km from the south-western border, for current and future NAAQS's respectively. Exceedances of the future $PM_{2.5}$ NAAQS are expected at five (5) AQSRs, viz. #1, 5, 6, 13 and 14. With mitigation in place, exceedances of the future $PM_{2.5}$ daily NAAQS is largely confined to the site and exceedances are expected at two (2) AQSRs, viz. #5 and 13. Over an annual average the GLCs for unmitigated activities are within the future $PM_{2.5}$ NAAQS at all receptors except AQSR#13; for mitigated activities the annual GLCs are low and well within the future standard.

- Simulated maximum daily dustfall rates for Scenario 1, for both unmitigated and design mitigated operations, are likely to be in compliance with the NDCR residential limit (600 mg/m²/day). No exceedances are expected at any of the AQSRs.
- The impact significance for Scenario 1 operations is *Medium to high* for unmitigated activities and *Low to medium* for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low to medium for both unmitigated and mitigated activities.

Operational phase (Scenario 2):

- The main contributing sources to ground level impacts due to Scenario 2a and 2b emissions remain the same as those listed for Scenario 1a and 1b.
- Simulated PM_{10} daily GLCs for Scenario 2, with no mitigation in place, are likely to be in non-compliance with the NAAQS for distances of between 2 km and 4.1 km from the project site border. The number of AQSRs where exceedances of the daily and annual PM_{10} NAAQS due to unmitigated and mitigated activities were simulated is expected to stay the same as for Scenario 1a and 1b.
- Simulated $PM_{2.5}$ daily GLCs for Scenario 2, show similar impacting areas as for Scenario 1a and 1b. The number of AQSRs where exceedances of the daily and annual $PM_{2.5}$ NAAQS due to unmitigated and mitigated activities were simulated is expected to stay the same as for Scenario 1a and 1b.
- Simulated maximum daily dustfall rates for Scenario 2, for unmitigated operations, are likely to be in non-compliance with the NDCR residential limit (600 mg/m²/day) at one AQSR viz. AQSR#13. No exceedances are expected at any of the AQSRs for mitigated operations.
- The impact significance for Scenario 2 operations remains the same as for Scenario 1.

Operational phase (Scenario 3):

- The primary and secondary sources of impact at AQSRs during Scenario 3a (unmitigated activities) are: in-pit operations followed by roads for PM_{10}; in-pit operations and crushing are the main sources for $PM_{2.5}$; and in-pit operations followed by roads for daily dustfall rates.
- The primary and secondary sources of impact at AQSRs during Scenario 3b (design mitigated activities) are: in-pit operations followed by roads for PM_{10},; in-pit operations followed by crushing for $PM_{2.5}$; and in-pit operations followed by crushing for daily dustfall rates.
- Simulated PM_{10} daily GLCs for Scenario 3, with no mitigation in place, are likely to be in non-compliance with the NAAQS for distances of between 950 m and 3.5 km from the project site border. Exceedances of the daily PM_{10} NAAQS are expected at three (3) AQSRs, viz. #1 (on-site informal housing), and #13 and 14 (farmsteads), whereas exceedances of the annual PM_{10} NAAQS are expected at two (2) AQSRs, viz. #1 and 13. With mitigation in place, exceedances of the PM_{10} daily NAAQS extend for a distance of up to 1.2 km from the project site border and daily exceedances are still expected at AQSR #1 and 13. Over an annual average the mitigated GLCs are within the standard.

- Simulated $PM_{2.5}$ daily GLCs for Scenario 3, with no mitigation in place, are likely to be in non-compliance with the current and future NAAQS for distances up to 1.2 km and 2.2 km from the site border respectively. Exceedances of the future daily $PM_{2.5}$ NAAQS's are expected at three (3) AQSRs, viz. #1, 13 and 14. With mitigation in place, exceedances of the $PM_{2.5}$ future daily NAAQS extend for a distance of up to 1 km from the site border and exceedances are still expected at AQSR #1 and #13. Over an annual average the GLCs are within the standard for both unmitigated and mitigated activities.
- Simulated maximum daily dustfall rates for Scenario 3, for both unmitigated and design mitigated operations, are likely to be in compliance with the NDCR residential limit (600 mg/m²/day). No exceedances are expected at any of the AQSRs.
- The impact significance for Scenario 3 operations remains the same as for Scenarios 1 and 2.

<u>Operational phase (Scenario 4):</u>

- The main contributing sources to ground level impacts due to Scenario 4a and 4b emissions remain the same as those listed for Scenario 3a and 3b.
- Simulated PM_{10} daily GLCs for Scenario 4, with no mitigation in place, show similar impacting areas as for Scenario 3a. The number of AQSRs where exceedances of the daily and annual PM_{10} NAAQS due to unmitigated and mitigated activities were simulated is expected to stay the same as for Scenario 3a and 3b.
- Simulated $PM_{2.5}$ daily GLCs for Scenario 2, show similar impacting areas as for Scenario 3a and 3b. The number of AQSRs where exceedances of the daily and annual $PM_{2.5}$ NAAQS due to unmitigated and mitigated activities were simulated is expected to stay the same as for Scenario 3a and 3b.
- Simulated maximum daily dustfall rates for Scenario 4, for unmitigated operations, are likely to be in non-compliance with the NDCR residential limit (600 mg/m²/day) at one AQSR viz. AQSR#13. No exceedances are expected at any of the AQSRs for mitigated operations.
- The impact significance for Scenario 4 operations remains the same as for Scenarios 1, 2 and 3.

<u>Closure and post-closure phases:</u>

- Likely activities to result in dust impacts during closure are: Infrastructure removal/demolition; topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings; and vehicle entrainment on unpaved road surfaces during rehabilitation – once that is done, vehicle activity associated with the operations should cease.
- Closure and Post-closure: the impacts are expected to be Low to Medium.

8.2 Conclusions

The impacts due to the proposed Project were assessed with respect to location of the opencast areas relative to the closest receptors. Two options were assessed for the disposal of discard from the beneficiation plant, namely disposal via discard stockpile or via backfilling.

No significant differences were found with respect to the options for discard disposal. However, the proposed Project operations are projected to result in exceedances at the closest receptors (AQSRs #1, #5, #13 and #14, viz. informal housing located on-site, a nearby school and two farmsteads located within the project site boundary) even with design mitigation measures in place (water suppression on roads, dust suppression fitted on drill rigs, roofing and one side covering of the overland conveyor, and water sprays at materials handling points and crushers).

It is recommended that the two on-site farmsteads not be used for residential purposes at the time of commencement of Kranspan mining operations. It is also recommended that continuous PM_{10} and $PM_{2.5}$ monitoring be conducted at the school and informal community from Year 3 onwards, to start an investigation into the impacts on these receptors well before nearby opencast mining occurs from Year 5 through Year 12. Should exceedances of the daily PM_{10} and/or $PM_{2.5}$ NAAQS occur, the relocation of the school and/or informal community must be considered.

The proposed Project operations should not result in significant ground level concentrations or dustfall levels at the nearby receptors provided the design mitigation measures are applied effectively. From an air quality perspective, the proposed project can be authorised permitted the recommended mitigation and monitoring measures are applied.[17]

8.3 Recommendations

A summary of the recommendations and management measures is given below:

- Construction and closure phases:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on untreated roads; and to apply water sprays on regularly travelled, unpaved sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
  - The access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.

[17] A new site layout was introduced after the completion of the current study. The new position of the plant and co-disposal stockpile is now closer to the on-site farmstead located in the centre of the mining property, but further away from the other on-site receptors, viz. a second on-site farmstead and informal community respectively. As the farmstead closest to the mining activities has now been bought by the mine, the change in position of the plant is not expected to result in higher air quality impacts than what was simulated in the impact assessment and the conclusions and recommendations are still valid.

- Operational phases:
  - In controlling dust due to drilling operations, dust suppression must be fitted on drill rigs to achieve an emission reduction efficiency of 97%.
  - For the control of vehicle entrained dust it is recommended that water (at an application rate >2 litre/m^2/hour), be applied. Literature reports an emissions reduction efficiency of 75%.
  - In controlling dust from crushing and screening operations, it is recommended that water sprays be applied to keep the ore wet, to achieve a control efficiency of up to 50%.
  - Mitigation of materials transfer points should be done using water sprays at the tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended.
  - In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist. A mitigation efficiency of 50 % is anticipated.
  - In minimizing windblown dust from the overland conveyor, roofing and covering of one side of the conveyor should be installed to achieve a mitigation efficiency of 50 %.
- Given the high impacts that are expected at the on-site informal community, nearby school and two on-site farmsteads it is recommended that the two farmsteads not be used for residential purposes at the time that opencast mining commences and that continuous PM_{10} and $PM_{2.5}$ monitoring be conducted at the school and informal community starting two years before opencast mining occurs near the two receptors. This will give time to track the impacts as opencast activities occur closer to these two receptors and to decide on additional mitigation measures or whether to relocate either or both of these receptors should exceedances of the NAAQS occur.
- Continuous monitoring of dustfall must be conducted as part of the Project's air quality management plan.

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Appendix A – Specialist Curriculum Vitae

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	10

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

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CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

Appendix B – Significance Rating Methodology

Impact Significance Rating Methodology

The significance of the identified impact is assessed by rating each variable numerically, according to defined criteria as provided in Table B-1. The purpose of the significance rating of the identified impacts is to develop a clear understanding of the influences and processes associated with each impact.

The severity, spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact and can obtain a maximum value of 10.

The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table B-1 and Table B-2.

The model outcome of the impacts is then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. Arguments for each specific impact assessment are presented in the text and encapsulated in the assessment summary table linked to each impact discussion.

Table B1: Criteria for assessing the significance of impacts

SEVERITY OF IMPACT	RATING
Insignificant/ non-harmful	1
Small/ potentially harmful	2
Significant/ slightly harmful	3
Great/ harmful	4
Disastrous/ extremely harmful	5
SPATIAL SCOPE OF IMPACT	RATING
Activity specific	1
Area specific	2
Whole project site/ local area	3
Regional	4
National/ International	5
DURATION OF IMPACT	RATING
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure/ permanent	5

FREQUENCY OF ACTIVITY/ DURATION OF ASPECT	RATING
Annually or less/ low	1
6 monthly/ temporary	2
Monthly/ infrequent	3
Weekly/ life of operation/ regularly/ likely	4
Daily/ permanent/ high	5
FREQUENCY OF IMPACT	RATING
Almost never/ almost impossible	1
Very seldom/ highly unlikely	2
Infrequent/ unlikely/ seldom	3
Often/ regularly/ likely/ possible	4
Daily/ highly likely/ definitely	5

Table B2: Significance ratings matrix

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table B3: Positive/negative mitigation ratings

Colour code	Significance Rating	Value	Negative impact management recommendation	Positive impact management recommendation
	Very high	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium to high	76-100	Improve current management	Maintain current management
	Low to medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very low	1-25	Maintain current management	Improve current management

Appendix C: Effects of Climate Change on the Region

Climate Change Reference Atlas

In 2017 the SAWS published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections. It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for two 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase).

RCP4.5 trajectory

Based on the median and the region in which the Kranspan Project and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1°C and 2.5°C for the near future and between 2.5°C and 3°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and between 0 mm and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase in summer, remain the same or slightly increase for autumn. Winter total rainfall is expected to decrease and spring to stay the same or decrease slightly for near future. The total seasonal rainfall is expected to remain the same or slightly decrease for summer, winter and spring for the far future. Autumn total rainfall is expected to increase for the far future.

RCP8.5 trajectory

Based on the median, the region in which the Kranspan Project and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.5°C and 3°C for the near future and between 4.5°C and 5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and far future. For the near future the total seasonal rainfall is expected to increase for summer and remain the same or slightly increase for autumn and spring. Winter total rainfall is expected to decrease for the near future. The total seasonal rainfall is expected to decrease for autumn and winter for the far future. Spring and summer total rainfall is expected to increase for the far future.

Appendix D: Previous Kranspan Layout as Proposed on 20 November 2018

The site layout on which the dispersion modelling was based is shown below in Figure 49.

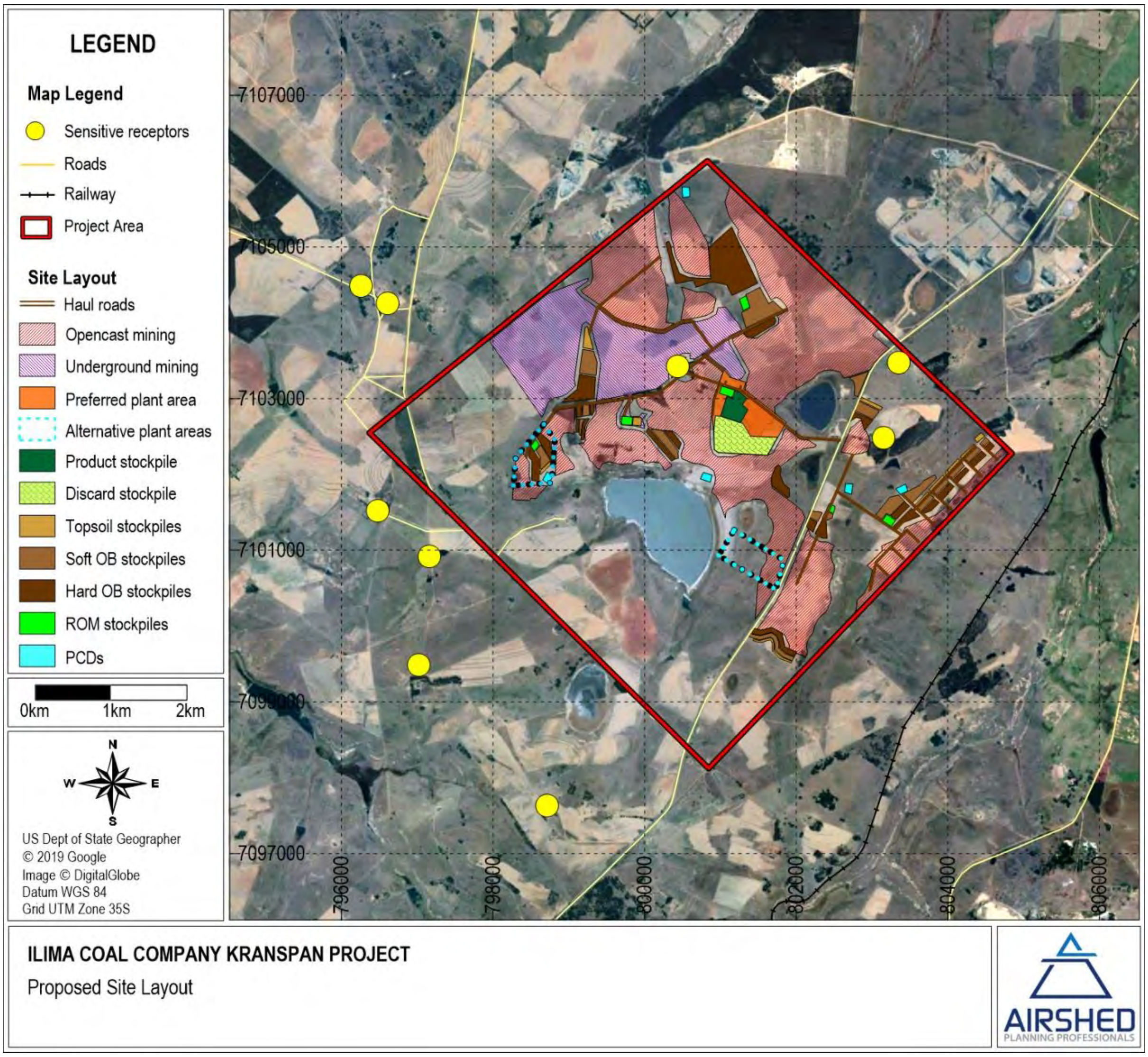

Figure 49: Previous site layout

Key differences to the layout which has most recently been proposed on 20 May 2019 (Figure 50) are:

The position of the plant area and co-disposal discard stockpile has changed from the centre of the mine area to position A indicated in Figure 50. New overburden facilities will be established at positions B and C (no-coal zones). The new plant layout is shown in Figure 51. The new position of the plant is closer to sensitive receptor 13 (see Figure 4) but further away from receptors 1 and 14. The air quality impacts from plant activities and windblown dust are therefore likely to be higher at receptor 13 (farmstead) but will not be higher at receptors 1 and 14 than what was simulated in Section 4. However, since the mine has recently acquired the property at receptor 13, the conclusions that were reached based on air quality dispersion modelling will not change.

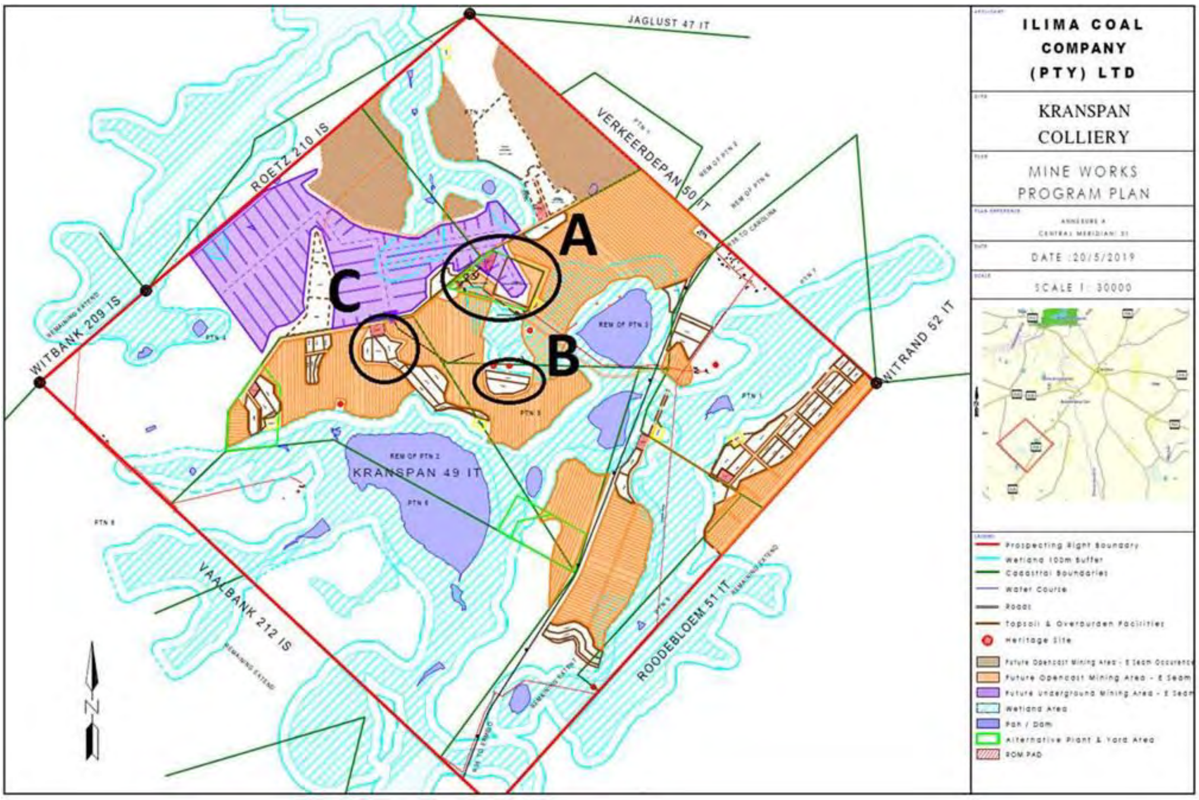

Figure 50: New site layout

- *A – New Plant / Offices / Surface option Co-Disposal position.*
- *B – New Overburden Facilities, on a no-coal zone where the old surface Co-disposal was planned.*
- *C – New Overburden Facilities: No underground mining will take place in these areas.*
    - *B & C - Due to limited overburden facility space, these areas had to be included.*

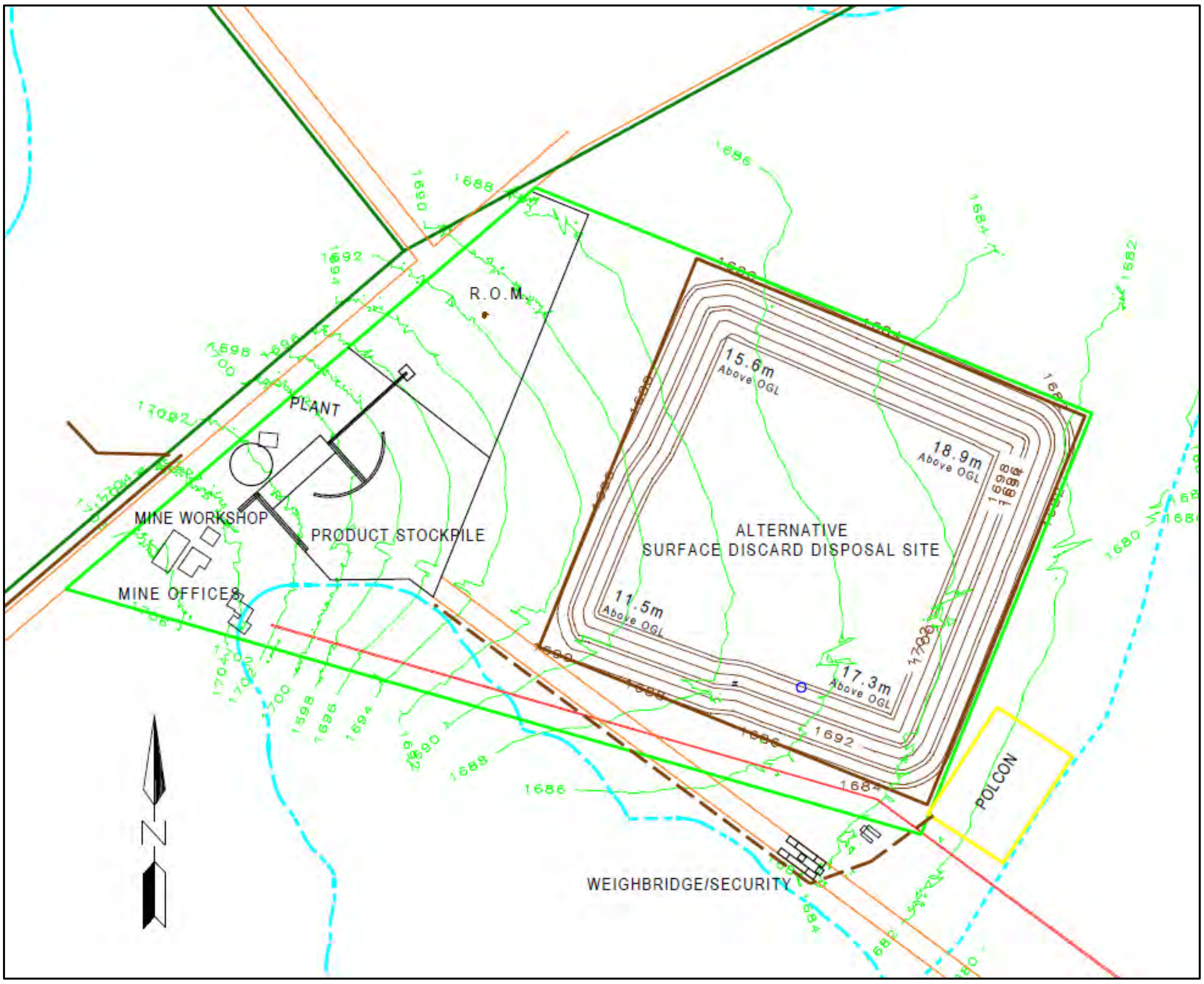

Figure 51: New plant layout

Terrestrial Ecology Report

Ilima Coal Company Kranspan Project

Carolina, Mpumalanga Province

May 2019

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Declaration of Independence

We declare that we have been appointed as independent consulting ecologists with no affiliation with or vested financial interests in the proponent, other than remuneration for work performed. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. Remuneration for our services by the proponent is not linked to approval by any decision-making authority responsible for authorising this development.

W.L.McCleland *6 February 2019*

1. INTRODUCTION

1.1. BACKGROUND

Ilima Coal Company (Pty) Ltd. (“Ilima”) has been granted a Prospecting Right (MP30/5/1/2/2/102PR) for the Kranspan Prospecting Right area. Ilima intends to develop a coal mine on the site (“Kranspan Project”) and have appointed ABS Africa to undertake the Environmental and Social Impact Assessment (ESIA) as part of pre-feasibility and detailed feasibility assessments. This specialist report forms part of the ESIA, and concerns the terrestrial ecosystems that may be impacted by the proposed mine. This report is based on a desktop review of available data and a field survey undertaken by ECOREX in January 2019.

1.2 PROJECT DESCRIPTION

A full project description is given in the main body of the ESIA.

1.3 AIMS OF THIS REPORT

The aims of this report were:

- *Review*: To collate and review relevant and available ecological information for the project area;

- *Baseline Conditions*: To summarise the baseline ecological conditions in the project area, based on a desktop review, wet season field survey, assessment of ecological importance, and existing threats to biodiversity;

- *Impact Assessment*: To identify and assess the significance of key potential impacts related to the proposed development on terrestrial ecosystems.

1.4 STUDY TEAM

Warren McCleland – Terrestrial Ecologist. Warren is the owner and director of ECOREX Consulting Ecologists CC, a consultancy of flora and vertebrate fauna specialists with offices in Gauteng and Mpumalanga, South Africa. He has been involved in specialist biodiversity assessments for a wide range of developments, particularly mining, throughout sub-Saharan Africa over the past 15 years. Countries of work experience outside of South Africa include Democratic Republic of the Congo, Republic of Guinea, Sierra Leone, Liberia, Mali, Tanzania, Kenya, Zambia, Malawi, Mozambique, Namibia and Swaziland. Warren is the co-author of the "Field Guide to the Trees & Shrubs of Mpumalanga & Kruger National Park" published in 2002, and is currently working on a field guide to the Wildflowers of the Kruger National Park. He is registered as a Professional Scientist (Ecological Science) with SACNASP (Reg.No. 003973).

Duncan McKenzie – Terrestrial Ecologist. Duncan has been involved in biodiversity assessments for ECOREX for ten years and countries of work experience include Lesotho, Swaziland, Mali, Mozambique, Guinea, Sierra Leone, South Africa, Tanzania and Democratic Republic of the Congo. Duncan has previously worked as a Regional Coordinator for the Mondi Wetlands Project and lectures on many aspects of conservation in Mbombela and the Kruger National Park. He is currently the Regional Co-ordinator for the South African Bird Atlas Project, sits on the KZN Bird Rarities Committee and is a co-author on the Wildflowers of the Kruger National Park project.

Darren Pietersen - Terrestrial Ecologist. Darren has been involved with research and surveys of various vertebrate communities for the past 10 years and has travelled extensively in Africa in the process, including to Mozambique, Zambia and Malawi. Darren has also assisted with specialist biodiversity assessments for EIAs in South Africa, Democratic Republic of the Congo and Liberia, where the emphasis was on vertebrate communities. Darren is currently working on the first field guide to the reptiles of Zambia and Malawi, as well as field guides to the reptiles and amphibians and birds of the Kruger National Park. He is the Project Manager for the University of Cape Town's ReptileMAP and FrogMAP virtual museum projects and is a research associate of the University of Pretoria's Mammal Research Institute.

Linda McKenzie – GIS. Linda is a GIS Specialist/GIS Analyst with over 13 years' experience in the industry. For the last six years she has operated her own GIS Consultancy called Digital Earth. She has extensive experience in both the private and public sector, and has worked on a wide variety of projects and GIS applications. Most recently, these include vegetation and sensitivity mapping, landcover data capture, municipal roads master planning, hydroelectric scheme and wind farm feasibility mapping and town planning, land surveyor and engineering support services. Linda currently serves as Vice Chairperson and Treasurer for GISSA Mpumalanga and is a registered Professional GISc Practitioner (PGP0170).

2. DETAILED TERMS OF REFERENCE

- Review relevant available information to understand the regional biodiversity setting and develop a list of species of conservation significance potentially present on the site.
- Analyse aerial or satellite imagery and prepare a preliminary map of vegetation communities within the project area.
- Undertake a rapid assessment of the project area during the wet season to ground truth the preliminary map and investigate the following:
    - types and condition of terrestrial habitats present within the project area (including an understanding of their vulnerability in relation to current threats and their uniqueness);
    - indications of the species richness within the terrestrial habitats (including key floral and faunal groups, dominant species, endemic species, threatened species, and alien invasive species);
    - indications of vegetation community structure and composition (using timed-meander transects where appropriate) at representative locations;
    - presence of sensitive habitats and landscapes.
- Assess the ecological importance of the different habitats represented.
- Identify and assess the significance of potential key impacts of the project on terrestrial ecology.

3. PROJECT AREA

The Kranspan Project is located approximately 13 km south-west of the town of Carolina in Albert Luthuli Local Municipality, Mpumalanga Province (Figure 1). The project area covers 3383 hectares and comprises nine portions of the farm Kranspan 49-IT. Ilima Coal has been granted a Prospecting Right for this area (No. 44/2016 (PR) [MP30/5/1/2/2/102PR]), which expires in March 2019.

Figure 1. Location of the Ilima Coal Project Area

4. METHODS

4.1 FLORA

4.1.1 Desktop

The Botanical Database of Southern Africa (BODATSA), which is curated by the South African National Biodiversity Institute (SANBI), was queried for a list of plant species that have been recorded from a 20 km radius of the project area. BODATSA contains records from the National Herbarium in Pretoria (PRE), the Compton Herbarium in Cape Town (NBG & SAM) and the KwaZulu-Natal Herbarium in Durban (NH).

Version 2017.1 of the Red List of South African plants (http://redlist.sanbi.org/index.php), which is managed as part of SANBI's Threatened Species Programme, was consulted for the current conservation status of each species in the above list. The term "Species of Conservation Concern" (SCC) as defined by Raimondo *et al*. (2009) was followed in this report, namely all species classified as threatened (Critically Endangered, Endangered and Vulnerable), as well as species classified as Data Deficient, Near Threatened, Critically Rare, Rare and Declining.

Mucina & Rutherford (2006) was the primary reference for determining the regional context of the vegetation occurring in the vicinity of the project area.

A broad-scale landcover map was compiled by Digital Earth using satellite imagery. This provided the first level of habitat differentiation into Modified and Natural Habitat following the definitions in the International Finance Corporation's Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living) (IFC, 2012). This map was used to plan the location of sample sites for the fieldwork phase.

4.1.2 Fieldwork

The primary field survey method was Timed-meander Searches, a semi-quantitative method that optimises the location of plant species of conservation concern (Goff *et al*., 1982; Huebner, 2007). The method has been shown to be highly effective and time efficient in detecting rare species and documenting α-diversity (Huebner, 2007). Approximately 20 minutes were spent searching all available habitats at each site, although highly diverse habitats required more time while sites situated in transformed habitats with secondary vegetation required less time. Inventories of identifiable vascular plants were made at each of the sites visited, recording presence/absence, as well as estimating dominance/cover-abundance according to Braun-Blanquet cover scales (Kent & Coker, 1992). Where plants could not be identified in the field, photographs of key diagnostic features were taken and specimens were collected and dried in a plant press for later identification.

4.2 TERRESTRIAL FAUNA

4.2.1 Desktop

Mammals

Friedmann & Daly (2004) and the Virtual Museum of African Mammals (MammalMAP, 2017) were used to prepare a list of mammal species that have been confirmed to occur within 2922CD as well as adjacent QDSs. Conservation status assessments for each species were obtained from Friedmann & Daly (2004) and online updates on the Endangered Wildlife Trust's Mammal Red List (https://www.ewt.org.za/Reddata/reddata.html).

Birds

The online database of the Southern African Bird Atlas Project (SABAP2) was queried for a list of bird species confirmed to occur in the relevant QDSs that the project area is located in, namely 2629BB and 2630AA[12]. At a finer mapping scale, lists of bird species recorded during SABAP2 in the the four pentads (mapping units) in which the project area is located (2610_3000, 2605_3000, 2610_2955 and 2605_2955) were downloaded and are included in Appendix 3. Taylor *et al.* (2016) was consulted for the most current conservation status of each species of conservation concern on the above lists.

Herpetofauna

The primary reference for compiling a list of potentially occurring reptiles was Bates *et al*. (2016), and Du Preez & Carruthers (2009) and Minter *et al.* (2004) for a list of potentially occurring amphibians. The Reptile Atlas of Southern Africa (ReptileMAP, 2017)[3] and Frog Atlas of Southern Africa (FrogMAP, 2017)[4], which are continuously updated online databases that reflect the most current distribution data for reptiles and amphibians in South Africa, were

[1] http://sabap2.adu.org.za/gap_analysis.php?DGC=SE2629#content_90perc
[2] http://sabap2.adu.org.za/gap_analysis.php?DGC=SE2630#content_90perc
[3] http://vmus.adu.org.za/, formerly SARCA

[4] http://vmus.adu.org.za/, formerly SAFAP

used to supplement the data from the above references and to indicate the most current taxonomy.

4.2.2 Fieldwork

Mammals

Mammals were surveyed through observations of direct and indirect evidence (sightings, scats, spoor) while conducting bird transects. A decision was made to not use standard rodent survey techniques, such as live walk-in Sherman traps, given the low likelihood of rodents of conservation concern in the project area. The zoological specialists would have needed to check traplines early each morning, which would have restricted the amount of time they would have had to access key habitats for bird species of conservation concern during optimal survey time (early morning). Motion-triggered Bushnell TrailCam cameras were installed at sites of focused large mammal activity, such as paths, waterholes and saltlicks. These sites were baited with small amounts of canned pilchards.

Birds

The MacKinnon list method as recommended by O'Dea *et al.* (2004) was used to survey bird populations. This is a rapid assessment technique in which all species seen or heard are grouped into consecutive lists of equal length and a species accumulation curve is generated by plotting cumulative species totals against number of lists. Ten-species lists were used, which Herzog *et al*. (2002) considered to be the best compromise between stable richness estimation curves and robust sample size. Birds were searched for by walking slowly through vegetation and recording all species seen or heard. Care was taken to remain at any point of bird activity and record all the species present, particularly mixed species flocks. Vocalizations of cryptic species were recorded and played back using a smartphone in order to lure those species into view and confirm identification. Surveys were focussed on the first five hours of daylight (approximately 6am-11am), with incidental observations recorded throughout the day.

Reptiles and Amphibians

The primary survey technique for herpetofauna was active searching of suitable habitat while conducting bird surveys. Active searching involved photographing reptiles that were sunning themselves on exposed sites, as well as lifting up and searching under rocks or logs, and catching any frogs viewed during the day along wetland transects. Nocturnal audio point counts were conducted at sites of frog activity; where necessary, frog calls were recorded with a smartphone and identification confirmed with existing recordings and consultation with other herpetologists.

4.3 ECOLOGICAL SENSITIVITY

For the purposes of this study, Ecological Sensitivity (ES) is considered to be a function of Conservation Value (CV) of the receptor (e.g. habitat unit) and its sensitivity to impacts or Receptor Sensitivity Index (RSI). CV is assessed according to presence of populations of Species of Conservation Concern (SCC) as well as suitability of habitat for supporting populations of SCC. RSI is calculated as a function of Vulnerability to impacts and Resilience, i.e. capacity to be restored to original state with limited human intervention.

Ecological Sensitivity is calculated as follows:

ES = CV + RSI, where

RSI = V + R

Table 1 indicates how ES is interpreted in relation to these variables.

Table 1. Ecological Sensitivity Matrix

Receptor Sensitivity Index		Resilience				
		Very Low	Low	Medium	High	Very High
Vulnerability	Very High	Very High	High	Med-High	Medium	Medium
	High	High	Med-High	Medium	Medium	Low
	Medium	Med-High	Medium	Medium	Low	Low
	Low	Medium	Low	Low	Low	Low
	Very Low	Low	Low	Low	Low	Low

Ecological Sensitivity		Conservation Value				
		Very High	High	Med-High	Medium	Low
Receptor Sensitivity Index	Very High	Very High	Very High	High	Med-High	Medium
	High	Very High	High	Med-High	Medium	Medium
	Med-High	High	Med-High	Medium	Medium	Low
	Medium	Med-High	Medium	Medium	Low	Low
	Low	Medium	Medium	Low	Low	Low

4.4 IMPACT ASSESSMENT

The significance of the impacts potentially affecting terrestrial biodiversity in the project area were assessed by rating each variable numerically, according to defined criteria as provided in Table 2. The severity, spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact, and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table 2 and Table 3**.**

Table 2. Criteria for Assessing the Significance of Impacts

Severity of impact	**Rating**
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5
Spatial scope of impact	**Rating**
Activity specific	1
Area specific	2
Whole project site / local area	3
Regional	4
National/International	5
Duration of impact	**Rating**
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure / permanent	5
Frequency of activity /	**Rating**
Duration of aspect	
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5
Frequency of impact	**Rating**
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

Activity: a distinct process or task undertaken by an organisation for which a responsibility can be assigned.

Environmental aspect: an element of an organisation's activities, products or services which can interact with the environment.

Environmental impacts: consequences of these aspects on environmental resources or receptors.

Receptors: comprise, but are not limited to people or man-made structures.

Resources: include components of the biophysical environment.

Frequency of activity: refers to how often the proposed activity will take place.

Frequency of impact: refers to the frequency with which a stressor will impact on the receptor.

Severity: refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.

Spatial scope: refers to the geographical scale of the impact.

Duration: refers to the length of time over which the stressor will cause a change in the resource or receptor

The outcome of the impacts is then assessed in terms of impact likelihood / probability. The Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes.

Table 3. Significance Rating Matrix

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

4.5 ASSUMPTIONS AND LIMITATIONS

- Certain plant species, particularly geophytes, will only flower in seasons when conditions are optimal and may thus remain undetected, even over a survey that encompasses several seasons. Other plant species may be overlooked because of very small size and / or extreme rarity. A sampling strategy will always represent merely a subset of the true diversity of the study area.

- Many animals occur at naturally low densities and are cryptic and very difficult to detect, especially predators and animals that are subjected to intensive hunting pressure. This makes it highly unlikely that all species occurring in a region will be detected during a survey as brief as the current study. The current fauna survey provides only an ecological "snapshot" of the communities present and is by no means exhaustive. However, the information is considered to be sufficient to be used as a baseline reference and an assessment of the biodiversity value of the habitats represented, and to provide a basis for an impact assessment.

5. BIODIVERSITY BASELINE DESCRIPTION

5.1 FLORA

5.1.1 Regional Context

5.1.1.1 National Vegetation Types

The project area is situated within the Grassland Biome, which dominates the high central and eastern plateau of South Africa (Highveld), as well as the mountainous region of Mpumalanga, western KZN and the Eastern Cape (Drakensberg). This area is characterised by summer rainfall and winter drought, and regular frost in winter (Mucina & Rutherford, 2006). Local plant species richness is high in the Grassland Biome and five centres of plant endemism have been described within the biome. Four geographically distinct bioregions are present within this biome, namely Drakensberg Grassland, Dry Highveld Grassland, Mesic Highveld Grassland and Sub-escarpment Grassland. The project area is situated within the Mesic Highveld Grassland Bioregion within the **Eastern Highveld Grassland** national vegetation type (Gm12), which is described in more detail below (following Mucina & Rutherford, 2006) and mapped in Figure 2:

Eastern Highveld Grassland

This vegetation type is endemic to Gauteng and Mpumalanga provinces, occurring from the East Rand in the west to Belfast in the east, and extending as far south as Bethal, Ermelo and Piet Retief. Terrain comprises slightly to moderately undulating plains with scattered rocky outcrops and pan depressions. Soils are mostly red to yellow sandy soils on shale and sandstone of the Madzaringwe Formation (Karoo Supergroup). Mean annual precipitation varies from 650 to 900 mm, of which almost all occurs in summer, and frost incidence varies from 13-42 days per year. Floristic composition and important taxa are indicated in Table 4 below. Eastern Highveld Grassland has a conservation status of **Endangered** because of a very high level of habitat loss (44%) and very low level of protection.

Table 4. Floristic composition and important taxa in Eastern Highveld Grassland

Important Taxa	
Dominant Grasses	*Aristida aequiglumis, A. congesta, A. junciformis, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D. tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E. plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Microchloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix.*

Herbaceous Plants	*Berkheya setifera (dominant), Haplocarpha scaposa (dominant), Justicia anagalloides (dominant), Pelargonium luridum (dominant), Acalypha angustata, Dicoma anomala, Helichrysum aureonitens, H. callicomum, H. oreophilum, Pentanisia prunelloides, Senecio coronatus, Hilliardiella oligocephala, Wahlenbergia undulata.*
Geophytes	*Gladiolus crassifolius, Haemanthus humilis subsp. hirsutus, Hypocis rigidula, Ledebouria ovatifolia.*
Succulents	*Aloe ecklonis.*
Low Shrubs	*Anthospermum rigidum, Stoebe plumosa.*

An azonal national vegetation type that is embedded throughout Eastern Highveld Grassland and is relevant to the project area is Eastern Temperate Freshwater Wetlands (AZf3). This is a widespread vegetation type occurring in Northern Cape, Eastern Cape, Free State, North-West, Gauteng, Mpumalanga and KwaZulu-Natal, and is associated with shallow stagnant or slow-moving waterbodies such as pans, seasonally flooded vleis and sluggish rivers.

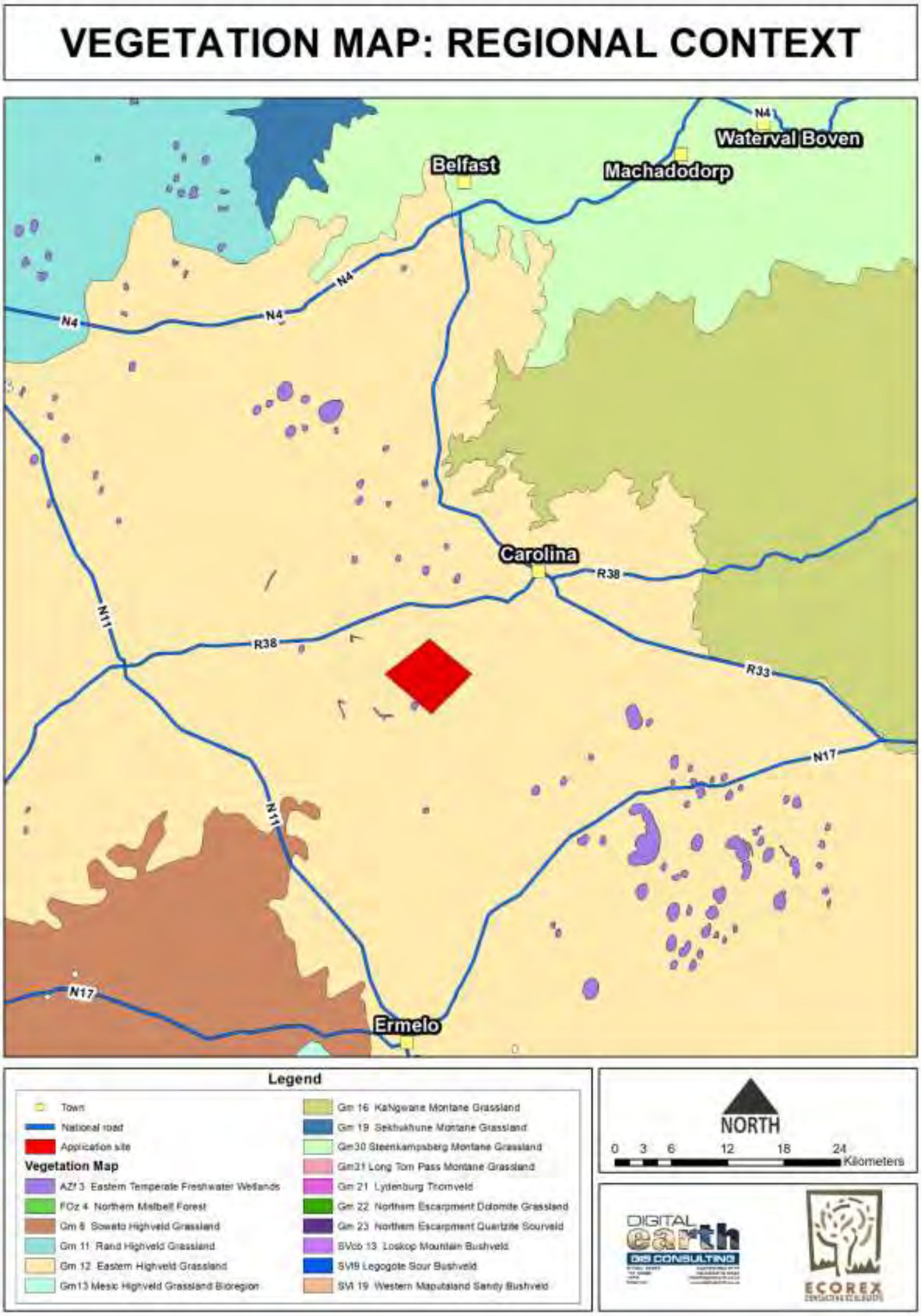

Figure 2. National Vegetation Types represented in the Project Area

5.1.1.2 Centres of Plant Endemism

The project area is not situated within any centres of plant endemism as defined by Van Wyk & Smith (2001).

5.1.1.3 Threatened Ecosystems

Eastern Highveld Grassland is a listed Threatened Ecosystem that is classified as **Vulnerable** under Notice 1002 of Government Gazette 34809, 9 December 2011. It should be noted that this not the same as the conservation status assigned by Mucina & Rutherford (2006), which is merely a published threat status, whereas the Threatened Ecosystem status has been gazetted and is thus more relevant to listed activities such as mining.

5.1.2 Local Context – Plant Species Richness and Vegetation Assemblages

SANBI's Botanical Database of Southern Africa (BODATSA) lists 401 plant species from 74 families for a 20 km radius of the project area (ECOREX, 2018). Since 341 plants species were recorded from the project area during January 2019 fieldwork, which is 85% of the BODATSA total, the true plant species diversity of the district is likely to be significantly higher than 401 species. The full list of 341 plant species confirmed to occur in the project area during fieldwork is provided in Appendix 1. The dominant plant families in the flora are Poaceae (69 spp), Asteraceae (47 spp), Cyperaceae (26 spp) and Fabaceae (23 spp).

Three broad-scale vegetation communities that represent Natural Habitat as defined by IFC (2012) have been identified within the project area (Figure 6). These were classified on the basis of vegetation structure (thicket, grassland, wetland), floristic composition (dominant and diagnostic species) and position in the landscape (crest, slope, valley bottom). An overview of each of these vegetation communities is given below.

Areas that can be classified as Modified Habitat, such as cultivated lands, buildings and tree plantations, cover a large proportion of the project area. These areas are not dealt with in the descriptions below.

***5.1.2.1* Low Shrubland on rocky outcrops and ridges**

This vegetation community, represented by small and fragmented patches of shrubland or thicket, occurs along sandstone ridges or outcrops in the project area (Figure 6). Vegetation structure is Low Closed Shrubland to Low Thicket (*sensu* Edwards, 1983) as illustrated in Figure 3. *Diospyros lycioides* subsp. *guerkei* is the dominant and diagnostic woody shrub throughout this community, with grass species such as *Aristida junciformis, Eragrostis plana, E. racemosa* and *Melinis repens* being dominant understory species. Numerous species are diagnostic for this community, meaning that they do not occur elsewhere in the project area, such as *Searsia tumulicola, Asparagus laricinus, Felicia filifolia, Helichrysum caespititium, Cyanotis lapidosa* and *Crassula setulosa*.

A total of 138 species (40% of the entire list) was recorded from Low Shrubland (Appendix 1), which is remarkably high considering the small area covered by this community. Median species richness along three TMSs was 70 (Appendix 2). Species fidelity, which is closely linked to community uniqueness, is high, with 46 species (33% of the community list) occurring nowhere else in the study area.

Only one conservation-important species was recorded, namely *Gladiolus dalenii* (Table 5). This is not considered to be of conservation concern as defined by Raimondo *et al*. (2009), but is protected under the Mpumalanga Nature Conservation Act (No. 10 of 1998).

Figure 3. Photos of Low Shrubland on rocky ridges

5.1.2.2 Untransformed Grassland

Much of the Natural Habitat represented in the project area comprises Untransformed Grassland (Figure 6), much of which has been seriously overgrazed for years and is moderately to poorly representative of Eastern Highveld Grassland (Figure 4). Two slopes in this vegetation community in the project area are characterised by numerous small, fragmented patches of sheetrock that are exposed above the surface, and is referred to as the Grassland – Sheetrock Mosaic, which is mapped separately in Figure 6.

Vegetation structure is mostly Low Closed Grassland (*sensu* Edwards, 1983) with sheetrock areas being devoid of vegetation apart from small patches of succulents or dwarf herbs. Dominant grasses are *Themeda triandra, Eragrostis plana* and *E. racemosa*, while other common species include *Alloteropsis semialata, Aristida junciformis, Cymbopogon pospischilii, Eragrostis chloromelas, E. gummiflua, Melinis nerviglumis* and *Panicum natalense*. Forbs and geophytes are reasonably diverse and include species such as *Helichrysum rugulosum, Hypochaeris radicata, Ipomoea oblongata, Acalypha villicaulis, Hilliardiella oligocephala, Indigofera hilaris, Eucomis autumnalis* subsp. *clavata* and *Ledebouria ovatifolia*. Xerophytic species typical of sheetrock habitat include *Selaginella dregei, Cyperus rupestris, Khadia carolinensis* and *Crassula capitella* and *C. vaginata*. Shrubs are scarce in this community, although *Diospyros lycioides* subsp. *guerkei* occasionally occurs at the edge of sheetrock, while *Seriphium plumosum* is present in areas that have been overgrazed.

Two hundred and ten species (62% of the entire list) were recorded from Untransformed Grassland, which is the highest species richness for any community in the project area, with 66 species being confined to the Grassland – Sheetrock Mosaic. Separate lists for Untransformed Grassland and the Grassland – Sheetrock Mosaic are presented in Appendix 1. Median species richness along four TMSs in Untransformed Grassland was 47.5, while along two TMSs in the Grassland – Sheetrock Mosaic it was 65 (Appendix 2). Species fidelity, which is closely linked to community uniqueness, is very high, with 102 species (49% of the community list) occurring nowhere else in the project area.

Twelve conservation-important species were recorded (Table 5), which is the highest number of these species for any vegetation community in the project area. One of these is considered to be of conservation concern as defined by Raimondo *et al*. (2009), namely *Khadia carolinensis*, which is classified as Vulnerable. This species is dealt with in more detail in section 5.1.3. The remaining eleven species are protected under the Mpumalanga Nature Conservation Act (No. 10 of 1998). Seven SCC were only located in the Grassland – Sheetrock Mosaic, which also has the highest median species richness in the project area, highlighting the high conservation value of this part of the Untransformed Grassland vegetation community.

Figure 4. Photos of moderately grazed (left) and heavily overgrazed (right) Untransformed Grassland

5.1.2.3 Wetlands

Three distinct wetland types are scattered throughout the project area (Figure 6):

- Pans – relatively saline, shallow pans surrounded by wetlands that are confined to the seasonally inundated margins; Kranspan is the largest of these pans, covering approximately 125 ha;
- Unchannelled Valley-bottom Wetlands and Seeps - seasonal wetlands occurring on gentle mid- to lower slopes and valley bottoms;
- Depression Wetlands – these are depressions within valley bottoms that are more permanently inundated than adjacent unchannelled wetlands and contain some standing water, although marginal and emergent vegetation is dominant, unlike endorheic pans.

Photos of these wetlands are presented in Figure 5. All three wetland types are dominated by sedges (Cyperaceae) and grasses (Poaceae), although species composition differs noticeably in each type. Dominant sedges and grasses throughout the wetland communities are *Leersia hexandra, Cyperus compressus* and *C. denudatus,* while common sedges and grasses in each wetland type include:

- Pans – *Kyllinga* species, *Schoenoplectus corymbosus*, *Agrostis eriantha, Andropogon eucomus, Calamagrostis epigejos, Imperata cylindrica*
- Unchannelled Valley-bottom Wetlands and Seeps - *Pycreus nitidus, Kyllinga erecta, K. melanosperma, Agrostis eriantha, Arundinella nepalensis*
- Depression Wetlands – *Eleocharis dregeana, Schoenoplectus corymbosus*

One hundred and two species (30% of the entire list) were recorded from the three Wetland communities, with Unchannelled Valley-bottom Wetlands and Seeps having the highest species richness (73 species), followed by Endorheic Pans (56 species) and Depression Wetlands (29 species) (Appendix 1). Species richness along two TMSs at Pans varied from 35-38 species, with a median of 36.5, which was marginally higher than Unchannelled Valley-bottom Wetlands and Seeps, which varied from 30-36 species (n=3) with a median of 36. The single TMS in Depression Wetlands produced 24 species. Species fidelity, which is closely linked to community uniqueness, is very high in Wetlands, with 65 species (64% of the community list) occurring nowhere else in the project area.

Three conservation-important species were recorded in Wetlands (Table 5), none of which are considered to be of conservation concern as defined by Raimondo *et al*. (2009). All three species are protected under the Mpumalanga Nature Conservation Act (No. 10 of 1998) and were confined to Wetlands in the project area.

Figure 5. Photos of Wetlands in the project area. Wetland at edge of Pan (top left); Unchanelled Valley-bottom Wetland (top right); Pan (bottom left); Depression Wetland (bottom right)

Table 5. Conservation-important Species confirmed to occur in the Project Area

Taxa	Red Data	Protected	Vegetation Communities						
			Outcrop Shrubland	Untransformed Grassland	Untransformed Grassland with Sheetrock	Pans	Unchannelled Valley-bottom Wetlands and Seeps	Depression Wetlands	Transformed / Degraded/ Crops
Family Aizoaceae									
Khadia carolinensis L. Bolus	VU				+				
Family Amaryllidaceae									
Boophone disticha (L.f.) Herb.		MNCA		+					
Brunsvigia radulosa Herb.		MNCA		+	+				
Haemanthus humilis Jacq. subsp. *hirsutus* (Baker) Snijman		MNCA			+				
Family Asphodelaceae									
Aloe ecklonis Salm-Dyck		MNCA			1				
Family Hyacinthaceae									
Eucomis autumnalis subsp. *clavata* (Baker) Reyneke		MNCA			1				
Family Iridaceae									
Gladiolus crassifolius Baker		MNCA			+				
Gladiolus dalenii Van Geel subsp. *dalenii*		MNCA	+						
Gladiolus papilio Hook.f.		MNCA					+		
Gladiolus permeabilis F.Delaroche		MNCA		+	+				
Family Orchidaceae									
Disa versicolor Rchb.f.		MNCA		+		+	+	+	
Eulophia foliosa (Lindl.) Bolus		MNCA		+			+		
Eulophia hians Spreng. var. *hians*		MNCA			+				
Satyrium sp. (no flowers)		MNCA			+				
Total	**1**	**13**	**1**	**5**	**9**	**1**	**3**	**1**	**0**

VU = Vulnerable
MNCA = Mpumalanga Nature Conservation Act
+ = rare, only represented by scattered individuals
1 = uncommon; moderate number of individuals but nowhere common

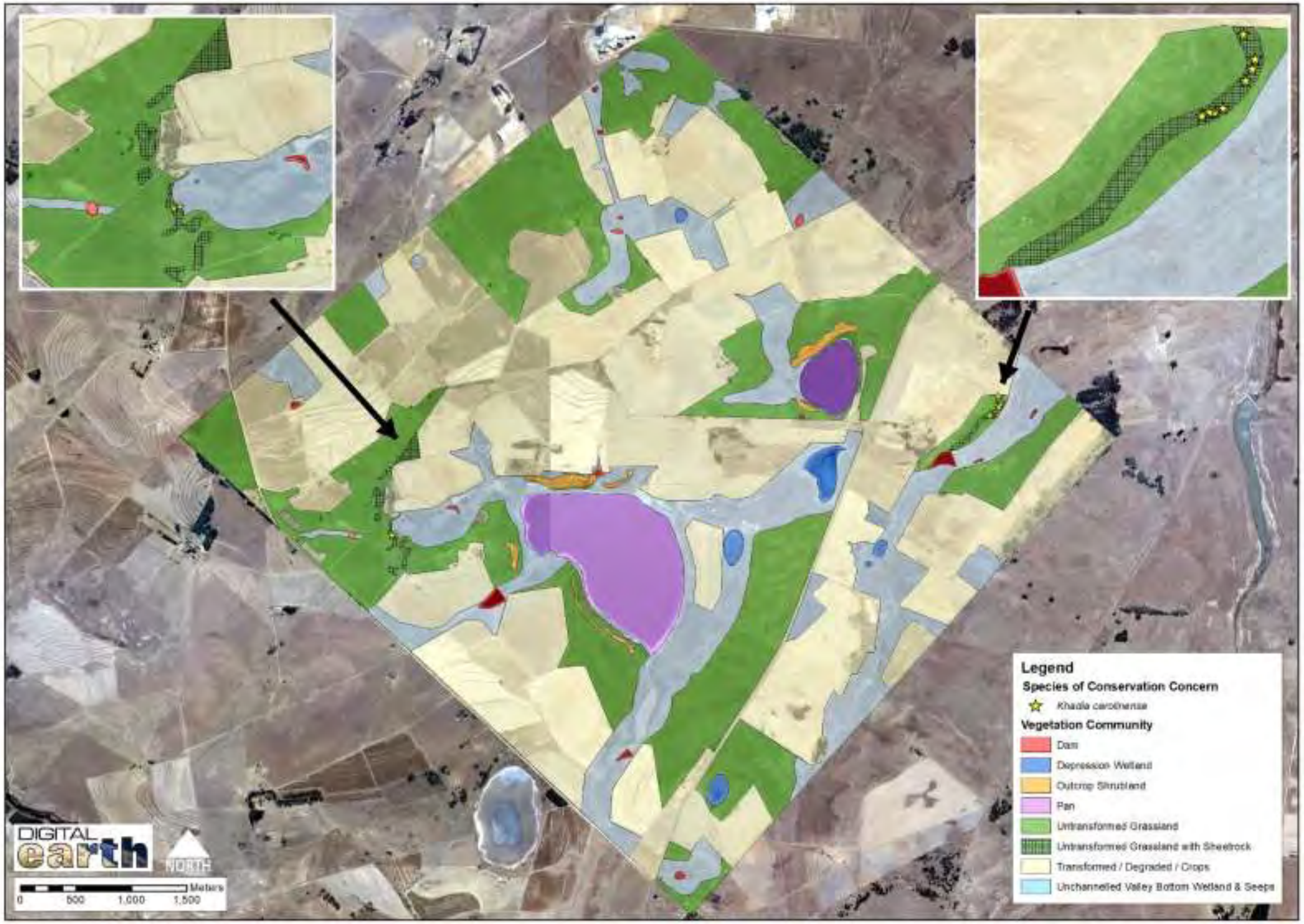

Figure 6. Vegetation Communities represented in the Project Area

5.1.3 Species of Conservation Concern

Thirteen Species of Conservation Concern (SCC) have been recorded from the two quarter-degree grids that the project area is situated in (2629BB, 2630AA) (Appendix 4). Ten of these are classified as threatened (Critically Endangered, Endangered or Vulnerable), although most of these have a low likelihood of occurrence because of a lack of suitable habitat and / or altitude. One of these species, *Khadia carolinensis* (VU), was confirmed to occur during fieldwork and is discussed in more detail below. Two other species were not encountered during fieldwork but are small, easily overlooked species and are still thought to have a moderate likelihood of occurring. Both species are discussed in more detail below.

Khadia carolinensis

This small succulent is also endemic to Mpumalanga, occurring in Highveld grassland between Belfast and south of Carolina. It is associated with exposed rocky outcrops, especially sandstone sheetrock, usually on well-drained, sandy loam soils (Lötter et al., 2007). Much of the global population of this species is located over extensive coal reserves for which mining rights have been applied for, and the primary future threat to this species is open-cast coal mining, resulting in a conservation status of **Vulnerable** (Lötter et al., 2007). A small population was confirmed in the project area during fieldwork. Plants were found on small areas of sandstone sheetrock in untransformed grassland, in ten small colonies varying in size from 3-38 plants (Table 6). Photos of this species are shown in Figure 7.

Table 6. Details of *Khadia carolinensis* colonies in the project area

Colony	No. of Plants	Latitude	Longitude
Kranspan-01	38	-26.163516	30.038777
Kranspan-02	13	-26.163986	30.038993
Kranspan-03	12	-26.164166	30.038945
Kranspan-04	8	-26.164392	30.038820
Kranspan-05	10	-26.164909	30.038395
Kranspan-06	20	-26.164981	30.038238
Kranspan-07	12	-26.164996	30.038138
Kranspan-08	17	-26.165046	30.037998
Kranspan-09	3	-26.174366	29.984317
Kranspan-10	10	-26.174445	29.984023

Figure 7. Photos of *Khadia carolinensis* in the project area

Alepidea longeciliata

This small herb is endemic to Highveld Grassland in Mpumalanga, occurring in a small area between Breyten, Lothair, Middelburg and Stoffberg, although the records from Middelburg and Stoffberg are putative and its distribution seems to be centred on the Carolina area (De Castro & McCleland, 2015). *Alepidea longeciliata* occurs in grassland overlaying Karoo sandstone and is specifically associated with seasonally wet soils on hillslope seeps in hygrophilous grassland. It is threatened primarily by habitat loss to agriculture and mining, particularly coal mining, and has been assessed as **Endangered** (von Staden et al., 2009). A population is known from a property adjacent to Kranspan 49-IT (De Castro & McCleland, 2015) in similar habitat to that represented in the project area. It was not located during fieldwork, but this small species is easily overlooked and it is still thought to have a moderate likelihood of being present in the project area.

Aspidoglossum xanthosphaerum

This species is a slender herb that is nearly endemic to Mpumalanga, occurring in grassland above 1600 masl. It has been assessed as **Vulnerable** by Nicholas & Victor (2006). Even though *Aspidoglossum xanthosphaerum* is currently only known from four widely separated areas between Breyten and Wakkerstroom, it is very easily overlooked and is likely to be present on more localites than those currently known. Specific habitat requirements are poorly known, but specimens collected from near Breyten were located in short grassland on gentle hillslopes, habitat that is present in the project area (De Castro, 2006). It is thus considered to have a moderate likelihood of occurring, even though there are no records from adjacent properties and it was not located during fieldwork.

5.1.4 Endemic Species

Even though the project area is not situated within any centres of plant endemism as defined by Van Wyk & Smith (2001), eleven range-restricted species that are endemic to Mpumalanga are known to occur in the quarter-degree grids that the project area is situated in (ECOREX 2018), although only one of these was located during fieldwork, namely *Khadia carolinensis,* while *Aspidoglossum xanthosphaerum* and *Alepidea longeciliata* have a moderate likelihood of being present. Each of these species is discussed in section 5.1.3.

5.1.5 Protected Species

Thirty-seven plant species occurring in the general vicinity of the project area are protected under Schedule 11 of the Mpumalanga Nature Conservation Act No. 10 (1998) (ECOREX 2018). Eleven of these species were confirmed to occur during fieldwork (Appendix 1).

5.1.6 Invasive Alien Species

Approximately 10% of the plant species recorded during fieldwork (36 species) are non-indigenous or alien, of which nine species are declared invasive species under the National Environmental Management: Biodiversity Act 2004 (Act No. 10 of 2004), Alien and Invasive Species Lists, 2014 (Table 7).

Table 7. Alien species recorded in the project area

Alien Species	Listed Invasive Alien Species Category	Vegetation Communities						
		Outcrop Shrubland	Plains Grassland with Sheetrock	Plains Grassland	Pan Edge Wetland	Hillslope Wetland	Freshwater Pan	Transformed / Degraded/ Crops
Acacia mearnsii De Wild.	2							x
Agrimonia procera Wallr.	1b	x						
Amaranthus hybridus L.		x						x
Bidens bipinnata L.		x						x
Bidens pilosa L.		x						x
Cirsium vulgare (Savi) Ten.	1b	x		x	x	x		x
Cosmos bipinnatus Cav.		x		x	x			x
Crepis hypochaeridea (DC.) Thell.		x		x				
Cuscuta sp.	1b	x	x					
Cymbopogon pospischilii (K.Schum.) C.E.Hubb.		x	x					
Cyperus esculentus L.								x
Datura stramonium L.	1b							x
Erigeron sumatrensis Retz.		x	x	x	x	x		x
Eucalyptus camaldulensis Dehnh.	2							x

Glycine max (L.) Merr.								x
Gomphrena celosioides Mart.		x		x				x
Hibiscus trionum L.				x		x		
Oenothera rosea L'Hér. ex Aiton			x	x				
Paspalum urvillei Steud.						x		
Physalis peruviana L.		x						
Portulaca oleracea L.		x						
Quercus robur L.								x
Ranunculus multifidus Forssk.						x		
Raphanus raphanistrum L.								x
Richardia brasiliensis Gomes		x	x	x	x			x
Rubus sp.		x						
Rumex acetosella L. subsp. *angiocarpus* (Murb.) Murb.		x	x	x		x		
Rumex crispus L.				x		x		
Salix babylonica L.								x
Solanum elaeagnifolium Cav.	1b		x	x				
Solanum nigrum L.		x						
Solanum sisymbriifolium Lam.	1b	x	x	x				
Sonchus oleraceus (L.) L.				x	x			
Verbena bonariensis L.	1b		x	x	x	x		
Verbena tenuisecta Briq.								
Zea mays L.								x
	9	18	9	14	6	8	0	17

Listed Invasive Species Categories

1b = invasive species that must be controlled

2 = invasive species which requires a permit to carry out a restricted activity within an area specified in the Notice or an area specified in the permit

5.2 TERRESTRIAL FAUNA

5.2.1 Mammals

Regional Context

The project area is situated within the Grassland biome, which is confined to the cool, high-lying plateau of eastern South Africa, Swaziland and Lesotho, as described by Mucina & Rutherford (2006). A number of small mammal species are endemic to this biome, of which only two have been confirmed to occur within the general vicinity of the project area (Friedman & Daly, 2004): Hottentot's Golden Mole (*Amblysomus hottentotus*) and Highveld Golden Mole (*A. septentrionalis*).

Species Richness

Thirty-three mammal species have been recorded in the QDSs in which the project area is situated (ECOREX, 2018). Fifteen species were recorded during January 2019 fieldwork (Appendix 5), although this isn't an accurate indication of mammal species richness in the project area since no trapping for rodents or nocturnal surveys for bats were undertaken. However, even though these groups are underrepresented in this survey, it is unlikely that trapping and dedicated bat surveys would have produced data that would have changed the sensitivity analysis of this report.

Species of Conservation Concern

Ten species of conservation concern occur on the Highveld in the general vicinity of the project area, of which eight have been recorded in the quarter-degree grids in which the project area is situated (Appendix 7). Five of these have a moderate to high likelihood of occurring in the project area, all of which are classified as Near Threatened (NT). One of these species, Serval (*Leptailurus serval*), was confirmed to occur in several habitats in the project area during fieldwork. Another NT species, Southern African Hedgehog (*Atelerix frontalis*), was found on adjacent property during ECOREX fieldwork for De Castro & McCleland (2015) and thus has a high likelihood of being present in the project area. Two additional species for which there are no records in the vicinity of the project area, but which have a moderate likelihood of occurring are one Vulnerable (VU) species (Spotted-necked Otter *Hydrictis maculicollis*) and one NT species (African Clawless Otter *Aonyx capensis*).

5.2.2 Birds

Regional Context

The project area is situated within the Afrotropical Highlands biome as defined by Fishpool & Evans (2001). This biome is located in fragmented patches throughout the Afromontane belt of Africa and corresponds roughly to the Grassland Biome in South Africa. Twenty-four species occurring in South Africa are listed by Barnes (1998) as being endemic to the biome, i.e. not occurring outside of the biome. Many of these are forest species that will not occur in the project area, and only one biome-restricted endemic (Southern Bald Ibis *Geronticus calvus*) has been confirmed to occur in the same quarter-degree grids in which the project area is situated during the current Southern African Bird Atlas Project (SABAP2).

Kranskop 49-IT is situated along the eastern boundary of the Amersfoort – Bethal – Carolina District Important Bird Area (IBA) and the Chrissie Pans IBA is located to the south-east of the project area (Marnewick et al., 2015).

Species Richness and Assemblages

Prior to fieldwork for this study, the quarter-degree grids 2629BB and 2630AA, in which the project area falls, had a combined list of 212 bird species recorded during the ongoing second Southern African Bird Atlas Project (SABAP2)[5], a total probably approaching true species diversity for the district. SABAP2 data also indicated that 134 bird species had been recorded from the four pentads (mapping units) in which the project area is situated (2610_3000, 2605_3000, 2610_2955, 2605_2955) (ECOREX 2018). A pentad is a much smaller mapping unit than a quarter-degree grid, measuring approximately 77 km^2, and is thus a better indication of which species are likely to occur in the project area. However, none of the pentads listed above had been surveyed more than three times during SABAP2 prior to fieldwork for this study and were thus significantly undersampled and likely to support more species than indicated.

January 2019 fieldwork produced a list of 120 bird species in the project area (Appendix 5), representing 90% of the previously known species richness for the area. A species accumulation curve from MacKinnon list data presented in Appendix 6 indicates that sufficient sampling has been undertaken to represent the bird species present in the project area during fieldwork (Figure 8).

[5] http://sabap2.adu.org.za/ Accessed 13 November 2018

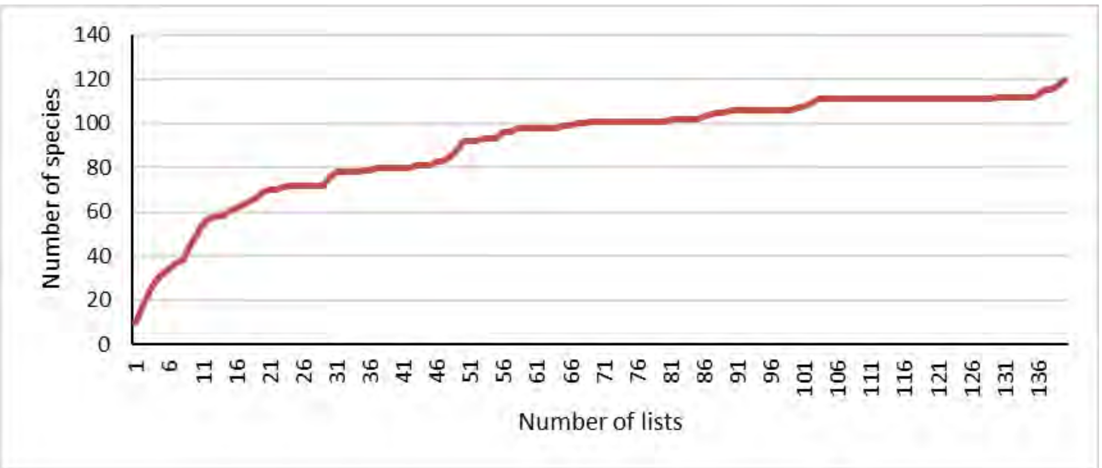

Figure 8. Species Accumulation Curve based on MacKinnon list fieldwork data

Four distinct bird assemblages are present in natural habitat, while two bird assemblages are present in modified habitat. Each of these assemblages is briefly described below.

5.2.2.1 Grassland Assemblage

This is the second most diverse bird assemblage in the project area and is associated with areas of untransformed grassland. Fifty-two species were recorded during fieldwork, representing 43% of the bird list (Appendix 5). The most frequently encountered species indicated in Table 8 include grassland habitat specialists that were not encountered in other assemblages in the project area, such as Cape Longclaw (*Macronyx capensis*) and Wing-snapping Cisticola (*Cisticola ayresii*). Other diagnostic species for this assemblage include Blue Korhaan (*Eupodotis caerulescens*), Spike-heeled Lark (*Chersomanes albofasciata*), Eastern Clapper Lark (*Mirafra fasciolata*), Cloud Cisticola (*Cisticola textrix*) and Ant-eating Chat (*Myrmecocichla formicivora*), all of which are strict Highveld grassland habitat specialists in Mpumalanga. No bird SCC were found in this assemblage during fieldwork, although a number of species potentially occur, such as Pallid Harrier (*Circus macrourus*), Southern Bald Ibis (*Geronticus calvus*), Blue Crane (*Grus paradiseus*) and Secretarybird (*Sagittarius serpentarius*).

Table 8. Most frequently encountered species in the Grassland Assemblage

Species	No. of Sightings	Reporting Rate
Cape Longclaw	64	0.08
Wing-snapping Cisticola	60	0.07
African Pipit	55	0.07
Common Quail	49	0.06
Barn Swallow	48	0.06
Zitting Cisticola	44	0.05

Yellow-crowned Bishop	35	0.04
Quailfinch	31	0.04
Cape Canary	28	0.03
Southern Masked Weaver	23	0.03

5.2.2.2 Rocky Ridge Assemblage

This is a very small assemblage confined to the few rocky outcrops in the project area. Only 16 species were confirmed during fieldwork (Appendix 5), with the most frequently ecountered species indicated in Table 9. However, limited time was spent surveying this assemblage and true species richness is likely to be slightly higher, although the limited amount and fragmented character of the ridge habitat makes it unlikely that a diverse bird assemblage is supported. Diagnostic species include Mountain Wheatear (*Myrmecocichla monticola*), a rock-dwelling specialist that is unlikely to visit other habitats in the project area, Malachite Sunbird (*Nectarinia famosa*), which is an irregular visitor when certain plant species are in flower in the outcrop shrubland / thickets, and Horus Swift (*Apus horus*). A feature of this assemblage is the high proportion of aerial insectivores that forage low over the rocky areas, such as Greater Striped Swallow (*Cecropis cucullata*), Barn Swallow (*Hirundo rustica*), Banded Martin (*Riparia cincta*), Common Swift (*Apus apus*) and White-rumped Swift (*Apus caffer*). One SCC was seen flying around rocky ridges but is unlikely to be a frequent member of this assemblage, namely Black-winged Pratincole (*Glareola nordmanni*), which is classified as NT.

Table 9. Most frequently encountered species in the Rocky Ridge Assemblage

Species	No. of Sightings	Reporting Rate
Greater Striped Swallow	6	0.19
Barn Swallow	4	0.13
Common Waxbill	4	0.13
Banded Martin	3	0.10
Malachite Sunbird	3	0.10
Horus Swift	2	0.06
Pin-tailed Whydah	2	0.06
Spotted Thick-knee	2	0.06

5.2.2.3 Wetland Assemblage

This is the most diverse bird assemblage in the project area, comprising 55 species (Appendix 1) and is a reflection of the diversity of wetland habitat present. The most frequently encountered species are included in Table 10, including a number of habitat specialists such as Levaillant's Cisticola (*Cisticola tinniens*), Pale-crowned Cisticola (*C. cinnamomeus*) and Long-tailed Widowbird (*Euplectes progne*). This is a very distinctive assemblage, with 26 species not being found elsewhere in the project area and three species only being shared with the Open Water Assemblage. These diagnostic species include strict wetland specialists such as Red-chested Flufftail (*Sarothrura rufa*), African Purple Swamphen (*Porphyrio madagascariensis*) and African Snipe (Gallinago nigripennis). The most important SCC in the project area occur in this assemblage, particularly African Marsh Harrier (*Circus ranivorus*), which is classified as Endangered (EN), and African Grass Owl (*Tyto capensis*), which is Vulnerable (VU). Two other SCC in this assemblage were Lesser Jacana (*Microparra capensis*) (VU), which is a very rare vagrant to the Highveld and is unlikely to occur regularly in this assemblage, and Black-winged Pratincole (NT).

Table 10. Most frequently encountered species in the Wetland Assemblage

Species	No. of Sightings	Reporting Rate
Levaillant's Cisticola	21	0.08
Barn Swallow	14	0.05
Common Waxbill	14	0.05
Yellow-crowned Bishop	14	0.05
Pale-crowned Cisticola	13	0.05
Whiskered Tern	12	0.05
Southern Masked Weaver	10	0.04
Southern Red Bishop	10	0.04
Blacksmith Lapwing	9	0.03
Long-tailed Widowbird	9	0.03
Quailfinch	9	0.03

5.2.2.4 Open Water Assemblage

This assemblage is associated with the large, shallow pans in the project area. Only 23 species were recorded in this assemblage during fieldwork (Appendix 5), although water levels were very low and species richness is likely to be much higher when habitat is optimal. The most frequently encountered species are listed in Table 11, with ducks and geese being particularly prominent. Distinct feeding guilds in this assemblage include surface foraging waterfowl, such as Yellow-billed Duck (*Anas undulata*), Maccoa Duck (*Oxyura maccoa*), Red-knobbed Coot (*Fulica cristata*) and Little Grebe (*Tachybaptus ruficollis*), aerial insectivores such as Common Swift and White-rumped Swift, and wading birds that forage along the shoreline, such as Black-winged Stilt (*Himantopus himantopus*). The most diagnostic species in this assemblage are those that depend on open water or foraging and these species are unlikely to be found elsewhere in the project area, apart from some generalist species that also occur on man-made dams, such as Egyptian Goose (*Alopochen aegyptiaca*) and Little Grebe. The only SSC confirmed to occur in this assemblage was Maccoa Duck, which is classified as NT, although Black-winged Pratincole (NT) has a high likelihood of foraging over open water as well.

Table 11. Most frequently encountered species in the Open Water Assemblage

Species	No. of Sightings	Reporting Rate
Yellow-billed Duck	9	0.13
Little Grebe	6	0.09
Spur-winged Goose	5	0.07
Black-headed Heron	4	0.06
Cape Shoveler	4	0.06
Egyptian Goose	4	0.06
Red-billed Teal	4	0.06
Red-knobbed Coot	4	0.06
Reed Cormorant	4	0.06
Southern Pochard	3	0.04

5.2.2.5 Modified Habitat Assemblage (Cultivated Lands)

This is an artificial assemblage that is associated with Modified Habitat, in this case Cultivated Lands. Twenty-seven species were recorded in this assemblage during fieldwork, most of which are habitat generalists with a wide range of habitat tolerance, such as Helmeted Guineafowl (*Numida meleagris*), Southern Fiscal (*Lanius collaris*) and Cape Sparrow (*Passer melanurus*). Six of the most frequently encountered species listed in Table 12 are seed-eaters, indicating the primary food source in this habitat. No SSC were recorded.

Table 12. Most frequently encountered species in the Modified Habitat (Cultivated lands) Assemblage

Species	No. of Sightings	Reporting Rate
Southern Masked Weaver	6	0.10
Yellow-crowned Bishop	6	0.10
Common Waxbill	5	0.08
Southern Red Bishop	5	0.08
Swainson's Spurfowl	4	0.07
Barn Swallow	3	0.05
Levaillant's Cisticola	3	0.05
Red-billed Quelea	3	0.05

5.2.2.6 Modified Habitat Assemblage (Plantations, Homesteads)

This is another artificial assemblage associated with Modified Habitat, in particular plantations of alien trees and homesteads.Thirty-eight species were recorded during fieldwork (Appendix 5) and, as with the previous assemblage habitat generalists are dominant. A number of the species listed in Table 13 are forest / woodland species that have adapted to living in alien tree plantations, such as Cape Robin-chat (*Dessonornis caffer*), Willow Warbler (*Phylloscopus trochilus*), Greater Honeyguide (*Indicator indicator*) and Black-collared Barbet (*Lybius torquatus*), while other species have adapted to breeding and feeding on man-made structures such as buildings, including House Sparrow (*Passer domesticus*), Greater Striped Swallow (*Cecropis cucullata*) and Speckled Pigeon (*Columba guinea*). No SSC were recorded.

Table 13. Most frequently encountered species in the Modified Habitat (Plantations, Homesteads) Assemblage

Species	No. of Sightings	Reporting Rate
Cape Turtle Dove	11	0.11
Cape Robin-Chat	9	0.09
Southern Masked Weaver	8	0.08
Cape Canary	6	0.06
Diederik Cuckoo	6	0.06
Hadeda Ibis	6	0.06
Red-eyed Dove	6	0.06
Black-throated Canary	4	0.04
Dark-capped Bulbul	4	0.04
Southern Fiscal	4	0.04

Species of Conservation Concern

Eight threatened bird species have been recorded in the quarter-degree grids in which the project area is situated, namely one Critically Endangered (CR) species (Wattled Crane *Grus carunculatus*), two Endangered (EN) species (Grey Crowned Crane *Balearica regulorum*, Cape Vulture *Gyps coprotheres*) and five Vulnerable (VU) species (Southern Bald Ibis, Secretarybird *Sagittarius serpentarius*, White-bellied Korhaan *Eupodotis senegalensis*, Denham's Bustard *Neotis denhami* and African Grass Owl *Tyto capensis*). Four of these species have a moderate likelihood of occurring in the project area (ECOREX 2018), while both African Grass Owl and African Marsh Harrier (*Circus ranivorus*) (EN), which was not previously recorded within the QDS, were confirmed to occur in Unchannelled Valley-bottom Wetland habitat.

Five NT species have been recorded in the quarter-degree grids in which the project area is situated and have a moderate to high likelihood of being present in the project area (Appendix 7). One of these, Maccoa Duck, was confirmed on Kranspan, while an additional NT species not previously recorded in the area, Black-winged Pratincole (*Glareola nordmanni*), was seen foraging over grassland habitat. Blue Korhaan (*Eupodotis caerulescens*) was recorded in Untransformed Grassland and is possibly resident. Two NT species are only likely to be recorded in open water habitat at Kranspan, namely Lesser Flamingo (*Phoeniconaias minor*) and Greater Flamingo (*Phoenicopterus roseus*), while one species is most likely to occur in Untransformed Grassland habitat, namely Blue Crane (*Grus paradiseus*).

Three additional species for which there are no records in the vicinity of the project area have a moderate likelihood of occurring (Appendix 7). One of these is classified as VU (Lanner Falcon *Falco biarmicus*), while the other two are NT (Chestnut-banded Plover *Charadrius pallidus*, Pallid Harrier *Circus macrourus*).

5.2.3 Herpetofauna (Reptiles and Amphibians)

Regional Context

The project area is situated within the Grassland biome, which is confined to the cool, high-lying plateau of eastern South Africa, Swaziland and Lesotho, as described by Mucina & Rutherford (2006). Numerous reptile and amphibian taxa are endemic to this biome, although the project area is situated in an area of moderate to low endemism, with three endemic reptile species per QDS (Bates et al., 2014) and 4-6 endemic frog species per QDS (Minter et al., 2004).

Species Richness

Thirty (30) reptile species and 14 amphibian species have been recorded from the two QDSs in which the project area is located, with a mean of 20 reptile species and 12 amphibian species per QDS (ECOREX, 2018). Given the relatively small size of the project area and low habitat heterogeneity, it is unlikely that this full list of species will be present in the project area. Nine (9) reptile species and six amphibian species were recorded during fieldwork (Appendix 5), although trapping of reptiles and more extensive nocturnal surveys would have increased this total. However, even though herpetofauna are underrepresented in this survey, it is unlikely that these additional intensive surveys would have produced data that would have changed the sensitivity analysis of this report.

Species of Conservation Concern

No reptile species of conservation concern as assessed by Bates et al. (2014) have been observed within the vicinity of the project area, while one species that has been regionally assessed by the Mpumalanga Tourism & Parks Agency (MTPA) as NT (Spotted Harlequin Snake *Homoroselaps lacteus*) has been recorded in 2629BB (ECOREX, 2018). Three additional NT reptiles have been recorded in other QDSs in the general vicinity of the project area (Coppery Grass Lizard *Chamaesaura aenea*, Large-scaled Grass Lizard *C. macrolepis*, Striped Harlequin Snake *Homoroselaps dorsalis*), but these have a low likelihood of being present in the project area. No reptile SCC were recorded during fieldwork.

No amphibian species of conservation concern have been recorded from the vicinity of the project area, although one species has a low likelihood of occurring, namely Giant Bullfrog (*Pyxicephalus adspersus*), which has been classified as NT and is a protected species under NEMBA (2004). This species breeds in shallow temporary pans which are present within the project area and adjacent properties, but is very rare on the eastern Highveld and there are no recent records from the relevant QDSs. No amphibian SCC were recorded during fieldwork.

5.3 ECOLOGICAL SENSITIVITY

5.3.1 Mpumalanga Biodiversity Sector Plan

All of the Natural Habitat (untransformed vegetation) within the project area falls within Critical Biodiversity Areas (CBAs) according to the Mpumalanga Biodiversity Sector Plan (MBSP) (Lötter *et. al,* 2014)**.** Just over half of the untransformed grassland in the project area (736 ha) has been classified as **CBA: Irreplaceable**, while the pans, wetlands and other grassland have been classified as **CBA: Optimal** (Figure 9). These are the most sensitive habitats in the project area and represent the areas where impacts on ecology would be most significant. Critical Biodiversity Areas are areas that are essential for meeting biodiversity targets for species, ecosystems or ecological processes. The desired management objectives for CBAs are that they be **kept in a natural or near-natural state, with no further loss of habitat or species**. Only low-impact, biodiversity-sensitive land-uses such as low-intensity livestock grazing are considered appropriate, while land-uses such as any form of mining or prospecting, conversion of natural habitat for agriculture or plantation forestry, expansion of existing settlements or infrastructure, and the building of new infrastructure or linear developments such as roads, railways, pipelines, etc., **are considered inappropriate**. All the transformed areas, such as cultivated lands, are classified as either Heavily Modified or Moderately Modified: Old Lands. Areas falling within the Modified category are the preferred areas for a wide variety of land-use types, which includes mining development. Figure 9 shows the MBSP classification of land units within the project area.

5.3.2 Site-specific Ecological Sensitivity Analysis

Because the MBSP was compiled at a provincial scale, it is important to assess the project area at a local site-specific scale using relevant methodology. **This does not replace the assessment of the MBSP**, which gives the importance of the project area in relation to the rest of the province, but rather assesses the Ecological Sensitivity of the project area on the basis of the biodiversity baseline findings within the project area and the nature of the project and it's associated impacts.

An Ecological Sensitivity analysis of each of the vegetation communities represented in the project area was undertaken using the methodology described in section 4. Table 14 shows the calculation of the Receptor Sensitivity Index (RSI) for each community and Table 15 shows the calculation of Ecological Sensitivity, which is displayed in Figure 10. Almost all the vegetation communities in the project area have low Resilience, meaning that they can only be restored ecologically with significant human intervention, or cannot be restored at all. However, the Vulnerability to degradation / impact varies significantly, depending on how frequently impacts in these communities occur (e.g. Untransformed Grassland is highly favoured for agriculture and thus very vulnerable to degradation). This has resulted in a variable RSI, with Untransformed Grassland having the highest RSI.

Table 14. Vulnerability and Resilience of Vegetation Communities in the Project Area

Vegetation Community / Habitat	Vulnerability	Resilience	Receptor Sensitivity Index
Outcrop Shrubland	Medium	Medium	Medium
Untransformed Grassland	Very High	Low	High
Pans	High	Low	Med-High
Unchannelled Valley-bottom Wetlands & Seeps	High	Low	Med-High
Depression Wetlands	Medium	Low	Medium
Transformed / Modified Habitat	Low	Low	Low

The Conservation Value (CV) of all Natural Habitat in the project area is mostly High (Untransformed Grassland, Pans, Depression Wetlands) or Very High (Unchannelled Valley-bottom Wetlands and Seeps). These communities have such high ratings as a result of representation of highly threatened vegetation types, confirmed presence of threatened species, and / or high functional value (such as flood attenuation functions of Unchannelled Valley-bottom Wetlands). The integration of CV and RSI results in High Ecological Sensitivity for two vegetation communities in the project area, namely Untransformed Grassland and Unchannelled Valley-bottom Wetlands. These represent the areas where impacts on ecology will be most significant and where the Avoidance option of the Mitigation Hierarchy should be applied.

Table 15. Ecological Sensitivity of Vegetation Communities in the Project Area

Vegetation Community / Habitat	Conservation Value	Receptor Sensitivity Index	Ecological Sensitivity
Outcrop Shrubland	Med-High	Medium	Medium
Untransformed Grassland	High	High	High
Pans	High	Med-High	Med-High
Unchannelled Valley-bottom Wetlands & Seeps	Very High	Med-High	High
Depression Wetlands	High	Medium	Medium
Transformed / Modified Habitat	Low	Low	Low

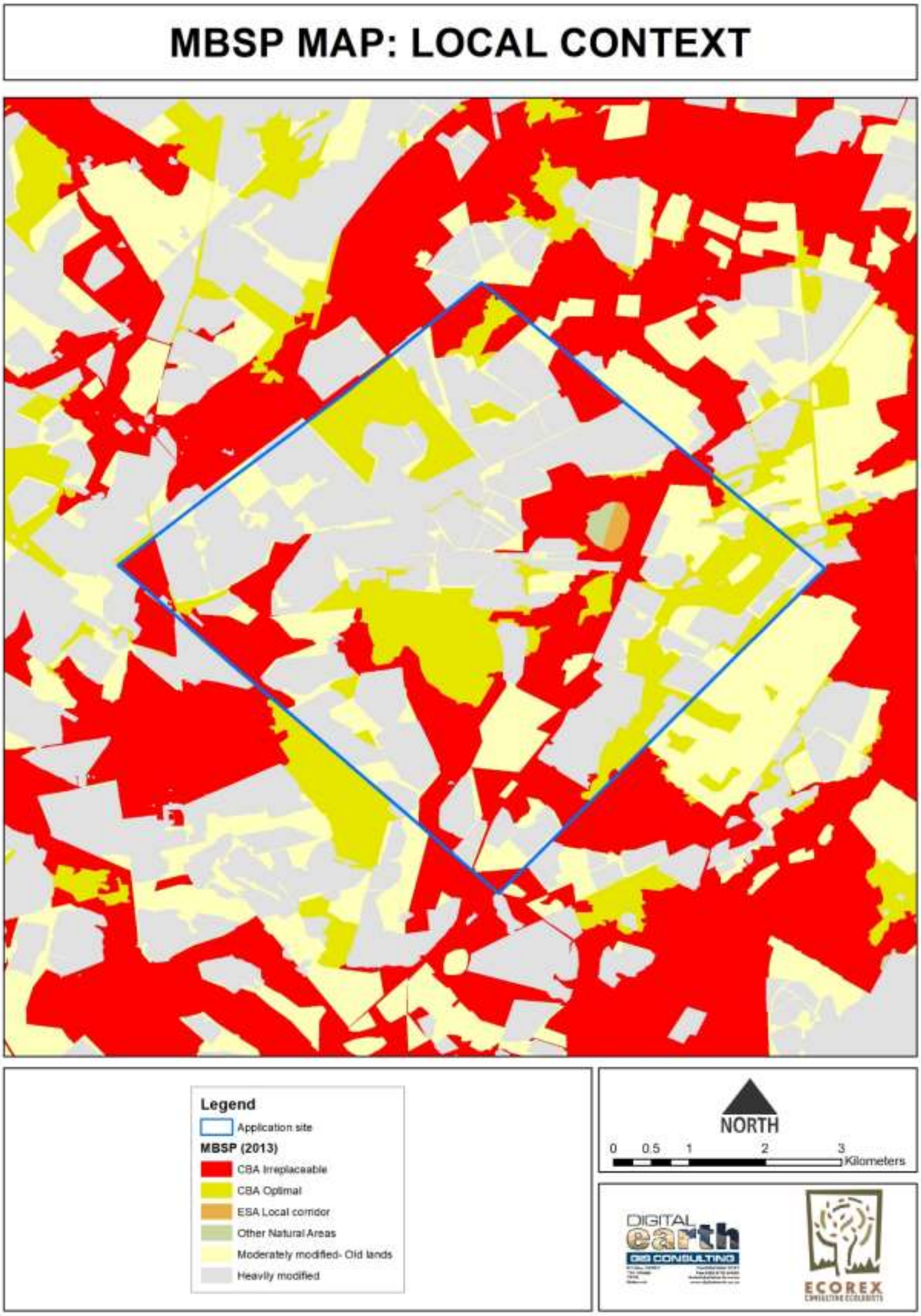

Figure 9. MBSP Classification of land units within and adjacent to the Project Area

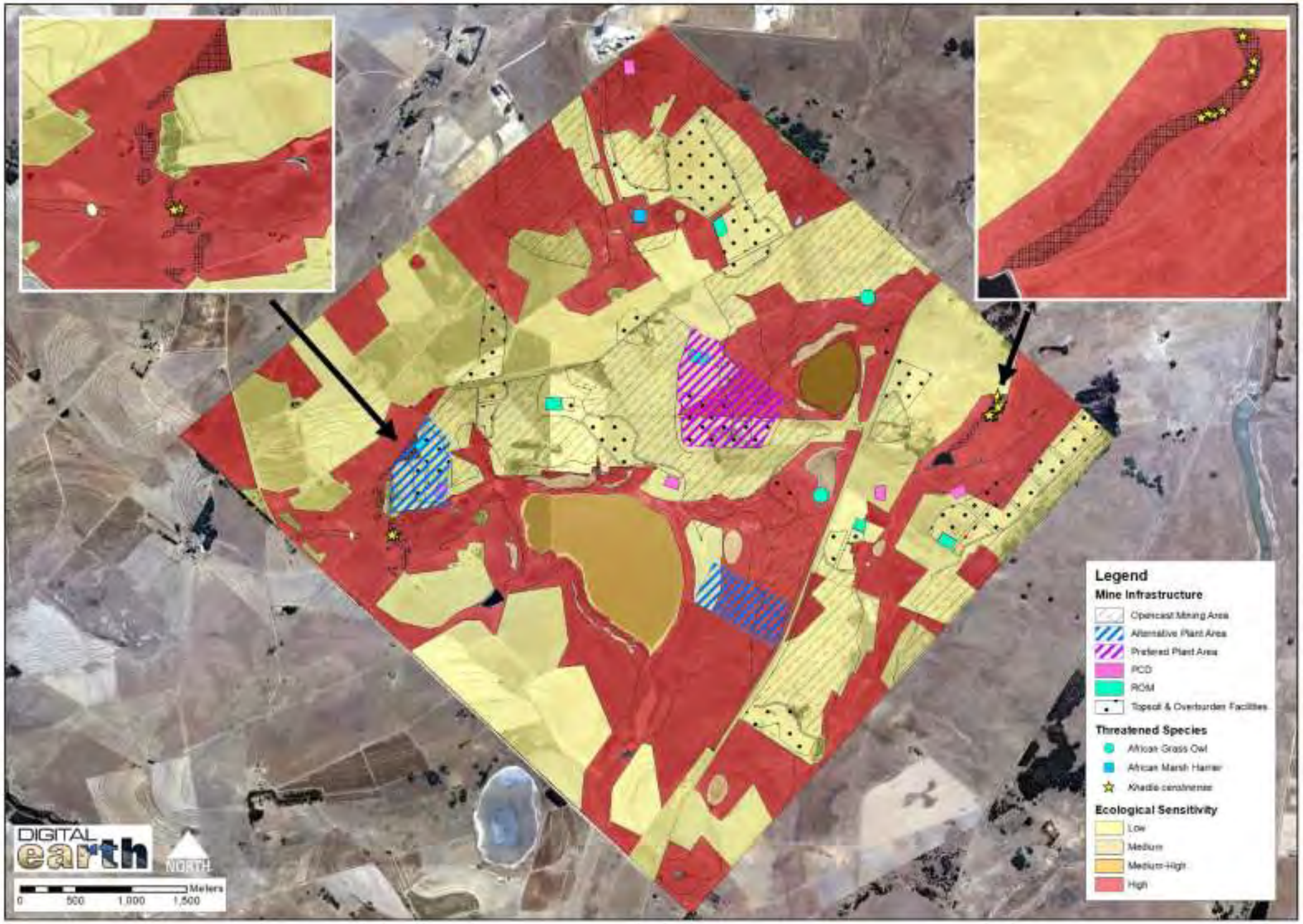

Figure 10. Ecological Sensitivity of Vegetation Communities in the Project Area

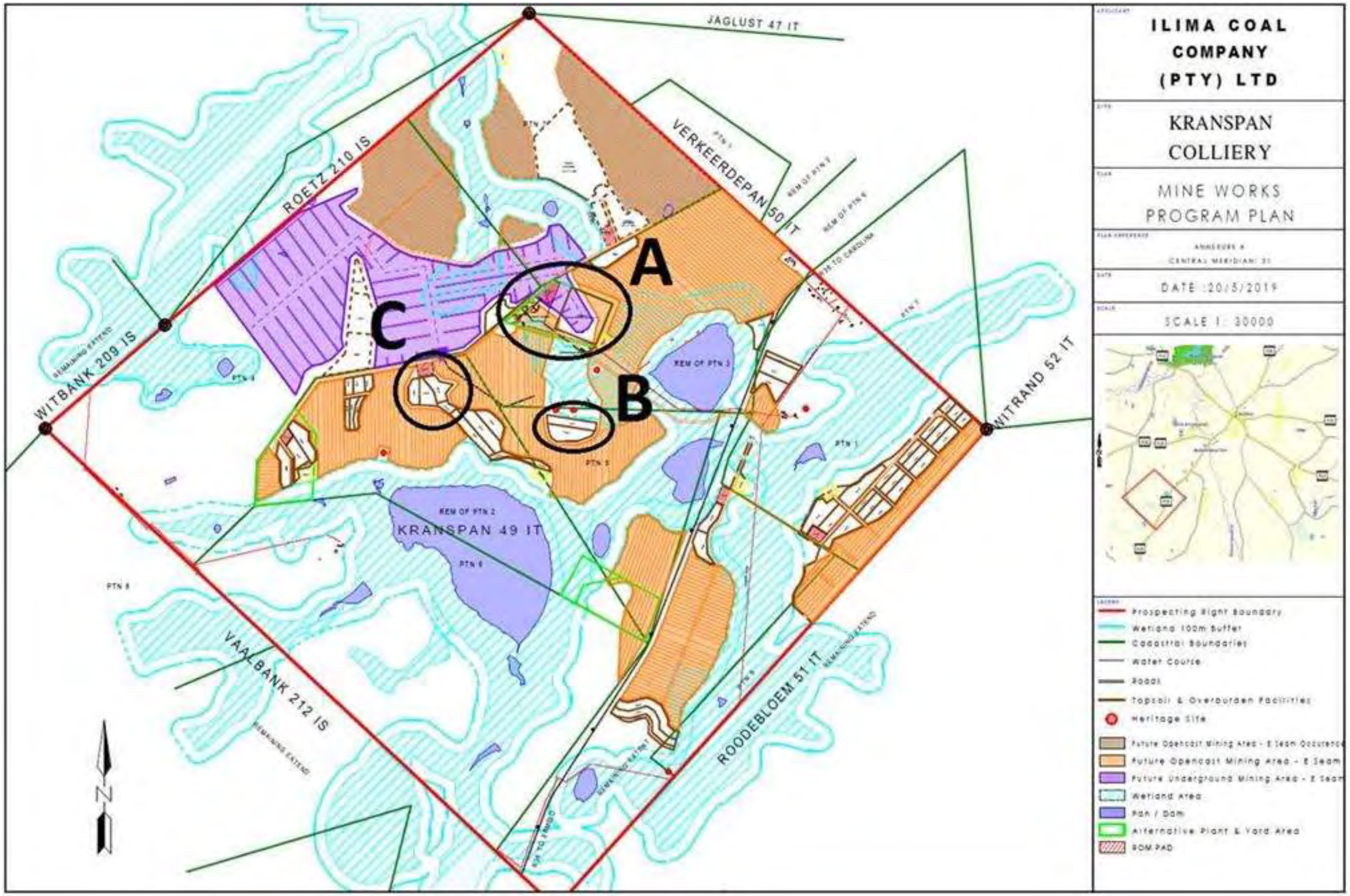

Figure 11. Latest Project Infrastructure

6. ASSESSMENT OF IMPACTS AND RECOMMENDATION OF MITIGATION MEASURES

During the preparation and construction phases it is possible that areas of natural habitat will be cleared during the creation of open-cast pits, creating or widening of access roads to the infrastructure, etc.

6.1 FLORA

The following key impacts to flora have been identified:

6.1.1 Disturbance or loss of an Endangered national vegetation type and listed Threatened Ecosystem (Vulnerable), Critical Biodiversity Areas, as well as associated populations of Species of Conservation Concern

Parts of the project area that comprise undisturbed Natural Habitat, i.e. untransformed grassland and wetlands, are likely to be lost with the development of future open cast mining areas as indicated in the most current layout (Figure 11). Untransformed Grassland and Unchannelled Valley-bottom Wetlands and Seeps are rated as having High Ecological Sensitivity, while Pans have Medium-High ES. These communities are also representative of an Endangered vegetation type, which has also been listed as a Threatened Ecosystem (Vulnerable) and are have been classified as either CBA: Irreplaceable or CBA: Optimal in the MBSP. These are the habitats in which SCC are most likely to occur and thus populations of these species are likely to also be impacted. The location of infrastructure and open pits within these habitats will significantly increase the severity of this impact.

One preferred and two alternative sites were proposed for the washing plant as indicated in Figure 10 but this has changed to a single preferred site in the latest layout (Figure 11). The western alternative site (which is no longer being considered) was adjacent to small colonies of a threatened plant (*Khadia carolinensis*); however, there are still topsoil and overburden facilities planned for this site, which could threaten these colonies through excessive dust productive resulting in a **High** impact significance rating. The only option within the mitigation hierarchy that could reduce the impact significance at the western site would be Avoidance. The most current layout of the preferred site is situated almost entirely in Modified Habitat, resulting in an impact significance of **Moderate**.

Project Activity		Flora	Likelihood	Consequence	

Clearing of Vegetation for Site Access, Infrastructure Siting and Mining of Open Pit	*Phase of Project*	Preparation and Construction Phases	*Frequency of Activity*	*Frequency of Impact*	*Severity*	*Spatial Scope*	*Duration*	*Significance Rating*
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	**Loss of Natural Habitat of High or Medium-High Ecological Sensitivity**	5	5	5	2	5	120
			Significance Post-Mitigation					
			5	5	2	2	5	90

Recommended Mitigation Measures

The only viable option within the Mitigation Hierarchy (Avoid / Minimize / Restore / Offset) for the impact on CBAs in the project area is Avoid. Applying the Minimize option would be in conflict with the MBSP, which considers open-cast mining to be an unacceptable land use activity in CBAs; thus, any open-cast mining within Untransformed Grassland or Unchannelled Valley-bottom Wetlands and Seeps would be inconsistent with the MBSP. It is highly unlikely that any Untransformed Grassland or Unchannelled Valley-bottom Wetlands and Seeps could be restored to pre-construction ecological state, even with extensive human intervention, invalidating the Restore option. The only way the Offset option would be viable is if adjacent or nearby relevant habitat with the relevant SCC is available for purchase for formal conservation. Since this investigation is beyond the scope of this study, the Offset option was not considered. However, destruction of habitat that has been designated as CBA: Irreplaceable cannot be mitigated by Offsets because by definition Irreplaceable Areas cannot be replaced and thus cannot be offset.

Avoidance is thus the only viable mitigation option as follows:

- Design open-cast areas to exclude the areas of Untransformed Grassland in the northern quarter of the project area and to avoid all Unchannelled Valley-bottom Wetlands and Seeps, particularly those where African Marsh Harrier (EN) and African Grass Owl (VU) have been confirmed to occur (Figure 10).
- Relocate Overburden facilities and Haul Roads to avoid all High or Med-High ES vegetation communities.
- Minimum vegetation clearance should be ensured by clearing only those areas that are utilised for infrastructure construction, mining areas and entries and waste dumping activities. A “permit to clear” procedure should be established in order to control and monitor vegetation clearance. Where it is possible and permissibile to relocate protected plant species, permits should be applied for from the relevant authority and the “permit to clear” procedure should also apply.

- Close monitoring of all movements of equipment, site personnel and workers should be carried out so as to minimize unauthorised activities in any part of the project area.

6.1.2 Introduction/proliferation of alien invasive species

Areas of exposed soil created through construction activities could provide a platform for alien invasive species to become established. The presence of a significant seed-bank of alien species already present in the project area increases the likelihood of this impact occurring, particularly in areas such as cleared road verges. From the preparation phase, through construction and operation, the various vehicles and equipment entering the site could also be a source of further alien species being introduced to the project area. The frequency of this activity, as well as disturbance of natural habitat, will be frequent during the life of the operation, with the associated likelihood of the impact thus being high. The significance of the impact in vegetation communities of High or Med-High ES will be **High**. A well-prepared and actioned Alien Plant Management Plan is usually suitable mitigation that could reduce the impact significance to **Medium-Low**.

Project Activity		**Flora**	**Likelihood**		**Consequence**			
Clearing of Vegetation for Site Access and Infrastructure, Vehicle Acitivity along Haul Roads	*Phase of Project*	Preparation, Construction and Operational Phases	*Frequency of Activity*	*Frequency of Impact*	*Severity*	*Spatial Scope*	*Duration*	*Significance Rating*
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	**Introduction/proliferation of alien invasive species**	4	4	4	4	5	104
			Significance Post-Mitigation					
			4	4	2	2	5	72

Recommended Mitigation Measures

- An Invasive Alien Plant management plan will need to be established as part of the mine's Environmental Management Programme (EMPr). The objective of this plan should be the continuous eradication of existing invasive populations and the detection of new populations, particularly in newly or constantly disturbed areas such as roadsides.
- A small team of labourers should be trained in the identification of the key invasive alien plant species, as well as the safe and effective use of relevant herbicides on these species.
- The team should be equipped with adequate equipment such as knapsack sprayers, which should be stored in a safe location with the herbicides.

- Accurate and auditable records should be kept of areas cleared of invasive aliens and the success of follow-up operations, so that the program can be audited as part of the overall EMPr audit.

6.1.3 Illegal utilisation of flora resources

It is likely that a number of traditional medicinal plants occur in Natural Habitat in the project area. The influx of labour teams during the construction phase could result in an increase in illegal harvesting of medicinal plants by contractors. It is assumed that any labour teams will be accommodated in nearby towns and not on site, which would lower this risk considerably.

It is unlikely that this would take place on a large scale and the pre-mitigation significance of the impact is rated as **Med-Low,** with the measures recommended below reducing the significance to **Low**.

<table>
<tr><th>Project Activity</th><th></th><th>Flora</th><th colspan="2">Likelihood</th><th colspan="3">Consequence</th><th></th></tr>
<tr><td rowspan="5">All staff activities that take place outdoors</td><td>Phase of Project</td><td>Preparation, Construction and Operational Phases</td><td>Frequency of Activity</td><td>Frequency of Impact</td><td>Severity</td><td>Spatial Scope</td><td>Duration</td><td>Significance Rating</td></tr>
<tr><td>Impact Classification</td><td>Indirect Impact</td><td colspan="6">Significance Pre-Mitigation</td></tr>
<tr><td rowspan="3">Resulting Impact from Activity</td><td rowspan="3">Increased utilisation of plant resources as a result of an influx of people into the study area</td><td>3</td><td>3</td><td>2</td><td>3</td><td>5</td><td>60</td></tr>
<tr><td colspan="6">Significance Post-Mitigation</td></tr>
<tr><td>2</td><td>2</td><td>1</td><td>2</td><td>4</td><td>28</td></tr>
</table>

Recommended Mitigation Measures

- Contractor staff should be accommodated off-site, reducing the risk of illegal harvesting taking place after hours.
- Labour supervisors and SHE officials should monitor the activities of labourers when working away from infrastructure in natural habitat.
- Part of staff induction should be awareness of the consequences of being caught harvesting plant resources.

6.2 FAUNA

The following key impacts to fauna have been identified:

6.2.1 Disturbance/loss of threatened faunal habitat and associated Species of Conservation Concern

Over 50% of the project area comprises Untransformed Grassland and Unchannelled Valley-bottom Wetlands and Seeps, and these habitats are likely to support faunal assemblages with populations of SCC. Untransformed Grassland and Unchannelled Valley-bottom Wetlands and Seeps are also rated as having High Ecological Sensitivity, while Pans have Medium-High ES.

In addition, certain open-Cast Areas will result in destruction of Unchannelled Valley-bottom Wetlands in which two threatened bird species have been confirmed to occur, namely African Marsh Harrier (EN) and African Grass Owl (VU), resulting in a **High** impact significance rating. The only option within the mitigation hierarchy that could reduce the impact significance would be Avoidance. Avoiding these key wetlands would reduce the impact significance to **Moderate**.

Project Activity		**Flora**	**Likelihood**		**Consequence**			
Clearing of Vegetation for Site Access, Infrastructure Siting and Mining of Open Pit	*Phase of Project*	Preparation and Construction Phases	*Frequency of Activity*	*Frequency of Impact*	*Severity*	*Spatial Scope*	*Duration*	*Significance Rating*
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	**Disturbance/loss of threatened faunal habitat and associated Species of Conservation Concern**	5	5	5	2	5	120
			Significance Post-Mitigation					
			5	5	2	2	5	90

Recommended Mitigation Measures

The only viable option within the Mitigation Hierarchy (Avoid / Minimize / Restore / Offset) is Avoid. Applying the Minimize option would be in conflict with the MBSP, which considers open-cast mining to be an unacceptable in CBAs; thus, any open-cast areas within Untransformed Grassland or Unchannelled Valley-bottom Wetlands and Seeps would be an unacceptable option. It is highly unlikely that any Untransformed Grassland or Unchannelled Valley-bottom Wetlands and Seeps could be restored to pre-construction ecological state, even with extensive human intervention, invalidating the Restore option. The only way the Offset option would be viable is if adjacent or nearby relevant habitat with the relevant SCC is available for purchase for formal conservation. Since this investigation is beyond the scope of this study, the Offset option was not considered. However, destruction of habitat that has been designated as CBA: Irreplaceable cannot be mitigated by Offsets because by definition Irreplaceable Areas cannot be replaced and thus cannot be offset.

Avoidance is thus the only viable mitigation option as follows:

- Design open-cast areas to exclude the areas of Untransformed Grassland in the northern quarter of the project area and to avoid all Unchannelled Valley-bottom Wetlands and Seeps, particularly those where African Marsh Harrier (EN) and African Grass Owl (VU) have been confirmed to occur (Figure 10). Relocate Overburden facilities and Haul Roads to avoid all High or Med-High ES vegetation communities.
- Minimum vegetation clearance should be ensured by clearing only those areas that are utilised for infrastructure construction, mining areas and entries and waste dumping activities. A "permit to clear" procedure should be established in order to control and monitor vegetation clearance.
- Close monitoring of all movements of equipment, site personnel and workers should be carried out so as to minimize unauthorised activities in any part of the project area.

6.2.2 Illegal utilisation of faunal resources

The presence of a labour force within the project area will increase the risk of illegal utilisation of fauna resources, such as hunting of small antelope and trapping of small mammals. The frequency of the disturbing activities will be throughout the life of the operation. It is assumed that any labour teams will be accommodated in nearby towns and not on site, which would lower this risk considerably. Since mammal fauna are not present in significant concentrations, it is unlikely that this would take place on a large scale. The pre-mitigation significance of the impact is assessed as **Med-Low.** Implementation of the measures recommended below could reduce the significance to **Low**.

Project Activity		**Flora**	**Likelihood**		**Consequence**			
All staff activities that take place outdoors	*Phase of Project*	Construction and Operational Phases	*Frequency of Activity*	*Frequency of Impact*	*Severity*	*Spatial Scope*	*Duration*	*Significance Rating*
	Impact Classification	Indirect Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	**Illegal utilisation of animal resources as a result of an influx of people into the study area**	3	3	4	3	5	72
			Significance Post-Mitigation					
			2	2	2	3	5	40

Recommended Mitigation Measures

- Contractor staff should be accommodated off-site, reducing the risk of illegal harvesting taking place after hours.
- Labour supervisors and SHE officials should monitor the activities of labourers when working away from infrastructure in natural habitat.
- Part of staff induction should be awareness of the consequences of being caught harvesting faunal resources.

7. CONCLUSIONS

The Ilima Kranspan Project is situated in Eastern Highveld Grassland in a landscape that comprises a mosaic of Modified and Natural Habitat. Given the high level of transformation and low level of formal protection of Eastern Highveld Grassland, a conservation status of Endangered has been given by Mucina & Rutherford (2006) and the entire vegetation type is a listed Threatened Ecosystem that has been classified as Vulnerable. As a result, any areas of Natural Habitat within this vegetation type are considered to have high conservation value and have been designated as Critical Biodiversity Areas in the MBSP. The site-specific Ecological Sensitivity analysis confirmed these areas to have high sensitivity and several threatened species were located during fieldwork in grassland (*Khadia carolinensis*) and wetland habitat (African Grass Owl, African Marsh Harrier).

While the mine infrastructure and open-cast pit layout have undergone several revisions, there are still areas that are located in Natural Habitat that have been designated as CBAs by the MBSP. **Open-cast mining is considered to be an incompatible landuse in CBAs by the MBSP.** While the areas that are classified as CBA: Optimal could potentially be mitigated by offsets, this would have to be the subject of a larger scale study on adjacent and nearby properties to identify potential options that would need to be adequately surveyed to determine whether they qualify as offsets or not. Areas classified as CBA: Irreplaceable cannot be mitigated through the Offset option and can only be sufficiently mitigated through Avoidance. If no further revisions of the layout are to be considered then there are parts of the mine plan that are in conflict with the landuse guidelines of the MBSP and the impacts in these areas cannot be reduced through any of the other mitigation options in the Mitigation Hierarchy.

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9. APPENDICES

Appendix 1. List of Plants recorded in the Project Area during fieldwork

Appendix 2. Timed-Meander Search Raw Data

Appendix 3. Timed-Meander Search Locality Data

Appendix 4. Plant Species of Conservation Concern potentially occurring in the Project Area

Appendix 5. List of Fauna recorded in the Project Area during fieldwork

Appendix 6. MacKinnon List Raw Data

Appendix 7. Fauna Species of Conservation Concern potentially occurring in the Project Area

Appendix 8. CV of Report Author

APPENDIX 1. LIST OF PLANTS RECORDED FROM THE PROJECT AREA DURING FIELDWORK

Taxa	Growth Form	Red Data	Protected	Vegetation Communities						
				Outcrop Shrubland	Untransformed Grassland	Untransformed Grassland with Sheetrock	Pans	Unchannelled Valley-bottom Wetlands and Seeps	Depression Wetlands	Transformed / Degraded/ Crops
Family Acanthaceae										
Blepharis innocua C.B.Clarke	herb					+				
Crabbea acaulis N.E.Br.	herb			+	+	+				
Justicia anagalloides (Nees) T.Anderson	herb			+	+	+				
Family Agavaceae										
Chlorophytum cooperi (Baker) Nordal	herb			+	+	+				
Chlorophytum sp.	herb			+						
Family Aizoaceae										
Delosperma sutherlandii (Hook.f.) N.E.Br.	succulent			+	+	+				
Khadia carolinensis L. Bolus	succulent	VU				+				
Family Amaranthaceae										
* *Amaranthus hybridus* L.	herb			+						+
Cyathula cylindrica Moq.	herb			+						
* *Gomphrena celosioides* Mart.	herb			1	+					+
Family Amaryllidaceae										
Boophone disticha (L.f.) Herb.	bulb		MNCA		+					
Brunsvigia radulosa Herb.	bulb		MNCA		+	+				
Haemanthus humilis Jacq. subsp. *hirsutus* (Baker) Snijman	bulb		MNCA			+				
Family Anacardiaceae										
*Searsia dentata (*Thunb.) F.A.Barkley	shrub			+		+				

Searsia tumulicola (S.Moore) Moffett var. *meeuseana* (R.Fern. & A.Fern.) Moffett forma *pumila* (Moffett) Moffett	shrub			+						
Family Apiaceae										
Afrosciadium magalismontanum (Sond.) P.J.D.Winter	herb					+				
Centella asiatica (L.) Urb.	herb			1	1	+	1	1	+	
Family Apocynaceae										
Ancylobotrys capensis (Oliv.) Pichon	herb					+				
Asclepias albens (E.Mey.) Schltr.	herb				+	+				
Asclepias gibba (E.Mey.) Schltr.	herb				+					
Asclepias stellifera Schltr.	herb				+					
Gomphocarpus fruticosus (L.) W.T.Aiton	herb			+						
Schizoglossum periglossoides Schltr.	herb				+					
Family Aponogetonaceae										
Aponogeton junceus Lehm. ex Schltdl.	herb								+	
Family Asparagaceae										
Asparagus laricinus Burch.	dwarf shrub			+						
Family Asphodelaceae										
Aloe ecklonis Salm-Dyck	succulent		MNCA			1				
Trachyandra asperata Kunth	herb					+				
Family Aspleniaceae										
Asplenium cf. *cordatum*	fern			+						
Family Asteraceae										
Aster sp.	herb					+				
Asteraceae sp. (no flowers)	herb					+				
Berkheya insignis (Harv.) Thell.	herb			+	+					
Berkheya radula (Harv.) De Wild.	herb				+					
Berkheya setifera DC.	herb			+	+	+				
* *Bidens bipinnata* L.	herb			+						+
* *Bidens pilosa* L.	herb			+						1
Blumea axillaris (Lam.) DC.	herb									+
Callilepis laureola DC.	herb			+						
* *Cirsium vulgare* (Savi) Ten.	herb			+	+		+	+		+
Conyza sp.	herb					+				
* *Cosmos bipinnatus* Cav.	herb			+	+		+			1
Cotula anthemoides L.	herb			+		+	+			
* *Crepis hypochaeridea* (DC.) Thell.	herb			+	+					

Denekia capensis Thunb.	herb							+	+	
Dicoma anomala Sond.	herb			+	+					
* *Erigeron sumatrensis* Retz.	herb			+	1	+	+	+		1
Euryops laxus (Harv.) Burtt Davy	herb			+		+				+
Felicia filifolia (Vent.) Burtt Davy	herb			+						
Felicia muricata (Thunb.) Nees	herb			+						
Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessler	herb			+	+	+				
Gerbera ambigua (Cass.) Sch.Bip.	herb				+					
Haplocarpha lyrata Harv.	herb				1					
Haplocarpha scaposa Harv.	herb			+	+	+				
Helichrysum aureonitens Sch.Bip.	herb				1	+	1	1	+	
Helichrysum caespititium (DC.) Harv.	herb			+						
Helichrysum cephaloideum DC.	herb			+						
Helichrysum coriaceum (DC.) Harv.	herb						+	+		
Helichrysum oreophilum Klatt	herb				+	+				
Helichrysum pilosellum (L.f.) Less.	herb			+	+	+				
Helichrysum rugulosum Less.	herb			1	1	1				
Helichrysum sp.	herb				+					
Hilliardiella aristata (DC.) H.Rob.	herb			+	1					
Hilliardiella oligocephala (DC.) H.Rob.	herb				1	1				
Hypochaeris radicata L.	herb			1	1	1	+	+		+
Nidorella anomala Steetz	herb				+	+				
Nidorella auriculata DC.	herb			+	+			+		
Nidorella pinnata (L.f.) J.C.Manning & Goldblatt	herb					+		+		
Senecio consanguineus DC.	herb				+	+				
Senecio erubescens Aiton	herb				+					
Senecio cf. harveyanus	herb			+						
Senecio cf. *inaequidens*	herb							+		
Senecio latifolius DC.	herb								+	
Senecio sp.	herb			+						
Senecio madagascariensis Poir.	herb				+		+			+
Seriphium plumosum L.	dwarf shrub			1	2	1	+			
* *Sonchus oleraceus* (L.) L.	herb				+		+			
Family Brassicaceae										
* *Raphanus raphanistrum* L.	herb									+
Family Campanulaceae										

Wahlenbergia denticulata (Burch.) A.DC. var. *transvaalensis* (Adamson) W.G.Welman	herb			+	1	+	+	+		
Wahlenbergia virgata Engl.	herb				+					
Family Capparaceae										
Cleome monophylla L.	herb			+		+				
Family Caryophyllaceae										
Dianthus mooiensis F.N.Williams subsp. *mooiensis* var. *dentatus* Burtt Davy	herb			+	+					
Silene burchellii Otth	herb					+				
Family Commelinaceae										
Commelina africana L. var. *africana*	herb				1	+	+	+		
Commelina africana L. var. *krebsiana* (Kunth) C.B.Clarke	herb			+		+				
Cyanotis lapidosa E.Phillips	herb			+						
Cyanotis speciosa (L.f.) Hassk.	herb					+				
Family Convolvulaceae										
* *Cuscuta* sp.	climber			+		+				
Ipomoea bathycolpos Hallier f.	creeper					+				
Ipomoea oblongata E.Mey. ex Choisy	creeper			+		2				
Family Crassulaceae										
Crassula capitella Thunb.	succulent					+				
Crassula cf. *inanis*	succulent								+	
Crassula lanceolata (Eckl. & Zeyh.) Endl.	succulent			1		+				
Crassula pellucida L.	succulent								+	
Crassula setulosa Harv. var. *setulosa*	succulent			+						
Crassula vaginata Eckl. & Zeyh.	succulent				+	1				
Family Cucurbitaceae										
Cucumis hirsutus Sond.	creeper				+					
Family Cyperaceae										
Bulbostylis hispidula (Vahl) R.W.Haines	sedge				+		+			
Bulbostylis humilis (Kunth) C.B.Clarke	sedge			+						
Cyperaceae sp.1	sedge						1	+		
Cyperaceae sp.2	sedge			+	+			+		
Cyperus compressus L.	sedge				+		1	1	1	
Cyperus denudatus L.f.	sedge						1	1		
* *Cyperus esculentus* L.	sedge									1
Cyperus fastigiatus Rottb.	sedge							+		
Cyperus rupestris Kunth	sedge			1		1				
Cyperus sphaerocephalus Vahl	sedge				+	+				
Cyperus sp.1	sedge							+		

Cyperus sp.2	sedge				+			+		
Eleocharis dregeana Steud.	sedge								2	
Fimbristylis complanata (Retz.) Link	sedge					+				
Fuirena pubescens (Poir.) Kunth var. *pubescens*	sedge						+			
Isolepis costata Hochst. ex A.Rich.	sedge						+			
Kyllinga erecta Schumach.	sedge			+		+	1	1		
Kyllinga melanosperma Nees	sedge							1	+	
Kyllinga sp.1	sedge						1			
Kyllinga sp.2	sedge							1		
Pycreus nitidus (Lam.) J.Raynal	sedge							2		
Rhynchospora brownii Roem. & Schult.	sedge								+	
Schoenoplectus corymbosus (Roth ex Roem. & Schult.) J.Raynal	sedge						1		2	
Schoenoplectus sp.	sedge						1			
Scirpoides burkei (C.B.Clarke) Goetgh., Muasya & D.A.Simpson	sedge			+	1	1	+			
Scleria sp.	sedge			+						
Family Dipsacaceae										
Scabiosa columbaria L.	herb				+					
Family Droseraceae										
Drosera burkeana Planch.	herb						+			
Family Ebenaceae										
Diospyros lycioides Desf. subsp. *guerkei* (Kuntze) De Winter	shrub			3		1				
Family Ericaceae										
Erica drakensbergensis L.Guthrie & Bolus	dwarf shrub				+					
Family Euphorbiaceae										
Acalypha angustata Sond.	herb				1					
Acalypha villicaulis Müll.Arg.	herb					1				
Clutia natalensis Bernh.	herb					+				
Euphorbia clavarioides Boiss.	succulent				+					
Euphorbiaceae sp.	herb					+				
Family Fabaceae										
Aeschynomene sp. (no flowers)	herb					+				
* *Acacia mearnsii* De Wild.	tree									1
Argyrolobium tuberosum Eckl. & Zeyh.	herb							+		
Chamaecrista mimosoides (L.) Greene	herb				+					
Crotalaria sp.	herb						1			
Eriosema sp.1	herb			+						

Eriosema sp.2	dwarf shrub					+				
Erythrina zeyheri Harv.	dwarf shrub			+	+					
* *Glycine max* (L.) Merr.	herb									3
Indigofera comosa N.E.Br.	herb				+	1				
Indigofera hilaris Eckl. & Zeyh. var. *hilaris*	herb			+	+	1				
Indigofera hedyantha Eckl. & Zeyh.	herb			+	1	1				
Indigofera sp.	herb			+						
Leobordea foliosa (Bolus) B.-E.van Wyk & Boatwr.	herb					+				
Lotononis sp.	herb			+		+				
Rhynchosia monophylla Schltr.	creeper			+						
Rhynchosia sp.	herb			+						
Tephrosia capensis (Jacq.) Pers.	herb				+					
Tephrosia elongata E.Mey. var. *elongata*	herb					+				
Trifolium africanum Ser. var. *lydenburgense* J.B.Gillett	herb						+	+		
Vigna vexillata (L.) A.Rich.	climber			+		+				
Zornia capensis Pers.	herb			+	+	+				
Zornia milneana Mohlenbr.	herb					+				
Family Fagaceae										
* *Quercus robur* L.	tree									+
Family Gentianaceae										
Chironia palustris Burch. subsp. *transvaalensis* (Gilg) I.Verd.	herb				+		+	+		
Family Geraniaceae										
Monsonia angustifolia E.Mey. ex A.Rich.	herb				+					
Pelargonium luridum (Andrews) Sweet	herb				+	+		+		
Pelargonium sp.	herb				+					
Family Hyacinthaceae										
Albuca setosa Jacq.	geophyte				+					
Albuca shawii Baker	geophyte			+						
Dipcadi cf. *marlothii*	geophyte				+					
Eucomis autumnalis subsp. *clavata* (Baker) Reyneke	geophyte		MNCA			1				
Ledebouria cooperi (Hook.f.) Jessop	geophyte							1		
Ledebouria ovatifolia (Baker) Jessop	geophyte			1	1	1				
Ledebouria revoluta (L.f.) Jessop	geophyte							+		
Ornithogalum flexuosum (Thunb.) U.Müll.-Doblies & D.Müll.-Doblies	geophyte							+	+	
Schizocarpus nervosus (Burch.) van der Merwe form	geophyte				+					
Family Hydrocharitaceae										

Lagarosiphon muscoides Harv.	herb							+	+	
Family Hypericaceae										
Hypericum aethiopicum Thunb. subsp. *sonderi* (Bredell) N.Robson	herb				+			+	+	
Hypericum lalandii Choisy	herb				+			+		
Family Hypoxidaceae										
Hypoxis filiformis Baker	geophyte			+						
Hypoxis iridifolia Baker	geophyte			+		+				
Hypoxis obtusa Burch. ex Ker Gawl.	geophyte				+					
Hypoxis rigidula var. *pilosissima* Baker	geophyte			+	+	+				
Hypoxis rigidula Baker var. *rigidula*	geophyte				+					
Family Iridaceae										
Aristea torulosa Klatt	geophyte				+		+		+	
Gladiolus crassifolius Baker	geophyte		MNCA			+				
Gladiolus dalenii Van Geel subsp. *dalenii*	geophyte		MNCA	+						
Gladiolus papilio Hook.f.	geophyte		MNCA					+		
Gladiolus permeabilis F.Delaroche	geophyte		MNCA		+	+				
Watsonia pulchra N.E.Br. ex Goldblatt	geophyte				+					
Family Juncaceae										
Juncus dregeanus Kunth subsp. *dregeanus*	sedge								+	
Juncus oxycarpus E.Mey. ex Kunth	sedge						1	1	1	
Family Lamiaceae										
Aeollanthus buchnerianus Briq.	herb			1						
Leonotis ocymifolia (Burm.f.) Iwarsson	herb			+						
Ocimum obovatum E.Mey. ex Benth.	herb			+	+	+				
Ocimum sp.	herb			1						
*Stachys natalens*is Hochst. var. *galpinii* (Briq.) Codd	herb				+					
Family Lentibulariaceae										
Utricularia prehensilis E.Mey.	herb							+		
Utricularia sp.	herb								+	
Family Linderniaceae										
Craterostigma wilmsii Engl. ex Diels	herb			+						
Lindernia wilmsii (Engl. & Diels) Philcox	herb			+		+				
Family Lobeliaceae										
Lobelia erinus L.	herb						+			
Lobelia flaccida (C.Presl) A.DC.	herb			+	1	+	+	1		
Monopsis decipiens (Sond.) Thulin	herb			+	+	+	+	+		
Family Malvaceae										

Corchorus confusus Wild	herb				+					
Hermannia sp.	herb				+					
Hibiscus aethiopicus L. var. *ovatus* Harv.	herb			+		+				
* *Hibiscus trionum* L.	herb				+			+		
Family Marsileaceae										
Marsilea cf. *capensis*	fern						+			
Family Menispermaceae										
Stephania abyssinica (Quart.-Dill. & A.Rich.) Walp.	climber			1						
Family Menyanthaceae										
Nymphoides indica (L.) Kuntze	herb								+	
Nymphoides thunbergiana (Griseb.) Kuntze	herb							+	1	
Family Molluginaceae										
Psammotropha mucronata (Thunb.) Fenzl var. *foliosa* Adamson	herb			+						
Psammotropha myriantha Sond.	herb			+	+	+				
Family Myrtaceae										
* *Eucalyptus camaldulensis* Dehnh.	tree									1
Family Onagraceae										
* *Oenothera rosea* L'Hér. ex Aiton	herb				+	+				
Family Orchidaceae										
Disa versicolor Rchb.f.	herb		MNCA		+		+	+	+	
Eulophia foliosa (Lindl.) Bolus	herb		MNCA		+			+		
Eulophia hians Spreng. var. *hians*	herb		MNCA			+				
Satyrium sp. (no flowers)	herb		MNCA			+				
Family Orobanchaceae										
Buchnera sp.	herb				+		+			
Buchnera reducta Hiern	herb				+					
Cycnium tubulosum (L.f.) Engl.	herb						+	+		
Striga bilabiata (Thunb.) Kuntze subsp. *bilabiata*	herb					+				
Striga elegans Benth.	herb					+				
Family Oxalidaceae										
Oxalis corniculata L.	herb			+				+		
Oxalis obliquifolia Steud. ex A.Rich.	herb				+					
Family Papaveraceae										
Papaver aculeatum Thunb.	herb			+	+					+
Phrymaceae										
Mimulus gracilis R.Br.	herb				+					
Family Plantaginaceae										

Plantago major L.	herb			+	+	+				
Family Poaceae										
Agrostis eriantha Hack.	grass				+		3	2		
Agrostis lachnantha Nees var. *lachnantha*	grass							1		
Alloteropsis semialata (R.Br.) Hitchc.	grass			+	1	1				
Andropogon eucomus Nees	grass						2	+		
Aristida adscensionis L.	grass				1					
Aristida diffusa Trin.	grass				+					
Aristida junciformis Trin. & Rupr.	grass			2	1	1		+		
Aristida sciurus Stapf	grass						1			
Aristida sp.	grass				+					
Arundinella nepalensis Trin.	grass							2	1	
Bothriochloa bladhii (Retz.) S.T.Blake	grass				+			1		
Brachiaria serrata (Thunb.) Stapf	grass			+						
Calamagrostis epigejos (L.) Roth	grass						1	+		
Chloris virgata Sw.	grass						+			
Ctenium concinnum Nees	grass					+				
Cymbopogon caesius (Hook. & Arn.) Stapf	grass						+			
* *Cymbopogon pospischilii* (K.Schum.) C.E.Hubb.	grass			1		1				
Cynodon dactylon (L.) Pers.	grass			1	+		1		+	1
Digitaria eriantha Steud.	grass					+				
Digitaria tricholaenoides Stapf	grass				1					
Diheteropogon filifolius (Nees) Clayton	grass					+				
Eleusine coracana (L.) Gaertn.	grass									+
Elionurus muticus (Spreng.) Kunth	grass				+					
Eragrostis capensis (Thunb.) Trin.	grass				+	+				
Eragrostis chloromelas Steud.	grass			+	2	1				
Eragrostis curvula (Schrad.) Nees	grass			1	2	+				+
Eragrostis gummiflua Nees	grass			1	2	1		+		
Eragrostis plana Nees	grass			3	3	2	1	+		+
Eragrostis racemosa (Thunb.) Steud.	grass			2	1	2				
Eragrostis sp.	grass					1				
Harpochloa falx (L.f.) Kuntze	grass					+				
Helictotrichon imberbe (Nees) Veldkamp	grass				1					
Hemarthria altissima (Poir.) Stapf & C.E.Hubb.	grass							1	+	
Heteropogon contortus (L.) Roem. & Schult.	grass			1	1	+				+
Hyparrhenia sp. (no flowers)	grass				+					

Imperata cylindrica (L.) Raeusch.	grass			+			2	1		
Leersia hexandra Sw.	grass						3	3	3	
Loudetia simplex (Nees) C.E.Hubb.	grass					+				
Melinis nerviglumis (Franch.) Zizka	grass			2		1				
Melinis repens (Willd.) Zizka	grass			2	+	1				+
Microchloa caffra Nees	grass			1		+				
Miscanthus junceus (Stapf) Pilg.	grass						1	1		
Monocymbium ceresiiforme (Nees) Stapf	grass				+					
Panicum natalense Hochst.	grass				1	1				
Panicum schinzii Hack.	grass									1
Panicum sp.	grass			+						
Paspalum dilatatum Poir.	grass						1	1		
Paspalum scrobiculatum L.	grass							+		
* *Paspalum urvillei* Steud.	grass							+		
Phragmites australis (Cav.) Trin. ex Steud.	reed							+		
Pennisetum sphacelatum (Nees) T.Durand & Schinz	grass							1		
Pennisetum clandestinum Hochst. ex Chiov.	grass									1
Poaceae sp.1	grass			+						
Poaceae sp.2	grass						+			
Poaceae sp.3	grass							2		
Poaceae sp.4	grass				1					
Pogonarthria squarrosa (Roem. & Schult.) Pilg.	grass					+				
Rendlia altera (Rendle) Chiov.	grass				+					
Setaria nigrirostris (Nees) T.Durand & Schinz	grass						+	+		
Setaria sphacelata (Schumach.) Stapf & C.E.Hubb. ex M.B.Moss	grass			+	+	+				
Setaria sp.	grass			+	+					
Sporobolus africanus (Poir.) Robyns & Tournay	grass			1	1	+				
Sporobolus pectinatus Hack.	grass			1						
Themeda triandra Forssk.	grass			1	2	2				
Trachypogon spicatus (L.f.) Kuntze	grass			+	+					
Trichoneura grandiglumis (Nees) Ekman	grass				+					
Tristachya leucothrix Trin. ex Nees	grass				1					
Tristachya sp.	grass				+					
* *Zea mays* L.	grain									3
Family Polygalaceae										
Polygala africana Chodat	herb						+			
Polygala hottentotta C. Presl	herb				+					

Polygala transvaalensis Chodat	herb				+					
Family Polygonaceae										
Oxygonum dregeanum Meisn. subsp. *canescens* (Sond.) Germish. var. *canescens*	herb				+					
Persicaria decipiens (R.Br.) K.L.Wilson	herb							+	+	
Persicaria lapathifolia (L.) Gray	herb							+		
Persicaria sp.	herb								+	
* *Rumex acetosella* L. subsp. *angiocarpus* (Murb.) Murb.	herb			+	+	1		1		
* *Rumex crispus* L.	herb				+			+		
Family Portulacaceae										
* *Portulaca oleracea* L.	succulent			+						
Portulaca sp.	succulent						1			
Family Potemogetonaceae										
Potamogeton nodosus Poir.	herb							+	+	
Family Pteridaceae										
Cheilanthes viridis Sw.	fern			+		+				
Pellaea calomelanos (Sw.) Link	fern			+		+				
Pityrogramma argentea (Willd.) Domin	fern			1						
Family Ranunculaceae										
* *Ranunculus multifidus* Forssk.	herb							+		
Family Rosaceae										
* *Agrimonia procera* Wallr.	herb			+						
Cliffortia repens Schltr.	shrub			+	+					
* *Rubus* sp.	dwarf shrub			+						
Family Rubiaceae										
Anthospermum herbaceum L.f.	shrub			+	+					
Anthospermum rigidum Eckl. & Zeyh.	dwarf shrub					+				
Canthium gilfillanii O. B. Miller	dwarf shrub			+		+				
Oldenlandia herbacea (L.) Roxb.	herb			1		+				
Pentanisia angustifolia (Hochst.) Hochst.	herb			+	+	+				
Pentanisia prunelloides (Klotzsch) Walp.	herb				+					
Pygmaeothamnus chamaedendrum (Kuntze) Robyns var. *chamaedendrum*	herb			1	+	+				
* *Richardia brasiliensis* Gomes	herb			1	1	1	+			+
Family Ruscaceae										
Eriospermum cooperi Baker var. *cooperi*	geophyte			+						
Eriospermum porphyrovalve Baker	geophyte			+		+				

Family Salicaceae										
* *Salix babylonica* L.	tree									+
Family Santalaceae										
Thesium sp.	herb			+	+	+				
Family Scrophulariaceae										
Chaenostoma floribundum Benth.	herb			1						
Chaenostoma neglectum J.M.Wood & M.S.Evans	herb					+				
Chaenostoma sp.	herb			+						
Diclis rotundifolia (Hiern) Hilliard & B.L.Burtt	herb			+						
Hebenstretia angolensis Rolfe	herb			+						
Nemesia fruticans (Thunb.) Benth.	herb			+	+			+		
Selago densiflora Rolfe	herb			+	+					
Selago sp.	herb				+					
Zaluzianskya sp.	herb			+						
Family Selaginellaceae										
Selaginella dregei (C. Presl) Hieron.	fern			1		1				
Family Solanaceae										
* *Datura stramonium* L.	herb									+
* *Physalis peruviana* L.	herb			+						
* *Solanum elaeagnifolium* Cav.	herb				+	+				
* *Solanum nigrum* L.	herb			+						
* *Solanum sisymbriifolium* Lam.	herb			2	+	+				
Family Thymelaeaceae										
Gnidia fastigiata Rendle	herb					+				
Family Typhaceae										
Typha capensis (Rohrb.) N.E.Br.	rush							+		
Family Verbenaceae										
* *Verbena bonariensis* L.	herb				+	+	+	+		
* *Verbena tenuisecta* Briq.	herb									
Family Xyridaceae										
Xyris sp.	herb						+			
Total	**341**	**1**	**13**	**138**	**145**	**126**	**56**	**73**	**29**	**30**

VU = Vulnerable
MNCA = Mpumalanga Nature Conservation Act
* = alien plant species

APPENDIX 2. TIMED-MEANDER SEARCH RAW DATA

Species	Vegetation Community														
	Outcrop Shrubland	Pan	Unchannelled Valley-bottom Wetland	Pan	Outcrop Shrubland	Pan	Depression Wetland	Untransformed Grassland	Grassland with Sheetrock	Grassland with Sheetrock	Untransformed Grassland	Unchannelled Valley-bottom Wetland	Outcrop Shrubland	Untransformed Grassland	Unchannelled Valley-bottom Wetland
	Timed Meander Search No.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acalyphya angustata				1										1	
Acalypha vilicaulis										1					
Aeollanthus buchnerianus					1								+		
Aeschynomene sp. (no flowers)										+					
Afrosciadium magalismontanum										+					
Agrimonia procera					+										
Agrostis eriantha		3	2			3		+			+	2			2
Agrostis lachnantha			1									+			1
Albuca setosa				+											
Alloteriopsis semialata				1						1			+		
Aloe ecklonis										1					
Amaranthus hybridus					+										
Ancylobotrys capensis										+					
Andropogon eucomus		2	+			1									
Anthospermum herbaceum	+													+	
Anthospermum rigidum										+					

Aponogeton junceus							+								
Argyrolobium tuberosum															+
Aristea torulosa		+		+				+			+				
Aristida adscensionis				1				1						+	
Aristida diffusa											+				
Aristida junciformis	+				1			2	1		1	+	2	1	
Aristida sciurus		1													
Aristida sp.								+							
Arundinella nipalensis							1					1			2
Asclepias albens										+	+				
Asclepias gibba				+											
Asparagus laricinus	+				+								+		
Asplenium cf. *cordatum*													+		
Aster sp.										+					
Asteraceae sp.1										+					
Berkheya insignis	+							+							
Berkheya radula														+	
Berkheya setifera				+	+					+					
Bidens bipinnata	+				+										
Bidens pilosa					+								+		
Blumea axillaris															+
Bothriochloa bladhii				+				1				1			+
Brachiaria serrata					+										
Brunsvigia radulosa								+							
Buchnera reducta		+													
Buchnera sp.								+							
Bulbostylis hispidula						+							+	+	
Bulbostylis humilis	+												+		
Calamagrostis epigejos						1						+			
Callilepis laureola					+										
Canthium gilfillanii					+					+					
Centella asiatica	1	1	1	1		1		+		+		1		+	1
Chaenostoma floribundum	+												1		
Chaenostoma neglectum										+					
Cheilanthes viridis	+				+										
Chironia palustris			+			+					+	+			

Chloris virgata		+													
Chlorophytum cooperi					+			+		+			+	+	
Cirsium vulgare			+		+	+						+	+		+
Cleome monophylla					+					+					
Cliffortia repens	+													+	
Clutia natalensis										+					
Commelina africana	+			+	+			+	+	+	1	+	+		+
Conyza sp.									+						
Cosmos bipinnatus					+	+									
Cotula anthemoides	+					+				+					
Crabbea acaulis					+						+		+		
Crassula capitella										+					
Crassula cf. inanis							+								
Crassula lanceolata					1					+			+		
Crassula pellucida							+								
Crassula setulosa					+								+		
Crassula vaginata										1					
Craterostigma wilmsii					+										
Crepis hypochaeridea													+	+	
Crotalaria sp.						1									
Ctenium concinnum									+						
Cuscuta sp.					+					+					
Cyanotis lapidosa					+								+		
Cyanotis speciosa										+					
Cyathula cylindrica	+				+										
Cycnium tubulosum		+													
Cymbopogon caesius						+									
Cymbopogon pospischilii					1					1			1		
Cynodon dactylon	1	1			+	1	1						+		
Cyperaceae sp.1						2									+
Cyperaceae sp.2					+							+		+	
Cyperus compressus		1	1			1	1				+	1			+
Cyperus denudatus		1	+			1						1			+
Cyperus fastigiatus															+
Cyperus rupestris					1				1	+			1		
Cyperus sp. 1															+

Cyperus sp. 2											+	+			
Cyperus sphaerocephalus										+					
Delosperma sutherlandii	+			+	+				+	+	+			+	
Denekia capensis			+				+					+			+
Dianthus mooiensis				+	+						+				
Diclis rotundifolia	+												+		
Dicoma anomala	+			+										+	
Digitaria eriantha										+					
Digitaria tricholaenoides				1											
Diheteropogon filifolius									+						
Diospyros lycioides	1				3				1	+			3		
Dipcadi marlothii											+				
Disa versicolor		+		+			+					+			
Drosera burkeana		+													
Eleocharis dregeana							2								
Eragrostis capensis									+		1				
Eragrostis chloromelas	1			2				2	2	1				+	
Eragrostis curvula	1			2				1			1		+	2	
Eragrostis gummiflua	+			+	+			3		1	1		2	1	
Eragrostis plana	3	1	1	3	2	1		3	3	1	3	+	1	3	+
Eragrostis racemosa	2			1	2				2	1	1		1	1	
Eragrostis sp.									1						
Erica drakensbergensis											+				
Erigeron sumatrensis	1	+		+	+	+		+	+	+	+	+	+	+	
Eriosema sp.1	+														
Eriosema sp.2										+					
Eriospermum cooperi					+										
Eriospermum porphyrovalve									+				+		
Erythrina zeyheri	+														
Eucomis autumnalis										1					
Eulophia foliosa				+				+							
Eulophia hians										+					
Euphorbiaceae sp.										+					
Euryops laxus	+				+					+			+		
Felicia filifolia	+														
Felicia muricata	+														

Fimbristylis complanata										+					
Fuirena pubescens						+									
Gerbera ambigua	+								+						
Gladiolus crassifolius										+					
Gladiolus dalenii					+										
Gladiolus papilio			+									+			+
Gladiolus permeabilis				+						+					
Gnidia fastigiata									+						
Gomphocarpus fruticosus	+				+										
Gomphrena celosioides	+				1										
Haemanthus hirsutus									+						
Haplocarpa lyrata				1				1						+	
Haplocarpa scaposa	+				+				1						
Harpochloa falx										+					
Hebenstretia angolensis	+														
Helichrysum aureo-nitens		1	1			1	+	1		+	1				
Helichrysum caespititum	+														
Helichrysum coriaceum		+										+			
Helichrysum oreophilum				+						+					
Helichrysum pilosellum	+									+				+	
Helichrysum rugulosum	1			1					1					1	
Helichrysum sp.														+	
Helictotrichon imberbe				+				1							
Heteropogon contortus					1			1		+	1		+	+	
Hibiscus aethiopicus	+									+					
Hilliardiella aristata	+			1											
Hilliardiella oligocephala				1						1					
Hyparrhenia sp. (no flowers)														+	
Hypericum aethiopicum							+				+				
Hypericum lalandii											+				
Hypochaeris radicata	+			1		+		+	1	+	1	+	+	1	
Hypoxis filiformis					+										
Hypoxis rigidula var. *pilosissima*	+							+							
Hypoxis rigidula var. *rigidula*											+				
Imperata cylindrica	+	1				2						1			
Indigofera comosa										1	+				

Indigofera hedyantha					+					1	1			+	
Indigofera sp. (no flowers)					+										
Ipomoea oblongata					+					2					
Isolepis costata		+													
Juncus dregeanus							+								
Juncus oxycarpus			1			1	1					+			+
Justicia anagalloides	+								+	+	+				
Khadia carolinense									+						
Kyllinga erecta		1	1		1	1				+		1	+		
Kyllinga melanosperma							+								1
Kyllinga sp. 1		1													
Kyllinga sp. 2			1									1			
Lagarosiphon muscoides			+				+								+
Ledebouria cooperi			+									1			1
Ledebouria ovatifolia					1			1	1		+		+		
Ledebouria revoluta			+												
Leersia hexandra		2	3			3	3					2			3
Leobordea foliosa										+					
Leonotis ocymifolia	+				+								+		
Lindernia wilmsii					+				+						
Lobelia erinus		+													
Lobelia flaccida		+		+	+			1		+	+	1	+	+	
Lotononis sp.	+									+			+		
Marsilea cf. *capensis*						+									
Melinis nerviglumis	1									1			2		
Melinis repens	2				2				1	1			+		
Michrochloa caffra	1									+			1		
Miscanthus junceus						1									1
Monopsis decipiens		+	+			+		+	+	+	+	+			+
Monsonia angustifolia											+				
Nemesia fruticans					+										
Nidorella anomala										+				+	
Nidorella auriculata	+			+				+							
Nidorella pinnata										+					+
Nymphoides indica							+								
Nymphoides thunbergiana			+				1								+

Ocimum obovatum	+				+				+	+				+	
Ocimum sp.	1												+		
Oenothera rosea				1				+	+						
Oldenlandia herbacea	1				1				+	+			+		
Ornithogalum flexuosum							+								
Oxalis corniculata	+		+												
Oxalis obliquifolia								+							
Panicum natalesis										1	2			+	
Panicum sp.													+		
Papaver aculeatum					+										
Paspalum dilatatum						1						1			+
Paspalum scrobiculatum			+												+
Pelargonium luridum								+		+		+			+
Pellaea calomelanos	+				+				+				+		
Pennisetum sphacelatum															1
Pentanisia angustifolia	+			+						+	+			+	
Pentanisia prunelloides				+				+							
Persicara lapathifolia			+												
Persicaria decipiens															+
Persicaria sp.							+								
Physalis peruviana	+														
Pityrogramma argentea					1								1		
Plantago major	+		+	+				+	+	+	1			+	
Poaceae sp.1	+														
Poaceae sp.2		+				+									
Poaceae sp.3												2			
Poaceae sp.4				1											
Polygala africana		+													
Polygala hottentotta														+	
Portulaca oleraceae					+										
Portulaca sp.		+				1									
Potamogeton nodosus			+				+								
Psammotropha mucronata	+				+										
Psammotropha myriantha					+				+						
Pycreus nitidus															2
Pygmaeothamnus chamaedendrum					+					+	1		1		

Rhynchosia monophylla					+										
Richardia brasiliensis	2	+		1					1		1		+	1	
Rubus sp.					+										
Rumex acetosella			1	1				1	1	+	+		+	+	
Rumex crispus								+							
Satyrium sp. (no flowers)										+					
Scabiosa columbaria				+							+				
Schizocarpus nervosa form											+				
Scirpoides burkei	1	+							1	1	1				
Schoenoplectus corymbosus		+				1	2								
Schoenoplectus sp.						1									
Searsia dentata	+				+				+				+		
Searsia tumulicola var. *meeuseana*					+								+		
Selaginella dregei					1				1				+		
Selago densiflora	+			+										+	
Senecio consanguineus				+				1	+	+					
Senecio erubescens											+				
Senecio cf. *harveianus*													+		
Senecio cf. *inaequidens.*												+			+
Senecio latifolius							+								
Senecio madagascariensis		+				+									
Seriphium plumosum	1	+		1					2		+		+	2	
Setaria nigrirostris						+						+			
Setaria sp.	+		+												
Setaria sphacelata					1				+	1			+		
Silene burchellii										+					
Solanum elaeagnifolium													+	+	
Solanum nigrum					+								+		
Solanum sisymbriifolium	2			+	+				+	+			+	+	
Sonchus oleraceus						+					+				
Sporobolus africanus				1	1										
Sporobolus pectinatus	1				1								1		
Stachys natalensis											+				
Stephania abyssinica					1								+		
Striga bilabiata										+					

Striga elegans				+											
Tephrosia capensis				+											
Tephrosia elongata										+					
Themeda triandra	1			1				1	1	3	3		+	1	
Thesium sp.										+			+		
Trachypogon spicata	+														
Trifolium africanum		+	+			+									+
Tristachya leucothryx				1							1				
Tristachya sp.														+	
Typha capensis			+												+
Utricularia prehensilis															+
Utricularia sp.							+								
Verbena bonariensis								+		+		+			
Vigna vexillata					+					+					
Wahlenbergia denticulata	+			+		+		1	+	+	+	+		+	
Wahlenbergia virgata														+	
Watsonia pulchra				+											
Xyris sp.		+				+									
Zaluzianskya sp.													+		
Zornia capensis											+		+	+	
TOTAL	**70**	**35**	**30**	**51**	**74**	**38**	**24**	**39**	**44**	**86**	**50**	**36**	**62**	**45**	**36**

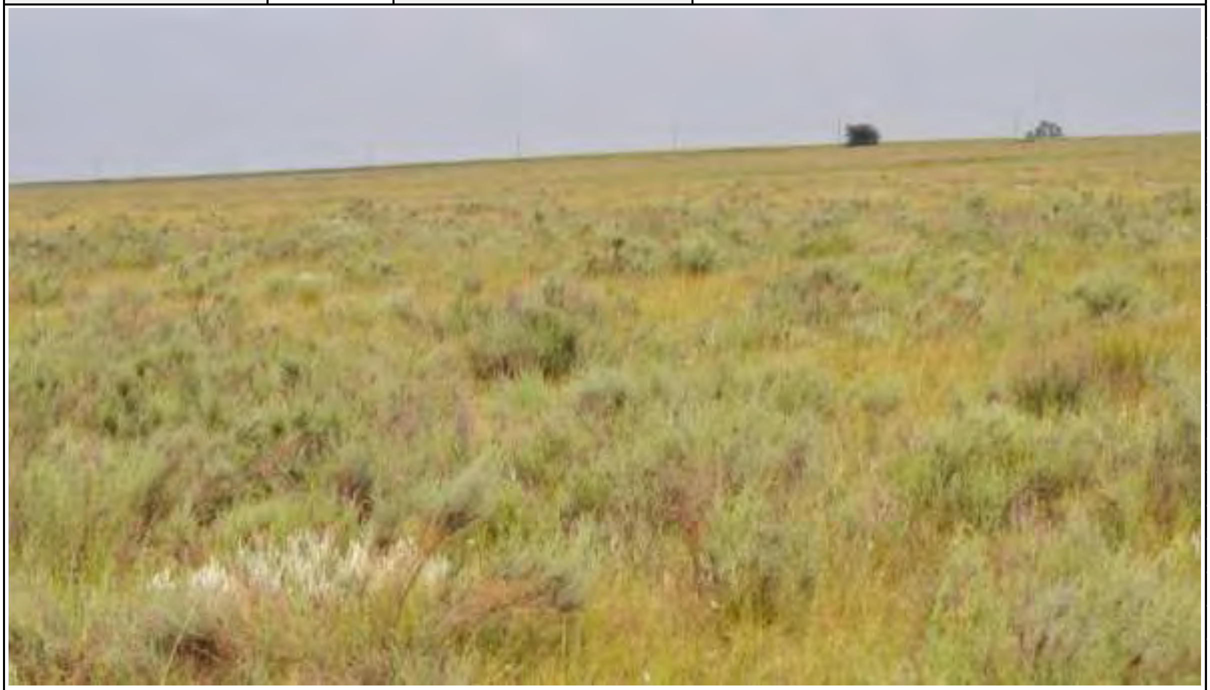
APPENDIX 3. TIMED-MEANDER SEARCH LOCALITY DATA

TMS No:	1	DATE:	14/01/2019	No. OF SPECIES:	71
TIME START:	13h03	LENGTH:	286m	PROJECT:	Kranspan
TIME END:	13h51	VEG COMMUNITY:		Outcrop Shrubland	

TMS No:	2	DATE:	14/01/2019	No. OF SPECIES:	35
TIME START:	14h03	LENGTH:	327m	PROJECT:	Kranspan
TIME END:	14h31	VEG COMMUNITY:		Pan Edge Wetland	

TMS No:	3	DATE:	14/01/2019	No. OF SPECIES:	30
TIME START:	14h49	LENGTH:	286m	PROJECT:	Kranspan
TIME END:	15h12	VEG COMMUNITY:		Hillslope Wetland	

TMS No:	4	DATE:	14/01/2019	No. OF SPECIES:	51
TIME START:	15h16	LENGTH:	730m	PROJECT:	Kranspan
TIME END:	15h35	VEG COMMUNITY:		Plains Grassland	



TMS No:	5	DATE:	15/01/2019	No. OF SPECIES:	74
TIME START:	06h40	LENGTH:	1200m	PROJECT:	Kranspan
TIME END:	07h30	VEG COMMUNITY:		Outcrop Shrubland	

TMS No:	6	DATE:	15/01/2019	No. OF SPECIES:	38
TIME START:	08h13	LENGTH:	575m	PROJECT:	Kranspan
TIME END:	08h30	VEG COMMUNITY:		Pan Edge Wetland	

TMS No:	7	DATE:	15/01/2019	No. OF SPECIES:	24
TIME START:	09h57	LENGTH:	462m	PROJECT:	Kranspan
TIME END:	10h24	VEG COMMUNITY:		Freshwater Pan	

TMS No:	8	DATE:	15/01/2019	No. OF SPECIES:	39
TIME START:	10h33	LENGTH:	299m	PROJECT:	Kranspan
TIME END:	10h51	VEG COMMUNITY:		Plains Grassland	

TMS No:	9	DATE:	15/01/2019	No. OF SPECIES:	44
TIME START:	12h20	LENGTH:	630m	PROJECT:	Kranspan
TIME END:	13h15	VEG COMMUNITY:		Plains Grassland with Sheetrock	

TMS No:	10	DATE:	16/01/2019	No. OF SPECIES:	86
TIME START:	07h08	LENGTH:	686m	PROJECT:	Kranspan
TIME END:	07h50	VEG COMMUNITY:		Plains Grassland with Sheetrock	

TMS No:	11	DATE:	16/01/2019	No. OF SPECIES:	51
TIME START:	09h44	LENGTH:	980m	PROJECT:	Kranspan
TIME END:	10h19	VEG COMMUNITY:		Plains Grassland	

TMS No:	12	DATE:	16/01/2019	No. OF SPECIES:	36
TIME START:	12h23	LENGTH:	373m	PROJECT:	Kranspan
TIME END:	12h42	VEG COMMUNITY:		Hillslope Seep	

TMS No:	13	DATE:	17/01/2019	No. OF SPECIES:	62
TIME START:	06h57	LENGTH:	1100m	PROJECT:	Kranspan
TIME END:	08h03	VEG COMMUNITY:		Outcrop Shrubland	

TMS No:	14	DATE:	16/01/2019	No. OF SPECIES:	46
TIME START:	10h15	LENGTH:	941m	PROJECT:	Kranspan
TIME END:	10h40	VEG COMMUNITY:		Plains Grassland	

TMS No:	15	DATE:	16/01/2019	No. OF SPECIES:	36
TIME START:	14h51	LENGTH:	492m	PROJECT:	Kranspan
TIME END:	15h18	VEG COMMUNITY:		Valley Bottom Wetland	

APPENDIX 4. PLANT SPECIES OF CONSERVATION CONCERN POTENTIALLY OCCURRING IN THE PROJECT AREA

Species	Family	Red Data Status	Habitat	Likelihood	Reason
Khadia carolinensis	Aizoaceae	VU	Well-drained, sandy loam soils among rocky outcrops, or at the edges of sandstone sheets, Highveld Grassland	Confirmed	Confirmed in 2630AA (Carolina Town and Townlands 43 IT, Groenvallei 40 IT, Jagtlust 47 IT)
Alepidea longeciliata	Apiaceae	EN	Highveld grassland, may be associated with pans	High	Confirmed in 2629BB (Bankfontein 215 IS, Jagtlust 47 IT)
Asclepias dissona	Apocynaceae	CR (PE)	Damp grassland	Low	Confirmed in 2630AA (Boesmanspruit 9 IT) but last recorded in 1932. Possibly extinct
Aspidoglossum xanthosphaerum	Apocynaceae	VU	Montane grassland, Highveld grassland, marshy sites	Moderate	Some suitable habitat present
Brachystelma angustum	Apocynaceae	VU	Pockets of shallow, humic soils on white quartzitic ridges	Low	Only known from north of Carolina
Riocreuxia aberrans	Apocynaceae	NT	Wedged in cracks among rocks on exposed quartzite ridges	Low	Unsuitable habitat present
Pachycarpus suaveolens	Apocynaceae	VU	Short or annually burnt grasslands, 1400-2000 mamsl	Low	Although historically recorded from the Carolina district, it is a very rare species and only known from eight localities
Asparagus fractiflexus	Asparagaceae	EN	High altitude, open grasslands, on rocky outcrops or among boulders	Low	Although historically recorded from the Carolina district, it is a very rare species and only known from four localities

Kniphofia triangularis subsp. obtusiloba	Asphodelaceae	Rare	Quartzitic rocky outcrops in montane grasslands	Low	Confirmed in 2630AA (near Slaaihoek), but in high-lying wetter areas of the Escarpment
Gerbera aurantiaca	Asteraceae	EN	Mistbelt grassland, well-drained doleritic areas	Low	Unsuitable habitat present
Merwilla plumbea	Hyacinthaceae	NT	Montane mistbelt and Ngongoni grassland, rocky areas on steep, well drained slopes	Low	Unsuitable habitat present
Gladiolus malvinus	Iridaceae	VU	Dolerite outcrops in grassland, around 2000 m	Low	Unsuitable geology and habitat present
Gladiolus paludosus	Iridaceae	VU	Wetlands or marshes in high altitude grassland that remain wet throughout the year or dry out for only a short period	Low	Rare and localised species

NT = Near Threatened
VU = Vulnerable
EN = Endangered
CR (PE) - Critically Endangered (Presumed Extinct)

APPENDIX 5. LIST OF FAUNA RECORDED IN THE PROJECT AREA DURING FIELDWORK

Common Name	Scientific Name	Red Data	Protected	Assemblages					
				Grassland	Rocky Ridge	Wetland	Open Water	Transformed - Cultivation	Transformed - Plantations, Urban
MAMMALS									
ORDER: RODENTIA									
Family Hystricidae (porcupines)									
Common Porcupine	*Hystrix africaeaustralis*			x	x			x	
Family Bathyergidae (mole-rats)									
Highveld Mole-rat	*Cryptomys* cf. *pretoriae*			x	x				
Family Muridae (murid rodents)									
Vlei Rat	*Otomys auratus*					x			
Highveld Gerbil	*Gerbilliscus* cf. *brantsii*			x					
ORDER: LAGOMORPHA									
Family Leporidae (hares)									
Scrub Hare	*Lepus saxatilis*			x					
ORDER: HYRACOIDEA									
Family Procaviidae (hyraxes)									
Rock Hyrax	*Procavia capensis*				x				
ORDER: TUBULIDENTATA									
Family Orycteropodidae (aardvark)									
Aardvark	*Orycteropus afer*		MNCA	x					
ORDER: CARNIVORA									
Family Felidae (cats)									
Serval	*Leptailurus serval*	NT	MNCA	x	x	x		x	
Family Canidae (dogs)									
Black-backed Jackal	*Canis mesomelas*			x				x	
Family Herpestidae (mongooses)									
Marsh Mongoose	*Atilax paludinosus*					x			
Yellow Mongoose	*Cynictis penicillata*			x	x				
Slender Mongoose	*Galerella sanguinea*				x				

Suricate	*Suricata suricatta*			x					
ORDER: ARTIODACTYLA									
Family Bovidae (bovids)									
Common Duiker	*Sylvicapra grimmia*			x				x	
Family Suidea (pigs)									
Bushpig	*Potamochoerus larvatus*					x			
SUBTOTAL	**15**	**1**	**2**	**10**	**6**	**4**	**0**	**4**	**0**
BIRDS									
ORDER: ANSERIFORMES									
Family Anatidae (ducks, geese and swans)									
Egyptian Goose	*Alopochen aegyptiaca*						fc		r
Red-billed Teal	*Anas erythrorhyncha*						o		
Cape Shoveler	*Anas smithii*						u		
Yellow-billed Duck	*Anas undulata*						fc		
Fulvous Whistling Duck	*Dendrocygna bicolor*						r		
Southern Pochard	*Netta erythrophthalma*						u		
Maccoa Duck	*Oxyura maccoa*	NT					r		
Spur-winged Goose	*Plectropterus gambensis*						o		
White-backed Duck	*Thalassornis leuconotus*						r		
ORDER: GALLIFORMES									
Family Numididae (guineafowl)									
Helmeted Guineafowl	*Numida meleagris*			fc		r		fc	fc
Family Phasianidae (pheasants, fowl and allies)									
Common Quail	*Coturnix coturnix*			c					
Natal Spurfowl	*Pternistis natalensis*								r
Swainson's Spurfowl	*Pternistis swainsonii*			c				c	c
Red-winged Francolin	*Scleroptila levaillantii*			r					
ORDER: PODICIPEDIFORMES									
Family Podicipedidae (grebes)									
Little Grebe	*Tachybaptus ruficollis*						o		
ORDER: CICONIIFORMES									
Family Ciconiidae (storks)									
White Stork	*Ciconia ciconia*			r*				r*	
ORDER: PELECANIFORMES									
Family Threskiornithidae (ibises and spoonbills)									

Hadeda Ibis	*Bostrychia hagedash*			c		c			c
Glossy Ibis	*Plegadis falcinellus*					u			
African Sacred Ibis	*Threskiornis aethiopicus*					u			
Family Ardeidae (herons and bitterns)									
Grey Heron	*Ardea cinerea*						r		
Intermediate Egret	*Ardea intermedia*					u	u		
Black-headed Heron	*Ardea melanocephala*					o	o		
Western Cattle Egret	*Bubulcus ibis*			fc		u			
ORDER: SULIFORMES									
Family Phalacrocoracidae (cormorants and shags)									
Reed Cormorant	*Microcarbo africanus*						o		
Family Anhingidae (anhingas and darters)									
African Darter	*Anhinga rufa*						r		
ORDER: ACCIPITRIFORMES									
Family Accipitridae (kites, hawks and eagles)									
Common Buzzard	*Buteo buteo*			fc				fc	
African Marsh Harrier	*Circus ranivorus*	EN				r			
Black-winged Kite	*Elanus caeruleus*			fc		fc			
African Fish Eagle	*Haliaeetus vocifer*						r		
European Honey Buzzard	*Pernis apivorus*								r
African Harrier-Hawk	*Polyboroides typus*								r
ORDER: OTIDIFORMES									
Family Otididae (bustards)									
Blue Korhaan	*Eupodotis caerulescens*			o					
ORDER: GRUIFORMES									
Family Sarothruridae (flufftails)									
Red-chested Flufftail	*Sarothrura rufa*					r			
Family Rallidae (rails, crakes and coots)									
Red-knobbed Coot	*Fulica cristata*						u		
Common Moorhen	*Gallinula chloropus*						r		
Lesser Moorhen	*Paragallinula angulata*					r			
African Purple Swamphen	*Porphyrio madagascariensis*					r			
ORDER: CHARADRIIFORMES									
Family Burhinidae (thick-knees)									

Spotted Thick-knee	*Burhinus capensis*			u	u				
Family Recurvirostridae (stilts and avocets)									
Black-winged Stilt	*Himantopus himantopus*						u		
Family Charadriidae (plovers)									
Kittlitz's Plover	*Charadrius pecuarius*					u			
Three-banded Plover	*Charadrius tricollaris*					o			
Blacksmith Lapwing	*Vanellus armatus*			u		fc			
Crowned Lapwing	*Vanellus coronatus*			c					
African Wattled Lapwing	*Vanellus senegallus*					o			
Family Jacanidae (jacanas)									
Lesser Jacana	*Microparra capensis*	VU				r			
Family Scolopacidae (sandpipers and snipes)									
Common Sandpiper	*Actitis hypoleucos*					r			
Little Stint	*Calidris minuta*					u			
Ruff	*Calidris pugnax*					r			
African Snipe	*Gallinago nigripennis*					u			
Wood Sandpiper	*Tringa glareola*					o			
Common Greenshank	*Tringa nebularia*					u			
Family Glareolidae (coursers and pratincoles)									
Black-winged Pratincole	*Glareola nordmanni*	NT			r	r			
Family Laridae (gulls, terns and skimmers)									
Whiskered Tern	*Chlidonias hybrida*					fc	fc		
White-winged Tern	*Chlidonias leucopterus*					r			
ORDER: COLUMBIFORMES									
Family Columbidae (pigeons and doves)									
Speckled Pigeon	*Columba guinea*								u
Laughing Dove	*Spilopelia senegalensis*								o
Cape Turtle Dove	*Streptopelia capicola*					r			c
Red-eyed Dove	*Streptopelia semitorquata*								fc
ORDER: CUCULIFORMES									
Family Cuculidae (cuckoos)									
Diederik Cuckoo	*Chrysococcyx caprius*								fc
ORDER: STRIGIFORMES									
Family Tytonidae (barn owls)									
African Grass Owl	*Tyto capensis*	VU				r			

Family Strigidae (owls)									
Marsh Owl	*Asio capensis*					u			
ORDER: APODIFORMES									
Family Apodidae (swifts)									
Little Swift	*Apus affinis*			r*	r*	r*	r*	r*	r*
Common Swift	*Apus apus*			o*	o*	o*	o*	o*	o*
White-rumped Swift	*Apus caffer*			o*	o*	o*	o*	o*	o*
Horus Swift	*Apus horus*				u*				
ORDER: CORACIIFORMES									
Family Meropidae (bee-eaters)									
European Bee-eater	*Merops apiaster*			r					
ORDER: BUCEROTIFORMES									
Family Phoeniculidae (wood-hoopoes)									
Green Wood Hoopoe	*Phoeniculus purpureus*								r
ORDER: PICIFORMES									
Family Lybiidae (African barbets)									
Black-collared Barbet	*Lybius torquatus*								u
Family Indicatoridae (honeyguides)									
Greater Honeyguide	*Indicator indicator*								r
ORDER: FALCONIFORMES									
Family Falconidae (caracaras and falcons)									
Amur Falcon	*Falco amurensis*			r					
ORDER: PASSERIFORMES									
Family Malaconotidae (bushshrikes)									
Bokmakierie	*Telophorus zeylonus*								r
Family Laniidae (shrikes)									
Southern Fiscal	*Lanius collaris*			c		u		c	c
Lesser Grey Shrike	*Lanius minor*			r					
Family Alaudidae (larks)									
Red-capped Lark	*Calandrella cinerea*			u		u			
Spike-heeled Lark	*Chersomanes albofasciata*			c					
Eastern Clapper Lark	*Mirafra fasciolata*			r					
Family Pycnonotidae (bulbuls)									
Dark-capped Bulbul	*Pycnonotus tricolor*								fc

Family Hirundinidae (swallows and martins)									
Greater Striped Swallow	*Cecropis cucullata*			fc	fc	r		r	r
Common House Martin	*Delichon urbicum*			r	r				
White-throated Swallow	*Hirundo albigularis*					u			
Barn Swallow	*Hirundo rustica*			c	c	c		c	
Banded Martin	*Riparia cincta*			fc	fc	fc			
Brown-throated Martin	*Riparia paludicola*					u			
Family Phylloscopidae (leaf warblers and allies)									
Willow Warbler	*Phylloscopus trochilus*								r
Family Acrocephalidae (reed warblers & allies)									
African Reed Warbler	*Acrocephalus baeticatus*							r	
Icterine Warbler	*Hippolais icterina*								r
Family Cisticolidae (cisticolas and allies)									
Wing-snapping Cisticola	*Cisticola ayresii*			c					
Pale-crowned Cisticola	*Cisticola cinnamomeus*					fc			
Zitting Cisticola	*Cisticola juncidis*			c				u	
Cloud Cisticola	*Cisticola textrix*			u					
Levaillant's Cisticola	*Cisticola tinniens*					c			
Black-chested Prinia	*Prinia flavicans*								u
Family Sturnidae (starlings)									
Pied Starling	*Lamprotornis bicolor*			o				o	
Family Muscicapidae (chats and Old World flycatchers)									
Cape Robin-Chat	*Dessonornis caffer*								o
Ant-eating Chat	*Myrmecocichla formicivora*			c					
Mountain Wheatear	*Myrmecocichla monticola*				r				
African Stonechat	*Saxicola torquata*			fc					fc
Family Nectariniidae (sunbirds)									
Malachite Sunbird	*Nectarinia famosa*				fc				
Family Passeridae (Old World sparrows)									
Southern Grey-headed Sparrow	*Passer diffusus*			r				r	r
House Sparrow	*Passer domesticus*								r
Cape Sparrow	*Passer melanurus*			fc				fc	u
Family Ploceidae (weavers and widowbirds)									
Yellow-crowned Bishop	*Euplectes afer*			c		u		c	c

White-winged Widowbird	*Euplectes albonotatus*			r					
Fan-tailed Widowbird	*Euplectes axillaris*			c		c		r	
Southern Red Bishop	*Euplectes orix*			c		c		c	c
Long-tailed Widowbird	*Euplectes progne*			c		c			
Cape Weaver	*Ploceus capensis*					r			
Southern Masked Weaver	*Ploceus velatus*			c	c	c		c	c
Red-billed Quelea	*Quelea quelea*			fc	r			fc	fc
Family Estrildidae (waxbills, munias and allies)									
Orange-breasted Waxbill	*Amandava subflava*			r		u		u	
Common Waxbill	*Estrilda astrild*			c	c	c		c	c
Quailfinch	*Ortygospiza atricollis*			c		c		r	
Family Viduidae (indigobirds and whydahs)									
Pin-tailed Whydah	*Vidua macroura*			c	r	c		u	u
Family Motacillidae (wagtails and pipits)									
African Pipit	*Anthus cinnamomeus*			c				r	
Cape Longclaw	*Macronyx capensis*			c					
Cape Wagtail	*Motacilla capensis*			r		fc		r	
Western Yellow Wagtail	*Motacilla flava*					r			
Family Fringillidae (finches and canaries)									
Black-throated Canary	*Crithagra atrogularis*			fc		u			u
Yellow Canary	*Crithagra flaviventris*			r					
Cape Canary	*Serinus canicollis*			c		u		r	u
SUBTOTAL	**120**	**5**	**0**	**52**	**16**	**55**	**23**	**27**	**38**
REPTILES									
ORDER: TESTUDINES									
Family Pelomedusidae (side-necked terrapins)									
South African Marsh Terrapin	*Pelomedusa galeata*						x		
ORDER: SQUAMATA									
Family Scincidae (skinks)									
Wahlberg's Snake-eyed Skink	*Panaspis wahlbergii*			x					
Cape Skink	*Trachylepis capensis*			x					
Speckled Rock Skink	*Trachylepis punctatissima*				x				
Montane Dwarf Burrowing Skink	*Scelotes mirus*				x				
Family Typhlopidae (blind snakes)									

Bibron's Blind Snake	*Afrotyphlops bibronii*			x					
Family Lamprophiidae (Old World snakes)									
Brown House Snake	*Boaedon capensis*				x				
Brown Water Snake	*Lycodonomorphus rufulus*			x					
Spotted Skaapsteker	*Psammophylax rhombeatus*			x					
SUBTOTAL	**9**	**0**	**0**	**5**	**3**	**0**	**1**	**0**	**0**
AMPHIBIANS									
ORDER: ANURA									
Family Hyperoliidae (reed frogs and allies)									
Bubbling Kassina	*Kassina senegalensis*					x	x		
Rattling Frog	*Semnodactylus wealii*			x		x			
Family Ptychadenidae (grass frogs, river frogs and allies)									
Striped Grass Frog	*Ptychadena porosissima*					x			
Family Pipidae (clawed frogs)									
Common Clawed Frog	*Xenopus laevis*						x		
Family Pyxicephalidae (bullfrogs and allies)									
Bronze Caco	*Cacosternum nanum*					x			
Delalande's River Frog	*Amietia delalandii*					x	x		
SUBTOTAL	**6**	**0**	**0**	**1**	**0**	**5**	**3**	**0**	**0**
TOTAL	**150**	**6**	**2**	**68**	**25**	**64**	**27**	**31**	**38**

EN = Endangered
V = Vulnerable
NT = Near Threatened
MNCA = Mpumalanga Nature Conservation Act
c = common (20 or more encounters)
fc = fairly common (10-19 encounters)
o = occasional (6-9 encounters)
u = uncommon (3-5 encounters)
r = rare (1-2 encounters)

APPENDIX 6A. MACKINNON LIST RAW DATA – LISTS 1-70

Species	McK1	McK2	McK3	McK4	McK5	McK6	McK7	McK8	McK9	McK10	McK11	McK12	McK13	McK14	McK15	McK16	McK17	McK18	McK19	McK20	McK21	McK22	McK23	McK24	McK25	McK26	McK27	McK28	McK29	McK30	McK31	McK32	McK33	McK34	McK35	McK36	McK37
Southern Masked Weaver	X	X														X	X		X		X		X		X	X			X	X	X	X		X			
Southern Fiscal	X													X		X				X		X		X				X									
Wing-snapping Cisticola	X			X	X	X	X	X					X		X		X	X		X					X		X								X		
Common Quail	X				X										X			X	X		X	X		X		X		X				X					X
Quailfinch	X		X								X	X							X					X		X		X				X				X	X
Southern Red Bishop	X		X							X				X			X				X				X	X											
Barn Swallow	X	X				X	X	X			X	X			X			X			X	X			X	X	X		X		X		X	X		X	
Yellow-crowned Bishop	X		X			X									X		X					X					X		X				X	X	X		X
House Sparrow	X																													X							
Red-billed Quelea	X																										X					X				X	X
Crowned Lapwing		X		X	X		X	X						X															X		X						
Black-chested Prinia		X						X																													
Zitting Cisticola		X	X			X														X	X		X		X			X					X	X	X	X	
Cape Longclaw		X		X	X	X	X	X				X	X		X	X		X		X	X	X				X	X	X		X				X			X
African Stonechat		X				X		X							X			X																	X		
Ant-eating Chat		X						X			X								X			X															
Cape Wagtail		X									X																										
Western Cattle Egret		X				X				X							X																				
Fan-tailed Widowbird			X																			X												X	X		X
Cape Canary			X	X	X			X							X		X								X				X		X	X	X		X		
African Reed Warbler			X																																		
Black-throated Canary			X																												X	X				X	X
Common Waxbill			X						X			X		X			X							X	X		X	X	X			X	X				
African Pipit			X	X	X		X	X	X				X		X			X	X							X									X	X	
Spike-heeled Lark				X			X		X					X		X																					

African Wattled Lapwing				X						X													X														
Common Swift				X								X													X												
Hadeda Ibis				X	X				X				X						X		X					X											
Malachite Sunbird				X																							X		X	X			X				
Greater Striped Swallow					X							X				X										X	X	X		X		X		X			
Banded Martin					X	X	X						X							X																	
Spotted Thick-knee					X																																
Pin-tailed Whydah						X											X		X		X	X		X	X						X				X	X	
Cape Turtle Dove						X													X			X	X				X				X						
Black-collared Barbet							X											X						X													
African Fish Eagle							X																X														
Three-banded Plover							X			X																								X			
Diederik Cuckoo								X			X		X							X			X					X									X
Pale-crowned Cisticola									X					X																							
Long-tailed Widowbird									X	X		X	X			X		X																			
Blacksmith Lapwing									X				X	X																						X	
Egyptian Goose									X																												
Red-billed Teal									X																												
Cape Shoveler									X																												
Reed Cormorant										X				X																							
Yellow-billed Duck										X													X														
Southern Pochard										X																											
Little Grebe										X																											
Red-knobbed Coot										X																											
Kittlitz's Plover											X																										
Common Greenshank											X																						X				
Black-winged Pratincole											X																										
Glossy Ibis											X																										
Levaillant's Cisticola											X		X	X			X																			X	
African Snipe												X																									
Whiskered Tern												X		X		X														X			X				
Wood Sandpiper												X																									

Black-winged Kite													X			X													X				X				
Cape Weaver															X																						
Intermediate Egret															X																						
Common Buzzard																X																					
Amur Falcon																X																					
Orange-breasted Waxbill																	X							X													
Helmeted Guineafowl																		X	X					X									X	X			
Red-eyed Dove																		X		X				X				X									
Pied Starling																			X																		
Swainson's Spurfowl																				X	X	X	X									X					X
Dark-capped Bulbul																				X					X		X										
Cape Robin-Chat																				X			X						X			X					
Icterine Warbler																					X																
Spur-winged Goose																							X					X									
Laughing Dove																								X		X			X								
Horus Swift																														X	X						
Southern Grey-headed Sparrow																														X							
Little Swift																														X							
Natal Spurfowl																														X							
Red-capped Lark																															X				X	X	
White-rumped Swift																															X			X			
Little Stint																																			X		
Bokmakierie																																					X
White-winged Widowbird																																					
Black-headed Heron																																					
Common Moorhen																																					
Black-winged Stilt																																					
Red-chested Flufftail																																					
Common Sandpiper																																					
Western Yellow Wagtail																																					
Grey Heron																																					
White-backed Duck																																					

Fulvous Whistling Duck																																					
African Sacred Ibis																																					
African Grass Owl																																					
Speckled Pigeon																																					
Blue Korhaan																																					
Willow Warbler																																					
European Bee-eater																																					
Lesser Grey Shrike																																					
Cape Sparrow																																					
Green Wood Hoopoe																																					
Greater Honeyguide																																					
Eastern Clapper Lark																																					
White-throated Swallow																																					
White Stork																																					
Cloud Cisticola																																					
Marsh Owl																																					
European Honey Buzzard																																					
Brown-throated Martin																																					
African Darter																																					
African Harrier-Hawk																																					
Mountain Wheatear																																					
Common House Martin																																					
African Marsh Harrier																																					
Lesser Moorhen																																					
Yellow Canary																																					
Maccoa Duck																																					
Lesser Jacana																																					
African Purple Swamphen																																					
Red-winged Francolin																																					
White-winged Tern																																					
Ruff																																					
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

APPENDIX 6B. MACKINNON LIST RAW DATA – LISTS 71-140

Species	McK71	McK72	McK73	McK74	McK75	McK76	McK77	McK78	McK79	McK80	McK81	McK82	McK83	McK84	McK85	McK86	McK87	McK88	McK89	McK90	McK91	McK92	McK93	McK94	McK95	McK96	McK97	McK98	McK99	McK100	McK101	McK102	McK103	McK104	McK105	McK106	McK107
Southern Masked Weaver	X		X		X							X		X					X	X				X	X	X		X						X	X		
Southern Fiscal			X																														X				
Wing-snapping Cisticola		X		X				X	X	X		X	X	X	X	X	X					X	X		X		x							X		X	X
Common Quail		X		X	X		X	X			X	X		X	X	X	X	X		X	X		X		X	X									X		
Quailfinch			X		X	X			X		X							X	X							X										X	
Southern Red Bishop	X	X		X						X		X		X											X			X							X		X
Barn Swallow	X	X				X	X		X		X		X		X	X	X	X			X	X		X			X	X					X	X		X	X
Yellow-crowned Bishop		X	X		X	X			X	X		X		X	X				X		X		X					X									
House Sparrow																																					
Red-billed Quelea		X			X												X		X	X								X									
Crowned Lapwing							X				X		X			X							X														
Black-chested Prinia																																					
Zitting Cisticola			X				X							X	X					X		X	X	X			X	X									
Cape Longclaw	X						X		X	X		X	X		X			X	X		X	X		X	X		X									X	X
African Stonechat					X											X					X														X		
Ant-eating Chat							X				X								X					X		X										X	
Cape Wagtail																													X								
Western Cattle Egret													X	X		X		X																	X		
Fan-tailed Widowbird		X	X						X											X						X											
Cape Canary												X	X		X					X		X		X		X											X
African Reed Warbler																																					
Black-throated Canary																						X															
Common Waxbill					X					X					X			X						X				X							X	X	
African Pipit			X			X	X	X	X		X	X		X	X		X		X		X		X			X			X						X		X
Spike-heeled Lark											X					X	X		X																	X	
African Wattled Lapwing																																				X	

Common Swift																																X	X				
Hadeda Ibis	X	X						X									X					X	X								X	X					
Malachite Sunbird																																	X				
Greater Striped Swallow																X					X												X				
Banded Martin											X						X							X			X										
Spotted Thick-knee																																					
Pin-tailed Whydah					X	X			X				X							X													X				
Cape Turtle Dove	X				X			X		X			X										X				X						X	X			
Black-collared Barbet																																					
African Fish Eagle																																					
Three-banded Plover	X																																				
Diederik Cuckoo																		X		X								X	X			X		X			
Pale-crowned Cisticola													X										X			X											X
Long-tailed Widowbird							X	X										X			X				X		X								X		X
Blacksmith Lapwing												X																									X
Egyptian Goose									X																					X		X				X	
Red-billed Teal				X																									X		X						
Cape Shoveler																													X	X							
Reed Cormorant																																				X	
Yellow-billed Duck	X					X																X			X				X	X	X						
Southern Pochard																														X							
Little Grebe																										X				X	X						
Red-knobbed Coot																													X	X							
Kittlitz's Plover																																					
Common Greenshank																																					
Black-winged Pratincole																																					
Glossy Ibis																																					
Levaillant's Cisticola	X		X	X		X			X					X								X				X	X										
African Snipe																																					
Whiskered Tern								X			X						X													X		X					
Wood Sandpiper	X			X																																	

Black-winged Kite		X		X						X			X										X				X										
Cape Weaver																																					
Intermediate Egret																																					
Common Buzzard					X	X																										X					
Amur Falcon																								X													
Orange-breasted Waxbill																											X		X								
Helmeted Guineafowl				X		X		X												X															X		
Red-eyed Dove			X							X																							X	X			
Pied Starling										X									X		X													X			
Swainson's Spurfowl				X			X	X		X		X				X													X								
Dark-capped Bulbul																																		X			
Cape Robin-Chat																																		X			
Icterine Warbler																																					
Spur-winged Goose															X										X				X	X	X	X			X		
Laughing Dove																																		X			
Horus Swift			X																												X						
Southern Grey-headed Sparrow																												X									
Little Swift																																					
Natal Spurfowl																																					
Red-capped Lark																																					
White-rumped Swift																															X	X					
Little Stint																																					
Bokmakierie																																					
White-winged Widowbird																																					
Black-headed Heron				X																		X			X					X							
Common Moorhen																																					
Black-winged Stilt						X								X																							
Red-chested Flufftail																																					
Common Sandpiper																																					
Western Yellow Wagtail																																					
Grey Heron																																					
White-backed Duck																																					

Fulvous Whistling Duck																																					
African Sacred Ibis																															X						
African Grass Owl																																					
Speckled Pigeon																					X										X						
Blue Korhaan								X																													
Willow Warbler																			X																		
European Bee-eater																																					
Lesser Grey Shrike																																					
Cape Sparrow		X					X																	X				X									
Green Wood Hoopoe																																					
Greater Honeyguide																																					
Eastern Clapper Lark																									X												
White-throated Swallow											X																										
White Stork																X																X					
Cloud Cisticola																	X	X																			X
Marsh Owl																		X																			
European Honey Buzzard																				X																	
Brown-throated Martin																														x							
African Darter																															X						
African Harrier-Hawk																																X					
Mountain Wheatear																																	X				
Common House Martin																																	X				
African Marsh Harrier																																					
Lesser Moorhen																																					
Yellow Canary																																					
Maccoa Duck																																					
Lesser Jacana																																					
African Purple Swamphen																																					
Red-winged Francolin																																					
White-winged Tern																																					
Ruff																																					
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

APPENDIX 7. FAUNA SPECIES OF CONSERVATION CONCERN POTENTIALLY OCCURRING IN THE PROJECT AREA

Species	Scientific Name	Red Data	Habitat	SABAP2 Reporting Rate for 2629BB	SABAP2 Reporting Rate for 2630AA	Likelihood	Reason
Mammals							
Highveld Golden Mole	*Amblysomus septentrionalis*	NT	Highveld grassland			Moderate	Suitable habitat present
African Clawless Otter	*Aonyx capensis*	NT	Rivers and streams			Moderate	Suitable habitat present
Southern African Hedgehog	*Atelerix frontalis*	NT	Savanna, grassland			High	Recorded on an adjacent farm in 2015 (pers.obs.)
Swamp Musk Shrew	*Crocidura mariquensis*	NT	Wetlands in savanna biome			Moderate	Suitable habitat present
Spotted-necked Otter	*Hydrictis maculicollis*	VU	Rivers and streams			Moderate	Suitable habitat present
Serval	*Leptailurus serval*	NT	Grassland, wetlands			Confirmed	
Oribi	*Ourebia ourebi ourebi*	EN	Grassland			Low	Although suitable habitat is present, there are no nearby records
Brown Hyaena	*Parahyaena brunnea*	NT	Wide variety of habitats bu prefers more arid regions			Moderate	Suitable habitat present
Grey Rhebok	*Pelea capreolus*	NT	High-altitude grassland			Low	Requires large tracts of natural grassland
Southern Mountain Reedbuck	*Redunca fulvorufula fulvorufula*	EN	High-altitude grassland			Low	Requires large tracts of natural grassland
Subtotal	10	10					
Birds							
Grey Crowned Crane	*Balearica regulorum*	EN	Wetland and grassland	-	5.3%	Moderate	Suitable habitat present
Chestnut-banded Plover	*Charadrius pallidus*	NT	Saline pans, shorelines	-	-	Low	Very rare in the general area, one record from near Chrissiesmeer
Pallid Harrier	*Circus macrourus*	NT	Dry grasslands	-	-	Moderate	Suitable habitat present
Blue Korhaan	*Eupodotis caerulescens*	NT*	Highveld grassland	8.0%	7.9%	Confirmed	

White-bellied Korhaan	*Eupodotis senegalensis*	VU	Open woodland and grassland	4.0%	-	Low	Although suitable habitat is present, there are no nearby records
Lanner Falcon	*Falco biarmicus*	VU	Wide variety of habitats	-	5.3%	Moderate	Suitable foraging habitat present only
Southern Bald Ibis	*Geronticus calvus*	VU	Montane grassland, ploughed lands	12.0%	18.4%	Moderate	Suitable foraging habitat present only
Black-winged Pratincole	*Glareola nordmanni*	NT	Highveld grassland, wetland	4.0%	-	Confirmed	
Wattled Crane	*Grus carunculatus*	CR	Undisturbed wetland and grassland	4.0%	-	Moderate	Suitable foraging habitat present only
Blue Crane	*Grus paradiseus*	NT	Undisturbed grassland in Mpumalanga	4.0%	-	Moderate	Suitable habitat present
Cape Vulture	*Gyps coprotheres*	EN	Wide variety of habitats, cliff nesting	-	-	Low	Although suitable habitat is present, there are no recent records
Denham's Bustard	*Neotis denhami*	VU	Fairly undisturbed grassland	4.0%	2.6%	Low	Suitable habitat present, but requires large tracts of natural grassland
Maccoa Duck	*Oxyura maccoa*	NT	Pans, dams, wetlands	20.0%	5.3%	Confirmed	
Lesser Flamingo	*Phoeniconaias minor*	NT	Saline pans	-	-	Moderate	Suitable habitat present
Greater Flamingo	*Phoenicopterus roseus*	NT	Saline pans	20.0%	-	Moderate	Suitable habitat present
Secretarybird	*Sagittarius serpentarius*	VU	Open woodland, grassland	-	13.1%	Moderate	Suitable habitat present
Botha's Lark	*Spizocorys fringillaris*	EN	Short, montane grassland	-	-	Low	Formerly recorded in 2629BB (SABAP1) but no recent records. May be locally extinct
African Grass Owl	*Tyto capensis*	VU	Grassland	-	-	Confirmed	
Subtotal	18	18					
Reptiles							
Coppery Grass Lizard	*Chamaesaura aenea*	NT	Highveld and Escarpement grasslands			Low	Rare in the general area, poorly known species
Large-scaled Grass Lizard	*Chamaesaura macrolepis*	NT	Grassland and open woodland			Low	Rare in the general area, poorly known species
Striped Harlequin Snake	*Homoroselaps dorsalis*	NT	Mostly high altitude Escaprment grasslands in Mpumalanga			Low	No suitable habitat present

Spotted Harlequin Snake	*Homoroselaps lacteus*	NT#	Wide variety of habitats			Low	Rare in the general area, poorly known species
Subtotal	4	4					
Frogs							
Giant Bull Frog	*Pyxicephalus adspersus*	NT	Pans in arid savanna and grassland			Low	Very rare in Mpumalanga, no recent records near the study area
Subtotal	1	1					
TOTAL	**33**	**33**					

NT = Near-threatened
VU = Vulnerable
EN = Endangered
CR = Critically Endangered
E = Endemic to South Africa, Lesotho and Swaziland
MNCA = Mpumalanga Nature Conservation Act
NEMBA = National Environmental Management: Biodiversity Act
# = Provincial assessment
* = IUCN assessment

APPENDIX 8. CV OF REPORT AUTHOR

Name	:	**Warren Lee McCleland**
Profession	:	Terrestrial Ecologist
Date of Birth	:	7 Sep 1972
Name of Firm	:	ECOREX Consulting Ecologists cc
Position in Firm	:	Sole Member
Years with firm	:	11
Nationality	:	South African

Qualifications :

- N.Dip. [Nature Conservation] Cape Peninsula University of Technology 1993

Membership in Professional Societies:

- South African Association of Botanists
- International Association for Impact Assessment (SA)

Languages :

	Speaking	Reading	Writing
English (home):	Excellent	Excellent	Excellent
Afrikaans:	Good	Good	Good
isiZulu:	Good	Fair	Fair
siSwati:	Fair	Poor	Poor

Countries of Work Experience : Angola**,** Botswana**,** Democratic Republic of the Congo**,** Kenya Lesotho, Liberia, Malawi, Mali, Mozambique, Namibia, Republic of Guinea, Sierra Leone, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe.

OVERVIEW OF EXPERIENCE

- 15 years experience in conducting baseline surveys, data analysis and report writing in various biomes in southern and tropical Africa, particularly savannah, forest and grassland biomes.
- 5 years experience game reserve management (KwaZulu-Natal, Mpumalanga)
- **Co-author of acclaimed Field Guide to Trees and Woody Shrubs of Mpumalanga & Kruger National Park, Jacana Publishers, 2002.**
- Specialist knowledge of identification of plants, mammals, birds, reptiles and frogs.
- Experience in reporting according to IFC Performance Standards for numerous international projects in Sierra Leone, Angola, Democratic Republic of the Congo, Republic of Guinea, Tanzania, Malawi, Mali, Mozambique and Zambia.
- Accredited with the discovery of a number of new plant species, most notably *Gladiolus diluvialis* Goldblatt & Manning (Fish River Canyon, Namibia), *Streptocarpus sekhukhuniensis* ms (Stoffberg, Mpumalanga – manuscript currently being edited) and *Barleria lebomboensis* Darbyshire, McCleland & Froneman (Lebombo Mts, Swaziland).
- **2014 Recipient of the Marloth Medal** from the Botanical Society of South Africa for co-authoring the Kruger tree field guide.

Employment Record:

2005 - present	ECOREX Consulting Ecologists CC	Ecologist; Sole Member
2001 - 2005	Lawson’s Birding Tours	Specialist Guide
2000 - 2001	Escarpment Ecological Consultants cc	Founder Director
1996 – 2000	Crystal Springs Game Reserve	Reserve Manager
1995	Mutemwa Lodge, western Zambia	Lodge manager, guide
1993 - 1994	Natal Parks Board	Cadet field ranger

SELECTED RECENT PROJECTS & EXPERIENCE

West Africa			
Mali	**2014**	Biodiversity Baseline Study and Impact Assessment for Kalana Gold Mine, Yanfolila	Epoch Resources – Fanie Coetzee (fanie@epochresources.co.za)
	2013	Biodiversity Baseline Study and Impact Assessment for Fekola Gold Mine, Fedougou	Epoch Resources – Fanie Coetzee (fanie@epochresources.co.za)
Republic of Guinea	**2012**	Review of Specialist Studies conducted for an EIA for an aluminium mine near Bel-Air, in Bofa Prefecture.	Epoch Resources – Fanie Coetzee (fanie@epochresources.co.za)
Sierra Leone	**2011**	Biodiversity Baseline Study and Impact Assessment for Marampa Iron Ore Mine, Lunsar	SRK (U.K.) - Nicola Rump (nrump@srk.co.uk)
East Africa			
Tanzania	**2011**	Biodiversity Baseline Study and Impact Assessment for Mkuju River Uranium Project, Selous Game Reserve, Songea	Epoch Resources – Fanie Coetzee (fanie@epochresources.co.za)
Southern and South-central Africa			
Angola	**2013**	Biodiversity Management Plan for the raising of the Cambambe Dam wall, Kwanza River, Dondo	ERM – Jessica Hughes (jessica.hughes@erm.com)
Democratic Republic of the Congo	**2014**	Biodiversity Baseline Study and Impact Assessment for Pumpi Copper Mine, Kolwezi	Epoch Resources – Fanie Coetzee (fanie@epochresources.co.za)
	2013	Biodiversity Assessment of selected wetland habitats, Kamoa Copper Mine, Kolwezi	Wetland Consulting Services – Gary Marneweck (GaryM@wetcs.co.za)
	2009-2011	Biodiversity Baseline Study and Impact Assessment for Kinsevere Copper Mine, Lubumbashi	Knight Piesold - Amelia Briel (abriel@knightpiesold.com)
	2008	Biodiversity Baseline Study for Ulindi Hydropower Scheme, Itombwe Mts, Kivu South	Knight Piesold - Amelia Briel (abriel@knightpiesold.com)
Malawi	**2015**	Terrestrial Ecology Survey of sugar mill site, Ethco, Dwangwa	ERM - Rachel Conti (Rachel.Conti@erm.com)
	2010	Terrestrial Ecology Survey of Kanyika Uranium Mine, Kasungu	Synergistics - Bronwyn Williams (bronwyn@synergistics.co.za)
Mozambique	**2016**	Biodiversity Baseline Study and Impact Assessment for an onshore gas pipeline, Inhassoro, Inhambane province	ERM – Jessica Hughes (jessica.hughes@erm.com)
	2015	Critical Habitat Assessment for coastal dry forest in Palma District, Cabo Delgado province	Enviro-Insight - Luke Verburgt (luke@enviro-insight.co.za)
	2015	Biodiversity Baseline Study for a Regional ESIA of Seismic Exploration blocks, SASOL, Inhassoro	Golder - Warren Aken (waken@golder.co.za)
	2014	Biodiversity Baseline Study and Impact Assessment for a coastal road between Pemba and Palma, Cabo Delgado province	ERM – Jessica Hughes (jessica.hughes@erm.com)
	2013	Biodiversity Monitoring Plan for Benga Coal Mine, Moatize	Rio Tinto - Isaac Ndlovu (Isaac.ndlovu@riotinto.com)
	2012	Biodiversity Baseline Study and Action Plan for the Muanza Quarry, Gorongosa NP, Sofala province	Nepid Consultants – Dr Rob Palmer rob@nepid.co.za)
	2011	Terrestrial Ecology component of the Biodiversity Study for the Four Dams Project (Corumana Dam, Gorongosa Dam, Metuchira Weir, Ressano Weir), Maputo and Sofala provinces	Austral-Cowi - Jacob Ulrich (jacob.ulrich@australcowi.co.mz)
Namibia	**2009**	Biodiversity Baseline Study and Impact Assessment for Neckartal Dam, Keetmanshoop	Knight Piesold - Amelia Briel (abriel@knightpiesold.com)
South Africa	**2013**	Faunal Baseline Study and Impact Assessment for Riemvasmaak Hydro-electric Scheme, Augrabies Falls NP	Aurecon - Nelis Bezuidenhout (Nelis.Bezuidenhout@aurecongroup.com)
	2010	Biodiversity Baseline Study and Impact Assessment for Hoogland Chrome Mine, Steenkampsberg Mts, Mpumalanga	Metago Environmental Engineers - Hylton Allison (hallison@slrconsulting.com)
	2010	Assessment of the status of *Pelargonium sidoides* and harvesting potential in Lesotho and South Africa	South African National Biodiversity Institute - Domitilla Raimondo (Raimondo@sanbi.org)
Swaziland	**2014**	Biodiversity Baseline Study and Impact Assessment for Ethemba Dam, Hlatikulu	Knight Piesold - Neal Neervoort (nneervoort@knightpiesold.com)
		Biodiversity Value Assessment for the Mhlumeni Community Conservation land, Siteki	Rod de Vletter (devletter@gmail.com)
Zambia	**2015**	Botanical survey for ESIA for Ngonye Falls Hydropower Project, Zambezi River, Senanga	Ecotone - Michiel Jonker (michiel@ecotone-sa.co.za)
	2013	Biodiversity Baseline Study and Impact Assessment for Mulungushi Hydropower Project, Kabwe	ERM – Zoe Daniels (Zoe.Daniel@erm.com)
	2008	Biodiversity Baseline Study and Impact Assessment for Lumwana Copper Mine, Solwezi	Knight Piesold - Amelia Briel (abriel@knightpiesold.com)
Zimbabwe	**2011**	Biodiversity Baseline Study and Impact Assessment for Bokai Platinum Mine, Gweru	Epoch Resources - Fanie Coetzee (fanie.coetzee@epochresources.co.za)

PUBLICATIONS

Books
Schmidt, E., Lötter, M.C. & McCleland, W.L. 2002. *Field Guide to Trees and Woody Shrubs of Mpumalanga & Kruger National Park*. Jacana Publishers, Houghton.

Peer-reviewed Journals
Darbyshire, I., McCleland, W.L. & Froneman, W. 2017. *Barleria lebomboensis* (Acanthaceae), an endangered new species from the Lebombo Mountains of Swaziland. *Phytotaxa* 323(2):173-181.

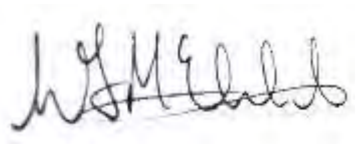
Cheek, M., Lawrence, P. & McCleland, W.L. 2018. *Cola dorrii* sp. nov. (Sterculiaceae) a threatened Maputaland Forest endemic of South Africa. *Kew Bulletin* 73(2).

McCleland, W.L. & Massingue, A. 2018. New populations and a conservation assessment of *Ecbolium hastatum* Vollesen. *Bothalia* 48(1).

Manning J., Goldblatt, P., McCleland, W.L. & Wightman, N. *in press*. *Zygotritonia atropurpurea* (Iridaceae: Crocoideae), a new local endemic species from northern Zambia of this small tropical African genus. *South African Journal of Botany*

DECLARATION

I declare that the particulars above are accurate and true to the best of my knowledge and belief.

SIGNATURE:  DATE: 6 February 2019

Impact Evaluation of Blasting
Kranspan Colliery, South Africa

Author: A J Rorke

Date: April 2019

Report Reference No: *EIA_Blasting_Krans_ Rev 1*

Contents

Executive Summary

An impact evaluation of blasting for the proposed Kranspan opencast strip mine has been conducted and is reported in this document. The impacts related to blasting induced vibration, air blast, fly rock and fumes have been evaluated. Their impact on structures, people, animals graves, ruins and heritage sites are included.

The impact assessment is based on the operational phase of the project, as no blasting is anticipated during the construction and closure phases of the project. The underground mining will be done with machines and no blasting is expected. Therefore, the risk assessment does not address blasting vibration from underground mining.

Mitigation measures will be needed to limit ground vibration, fly rock, air blast and fumes. Fly rock mitigation is critical for limiting risk along the R36 road that passes through the mining area. Vibration mitigation will be necessary for any blasting closer than 200 m from the R36 road and closer than 1000 m from the buildings on the farms Kranspan 49, Portion 6 and Portion 1.

With mitigating measures in place, as outlined in this report, all significance ratings will be **Low** for blasting impact. This includes an evaluation of negative impact on the following receptors that surround the proposed mine:

- People and livestock
- Buildings, roads and earth dams
- Graves and other heritage sites
- Poisonous fumes from blasting
- Nitrates dissolved from explosives

Several mitigation measures have been proposed for controlling the negative impact on blasting for each of the aspects (vibration, air blast, fly rock, fumes and water pollution) that would otherwise result in a more severe significance rating.

Farmer's boreholes will not be negatively impacted by blasting vibration, unless they are closer than 100 m from blasting. This report does not cover the impact on water table, as this receptor is not linked to blasting.

A summary of mitigation measures is:

1. There will be a **medium high** negative significance from blast induced ground vibration for the R36 road, a community next to the R36 on the northern side of the mining lease and two farm dwelling in in Kranspan 49, Portion 6 and Portion 1). This can be achieved through timing designs and initiation systems that ensure only one hole fires per instant in time during a blast.
2. Air blast and fly rock present a **high** negative significance and will need to be controlled by applying blast designs with stemming lengths that will effectively curb fly rock including controlled stemming application of the holes. Atmospheric conditions have a major impact on amplifying air blast in certain directions, but if effective stemming is applied and presplits are timed with short delays between each hole, air blast will be low, and amplification will be insignificant.
3. The temporary removal of people and stopping of road/rail traffic will be necessary to a safe distance of a minimum of 1000 m from blasting activities at blasting time to achieve a **Low** negative significance rating.

4. Heritage sites and graves within 150 m of blasting **medium-high** will experience a significance rating, but with mitigation measures the negative significance will drop to **Low**.

Independence Declaration

The author of this report is independent and does not work for any mining company based in South Africa. The work that has been done for this report has been performed in an objective manner and according to international standards, which mean the result and recommendations may not be positive to the client.

The author has the required expertise to conduct this study and report.

Introduction

This report provides an impact evaluation for the Operation Phase of blasting for surface blasting. A glossary of blasting related terms is provided at the end of this document for clarity.

Study Methodology

For ground vibration, the report is based on attenuation models provided in the literature.

The work is a desk-top exercise that involves specifically the determination of the impact of blasting activities during the opencast blasting operations. These are divided into the following blasting aspects that are common to all blasting practices:

1. Ground Vibration
2. Air blast
3. Fly rock
4. Fumes

The receptors considered are the existing infrastructure, houses, the people living in the areas surrounding the mine and heritage sites close to the proposed blasting operations.

Mitigation measures regarding blasting practice, monitoring and controls required to limit the impact of blasting on the surrounding areas are provided. These are accepted standard measures that are known to provide the necessary results required for a **Low** significance rating.

Study Team and Qualifications

The project team comprises Mr. A J Rorke whose CV is attached in Appendix 2 to this document.

Assumptions, Exclusions and Limitations

Exclusions

During the Construction and Decommissioning phases of the Kranspan Colliery no blasting operations will occur. This report therefore concentrates on the operational phase of mining.

There is no risk assessment for blasting in the underground operations, as mining will be done by mechanical methods and there will be no blasting related impacts.

Assumptions

Attenuation rates for vibration are site-specific and depend on the geology. There is no vibration attenuation information for the Kranspan area, and therefore conservative attenuation constants have been applied meaning that actual values are likely to be lower than the predicted values.

Uncertainties and Knowledge Gaps

There is uncertainty on the impact of blasting on animals in the vicinity. Loud bangs have a negative impact on animals. An example is the stress on pets from the noise of firecrackers going off.

However, the proposed maximum air blast limit of 125 dBL is low and therefore, mitigated blasting should be a relatively quiet activity that is unlikely to impact any animals negatively.

Description of Baseline Environment

Blasting generates short duration events that are noticeable by communities and individuals living in the immediate environment. These events tend to be emotive because of structural response (resonance) mainly to air blast and are easily recognized as being related to blasting.

People living near the existing mining areas will already be familiar with the ground and air blast generated by surface blasting in the three mining areas immediately surrounding the proposed Kranspan operation. The extension of mining in the area will therefore not create a new and unfamiliar stressor to them, except that people may already be sensitised and less tolerant especially of air blast.

Opencast mining method

Opencast strip mining is planned for either side of the R36 road in four separate areas. The plan shown in Figure 1 shows the surface mining areas and the sequences in which mining will happen. Mining will start with overburden depths of about 20m and this will increase to 30 m in years 8 to 11 in the northern part of the mine and will remain at about 11 metres in the southern portion of the mine.

Overburden and mid-burden depths impact vibration because deeper larger diameter holes are charged with higher volumes of explosives and therefore proportionately higher vibration levels. Calculation of vibration related to charge mass and distance from blasting is detailed in Appendix 1.

The designs that have been assumed for calculating the vibration levels for 30 m, 20 m and 11 m deep holes are given in Table 1.

The calculated ground vibration peak particle velocities in Table 2 is based on the three hole-depths above and on an unmitigated situation where up to three blastholes might fire simultaneously, thus tripling the charge mass and impacting the vibration amplitudes.

In mitigated blasting, only one hole will fire per delay. The mitigated ground vibration PPV's are provided in Table 3.

The attenuation curves for the two extremes in hole depth (30 m and 11 m) are given in Figure 2 for unmitigated blasting and Figure 3 for mitigated blasting.

Table 1. Likely blast designs for the major depth variations in overburden and mid-burden blasting.

	Deep Area blasting (250 mm holes)	**Shallow Area blasting (171 mm holes)**	**Shallow area blasting (171 mm holes)**
EXPLOSIVE			
Explosive Type	Emulsion blend	Emulsion blend	Emulsion blend
Charge Mass/Metre (kg/m)	61.52	59.06	26.48
Explosive Mass Per Hole (kg)	1507.14	856.30	198.59
BLAST GEOMETRY			
Stemming Length (m)	5.50	5.50	3.50
Column Length (m)	24.50	14.50	7.50
Hole Depth (m)	30.00	20.00	11.00
Hole Diameter (mm)	250.00	250.00	171.00

Table 2. Estimated PPV's for unmitigated blasting (three holes per delay)

VIBRATION	Deep Area blasting (250 mm holes)	Shallow Area blasting (171 mm holes)	Shallow area blasting (171 mm holes)
Charge mass per delay (kg)	**4521.40748**	**2568.897638**	**198.5855315**
Distance (m)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
100	593.8	372.5	45.1
300	96.9	60.8	7.4
650	27.1	17.0	2.1
800	19.2	12.1	1.5
900	15.8	9.9	1.2
1000	13.3	8.3	1.0
1250	9.2	5.8	0.7
1500	6.8	4.3	0.5
2000	4.2	2.7	0.3
3000	2.2	1.4	0.2

Table 3. Estimated PPV's for mitigated blasting (one hole per delay)

VIBRATION	Deep Area blasting (250 mm holes)	Shallow Area blasting (171 mm holes)	Shallow area blasting (171 mm holes)
Charge mass per hole (kg)	**1507.135827**	**856.2992126**	**198.5855315**
Distance (m)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
100	239.9	150.5	45.1
300	39.2	24.6	7.4
650	10.9	6.9	2.1
800	7.8	4.9	1.5
900	6.4	4.0	1.2
1000	5.4	3.4	1.0
1250	3.7	2.3	0.7
1500	2.8	1.7	0.5
2000	1.7	1.1	0.3
3000	0.9	0.5	0.2

Figure 1. Plan showing opencast strip mine (shaded areas) with the planned mining per year sequence (Supplied by EPA).

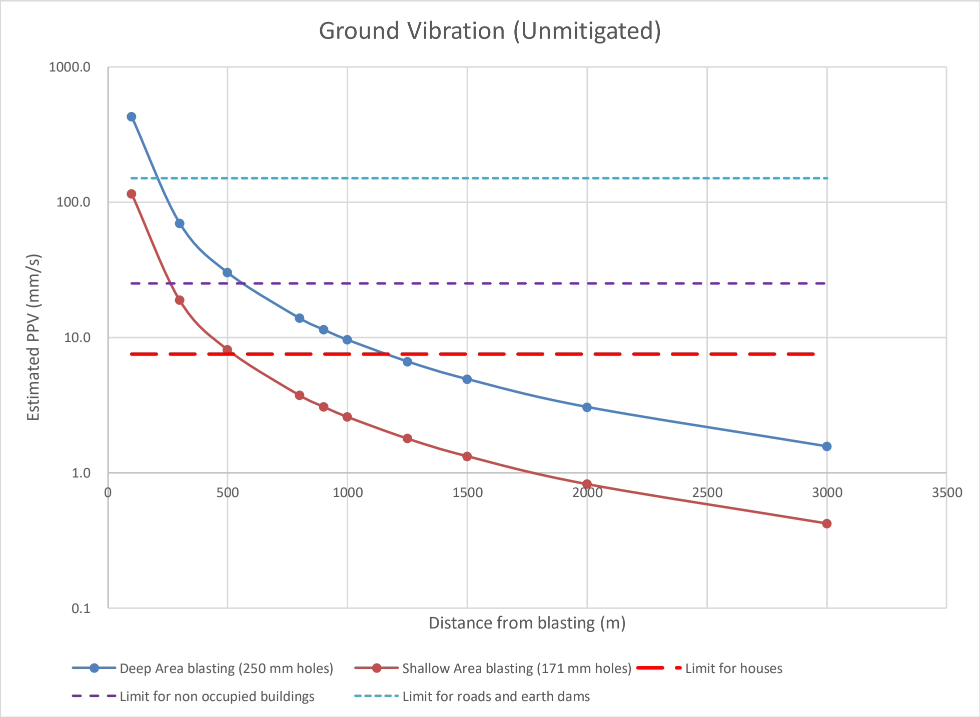


Figure 2. Predicted peak particle velocity from ground vibration for unmitigated blasting

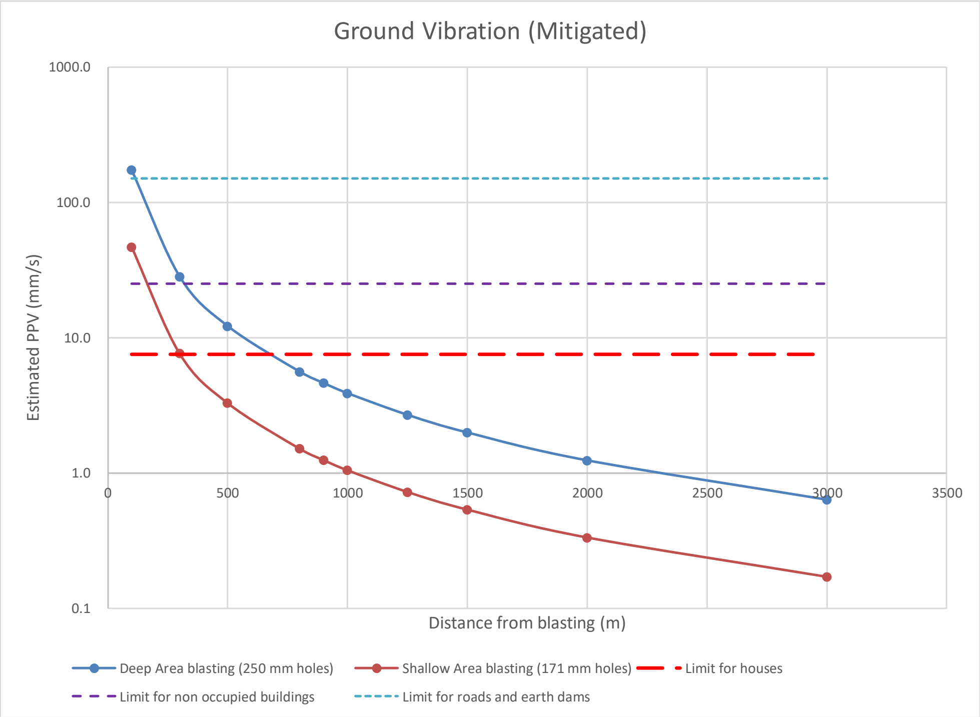


Figure 3. Predicted peak particle velocity from ground vibration for mitigated blasting

Zones of influence related to the different sources from blasting

There are five sources of risk from blasting

1. Vibration impact on houses, farm buildings, nearby ruins and stone cairns, roads, dams and boreholes
2. Fly rock impact on all structures (including graves and heritage sites), people and livestock

3. Air blast impact on houses, people and livestock
4. Poisonous fumes impact on people and livestock
5. Nitrates from explosives storage and use dissolving into the water systems affecting people and livestock

Distances and receptor references

The impacts from blasting attenuate with distance from blasting operations. These distances can be cross-referenced with the charts in Figure 2 (Unmitigated) and Figure 3 (Mitigated).

Table 4. List of sensitive receptors around the opencast mining area. The Map IDs can be referenced in the following zones of influence maps from Figure 4 to Figure 7.

Map ID	Description	Owner/Farm	Distance to deep mining (m)	Distance to shallow mining (m)
A	Farmstead	Jugtlust 47(Baadtjiesbult Boerdery Pty Ltd)	2432	
B	Farm buildings	Naudesbank 172	3209	
C	Farmstead and farm buildings	Naudesbank 172	3887	
D	Farm buildings	Naudesbank 172 (Kleyn Gysbert Samuel)	1470	
E	Farm workers houses	Naudesbank 172 (Kleyn Gysbert Samuel)	1872	
F	Farm workers houses	Naudesbank 172 (Kleyn Gysbert Samuel)	2608	
G	Farm buildings	Naudesbank 172 (Kleyn Gysbert Samuel)	1829	
H	Farmstead and farm buildings	Witbank 209 (CMJ Papenfuss Trust)	2205	
I	Farmstead and farm buildings	Vaalbank 212 (Roodeblom Trust)	1913	
J	Farmstead	Kromkrans 208	6075	
K	Farm workers houses	Vaalbank 212 (Moolman Martha Johanna)	2919	
L	Farm workers houses	Witbank 82	3587	2075
M	Buildings	Witbank 82	3301	2085
N	Farm buildings	Witrand 52	3804	2459
O	Buildings	Witrand 52	5164	4026
P	Farmstead and farm buildings	Goedehoop 45	5776	
Q	Farmstead and farm buildings	Goedehoop 45	5930	
R	Farm workers houses	Goedehoop 45	5358	
S	Farmstead and farm buildings	Jagtlust 47	3736	
T	Derelict buildings	Kranspan 49 (Roodebloem Trust)	24	
U	Farmstead and farm buildings	Kranspan 49 (CMJ Papenfus Trust)	425	
V	Farmstead	Smutsoog 214	4717	3474
W	Farmstead and farm buildings	Smutsoog 214	4915	3666
X	Buildings	Jugtlust 47	1526	
Y	Community	Kranspan 49, Portion 1	140	
Z	Farmstead and farm buildings	Kranspan 49, Portion 1	632	1055
1	Surface mine	Msobo Coal Pty Ltd	1261	
2	Surface mine	Jugtlust (Baadtjiesbult Boerdery Pty Ltd)	365	
3	Surface mine	Witbank 82	6933	5391
4	Earth dam	Jugtlust 47	2974	
5	Earth dam	Witrand 52	2980	1435
6	Longview railway siding	Witbank 82	2713	1482
7	Albion railway siding	Witbank 82	4098	2550

Vibration impact

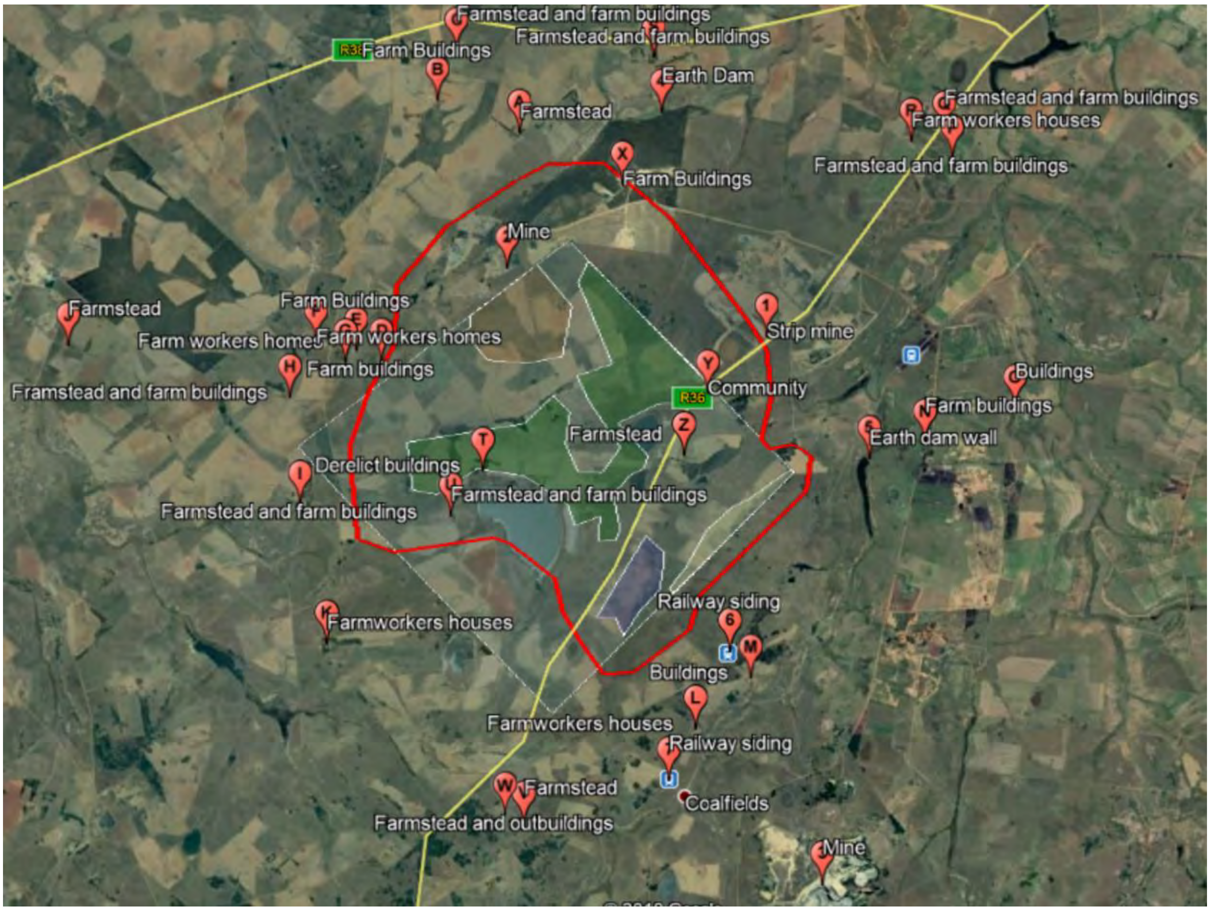


Figure 4. ***Unmitigated*** *zone of influence for vibration >7.5 mm/s (area enclosed by the red line). Note the zones of influence will depend on where blasting takes place and the red line in this image represents the maximum zone of influence when mining reaches the boundaries. The shaded polygons represent the proposed opencast mine areas.*

Vibration impact is influenced mainly by the depth of blasting. The mid-burden in the northern part of the mine will require blasthole depths up to 30 m, whereas the blasting in the south eastern side of the mine will require hole depths of 5 to 11 m. Deeper holes will require more explosives and therefore will radiate higher vibration amplitudes. Therefore, the zone of influence extends farther in the north compared to the south east. Figure 4 shows the zone of influence for vibration that is 7.5 mm or higher for the unmitigated condition of three holes firing at a time. In this case, the buildings on the farms Kranspan 49, Portion 6 and Portion 1 will be at risk, especially if they are occupied (Marker U and Z in Figure 4). The unmitigated significance rating for this property is **Medium-low at 63** when blasting occurs closer than 1000 m from the buildings.

A community close to the mining area (Y in Figure 4) will have an unmitigated significance rating that is **Medium-high**, and mitigation measures will be needed to bring the significance rating down to **Low**.

The R36 road runs through the mining property with surface blasting coming to within 150 m of the tarred surface in two areas. Before mitigation, vibration amplitudes when blasting closer than 200 m from the road will increase the risk of damage to the surface through desegregation. The unmitigated significance rating for the road at two points within the mine property is **Medium low at 63.** The influence zone for >150 mm/s is shown by the green line in Figure 5.

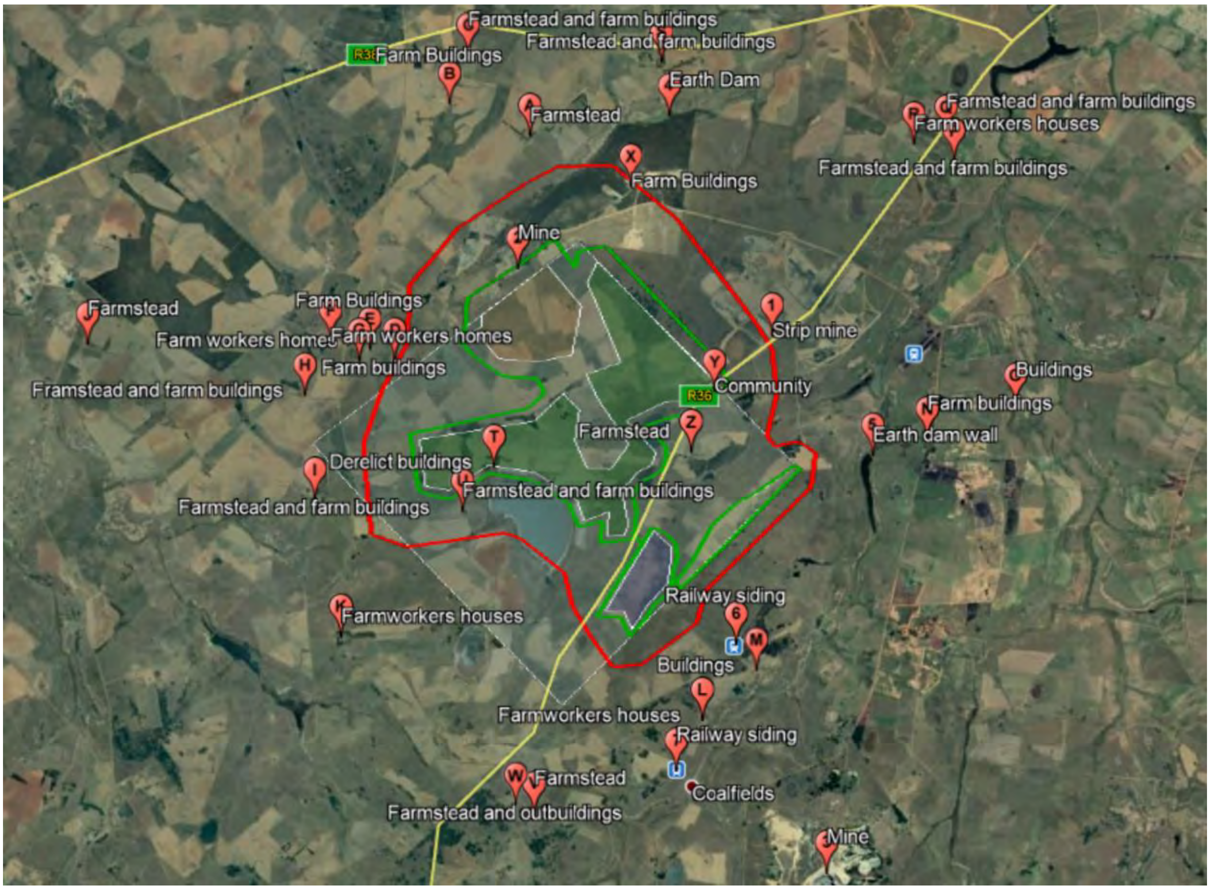


*Figure 5. **Unmitigated** zone of influence for vibration >150 mm/s (area enclosed by the green line). Note the 7.5 mm zone of influence (area enclosed by red line) is also shown for comparative purposes. The shaded polygons represent the proposed opencast mine areas.*

With the mitigation measures outlined on Page 25, the significance ratings for both receptors (road and the buildings on the farm Kranspan 49) drops to **Low** significance ratings of 42 and 28 respectively and blasting can occur at minimum distances of 150 m from the R36 road and 650 m from the buildings on the farm structures Kranspan 49 Portion 6 and Portion 1. This is illustrated by the mitigated area of influence (purple) compared to the unmitigated zone of influence (Red) in Figure 6.

However, the community at point Y (Figure 6) will remain inside the zone of influence and special management control measures have been outlined when blasting within 1000 m of this community to result in a significance rating to **Low.**

Similarly graves, ruins and heritage sites closer than 150 m from blasting will need special management controls as outlined from Page 25 to achieve a **Low** significance rating.

Wells (boreholes) will only be impacted in mitigated and unmitigated blasting to control vibration when they are closer than 100 m from blasting. Therefore, blasting will have **no significant impact** on boreholes and aquifers outside this range.

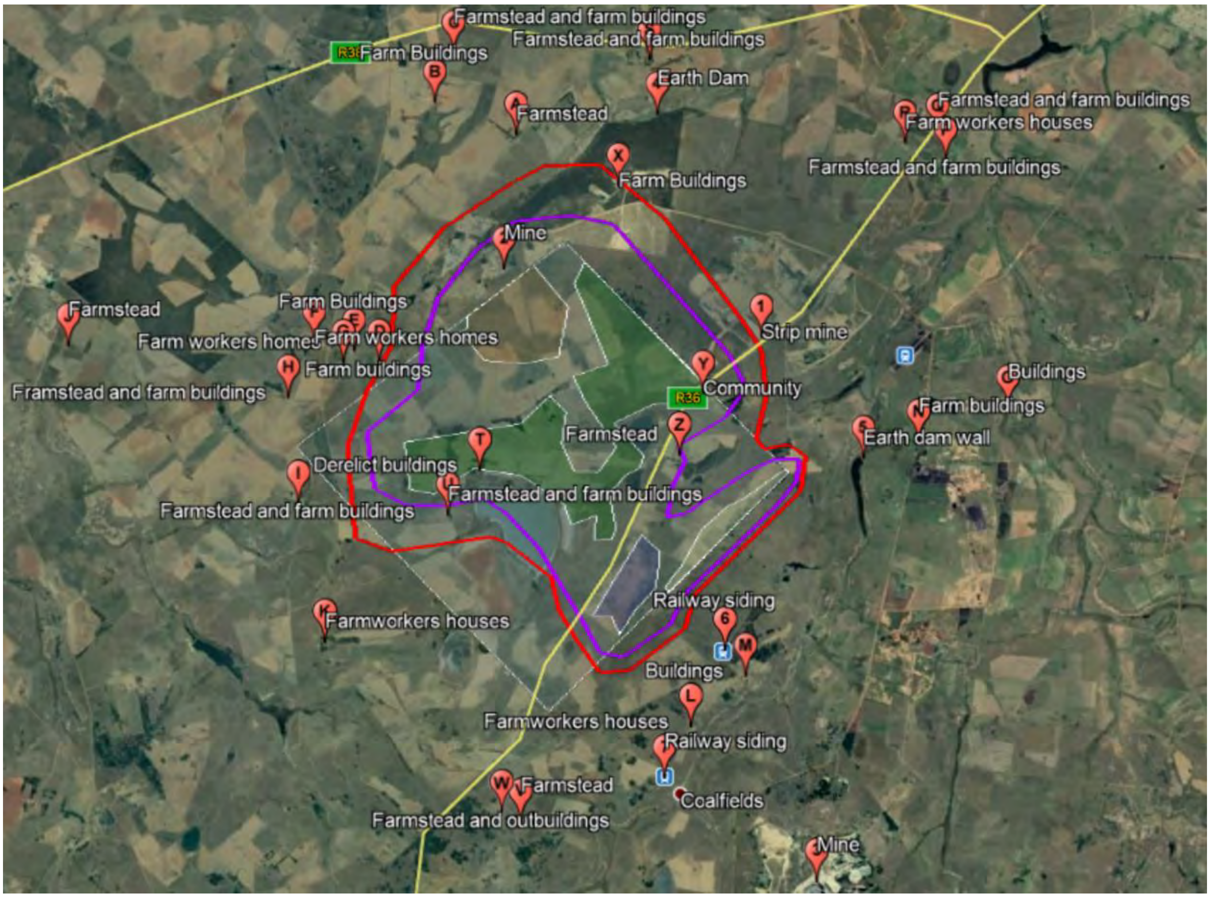


*Figure 6. **Mitigated** zone of influence for vibration >7.5 mm/s (area enclosed by the purple line). The unmitigated zone of influence for >7.5 mm/s is shown for comparative purposes (red line). The shaded polygons represent the proposed opencast mine areas.*

Fly rock impact

Fly rock in unmitigated blasting can be ejected to large distances from a blast, with a typical maximum of 1000 m. In mitigated conditions, this can reduce significantly to within a few hundred metres of blasting.

For unmitigated blasting, the impact significance is **Medium High** at 96 but can be brought down to a **Low** impact significance of 42 by applying the mitigation measures for controlling fly rock on page 25 when blasting occurs closer than 1000 m from any receptors.

The receptors that are negatively impacted by unmitigated blasting can be identified in Figure 7 and include a portion of the railway line to the south east of the mine, The R36 that runs close to the blasting activity and the mining activity to the northwest and northeast of the operation (markers 1 and 2 in Figure 7). Structures that are located closer than 500 m, such as part of the community in Portion 1, Kranspan 49 and heritage sites/graves will require special mitigation measures as outlined from Page 25 to achieve a **Low** significance rating.

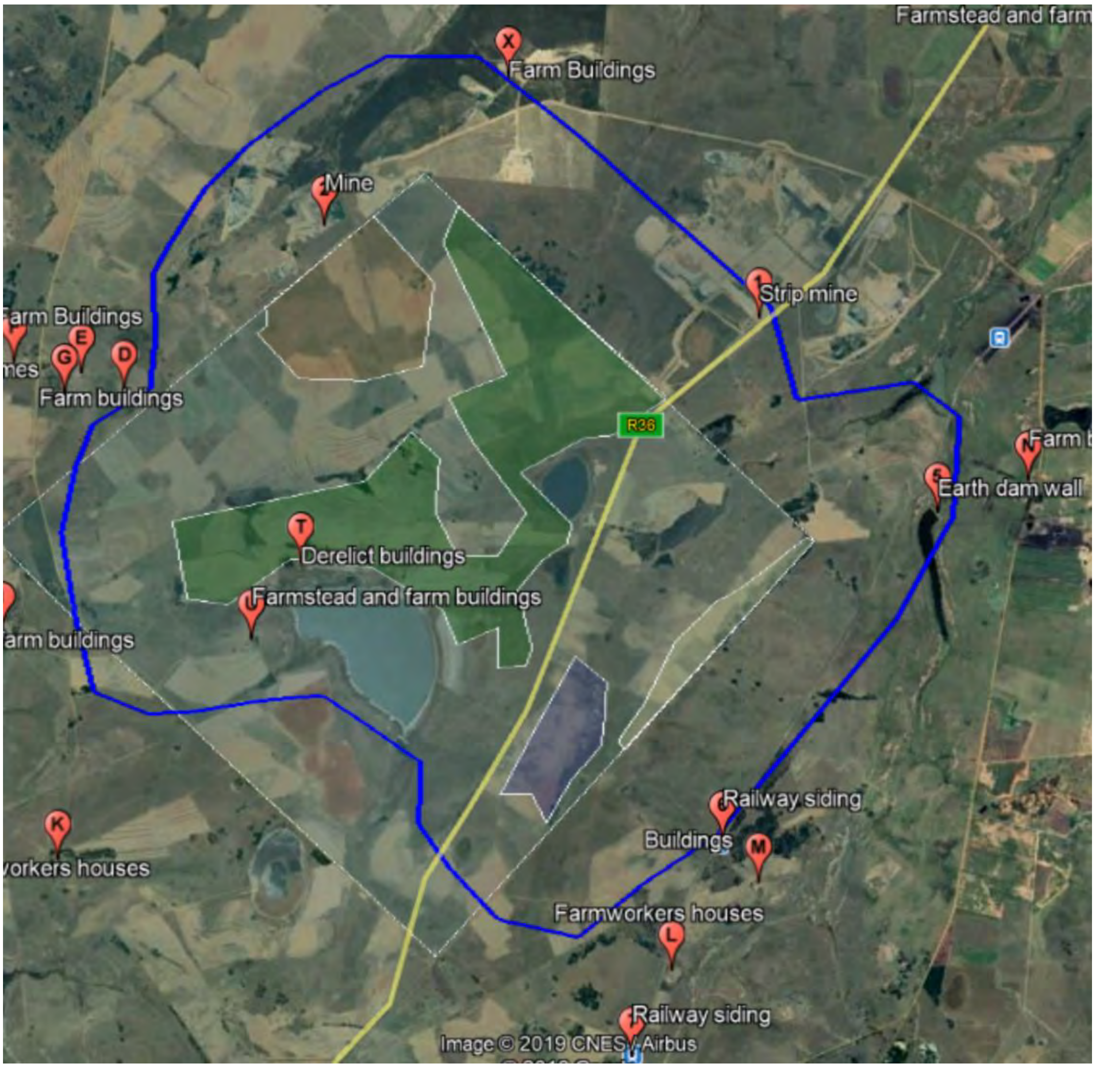


*Figure 7. Fly rock impact zone (**unmitigated**). As with the vibration zones of influence, the area impacted by fly rock will depend on the position that blasting occurs. The blue line in this Figure represents the maximum influence when mining reaches the boundaries. The shaded polygons represent the proposed opencast mine areas.*

Air blast impact

As outlined in Appendix 1, air blast levels depend on the presence of cloud cover or temperature inversions and on wind direction and speed. Very large distances can be impacted if blasting is not properly controlled to contain air blast.

Air blast presents the highest risk of complaints from neighbours. In unmitigated blasting, the significance will be **high** at a rating of 104 because of the large spatial scale. However, if stemming and timing is effectively controlled as described in the mitigation measures on page 25, the significance drops to a **low value of 49.**

Wind, atmospheric temperature inversions and cloud affect the range that is impacted by air blast in unmitigated conditions. Variability in atmospheric conditions prevents a meaningful zone of influence plan for mitigated and unmitigated air blast impact. In a downwind direction, unmitigated air blast can extend to between 5 and 10 km. However, when mitigated, air blast is effectively contained to within 100 m of a blast regardless of atmospheric conditions.

Blasting generated fumes impact

Blasting impacts the atmosphere in the form of carbon dioxide (CO_2), which is a greenhouse gas. The level of negative impact will depend, however, on the control in blasting to limit the formation of nitrous oxide gases which are toxic and are a major greenhouse gas. Mitigation against the formation of nitrous oxides is provided in this document.

A value of about 12% of the mass of explosives fired is converted to CO_2. The value can be used in calculating the overall carbon footprint of the operation.

Impact of nitrates dissolving in water

Historically, a water-soluble explosive was used in surface mines, however, these have been replaced in the last few decades by waterproof emulsions and emulsion blends.

The emulsion blends contain soluble ammonium nitrate prills. These are usually stored in on-site silos. Once blended, the product becomes water insoluble. The mitigation as described on Page 25 involves maximum explosives sleep times to reduce leaching of nitrates out of explosives in blast holes and providing for adequate bunding around ammonium nitrate silos.

Risk assessment tables

OPENCAST BLASTING								
Project Activity	Blast-induced ground vibration damage to buildings closer than 1000 m from blasting		Likelihood		Consequence			
Overburden and midburden blasting with blasting hole depths between 20 and 30 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Minor damage to buildings (real or perceived by building owners) in the form of cracks in walls. Complaints from homeowners	4	4	3	3	4	80
			Significance Post-Mitigation					
			4	3	2	2	4	56

Project Activity	Blast-induced ground vibration damage to buildings farther than 1000 m from blasting		Likelihood		Consequence			
Overburden and midburden blasting with blasting hole depths between 20 and 30 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Minor damage to buildings (real or perceived by building owners). Possible complaints from homeowners.	4	2	1	3	4	48
			Significance Post-Mitigation					
			4	2	1	1	4	36

Project Activity	Blast-induced ground vibration damage to buildings closer than 500 m from blasting		Likelihood		Consequence			
Overburden and midburden blasting with blasting depths between 5 and 11 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Minor damage to buildings (real or perceived by building owners) in the form of cracks in walls. Complaints from homeowners	4	4	3	3	4	80
			Significance Post-Mitigation					
			4	3	2	2	4	56

Project Activity	Blast-induced ground vibration damage to buildings farther than 500 m from blasting		Likelihood		Consequence			
Overburden and midburden blasting with blasting hole depths between 5 and 11 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Minor damage to buildings (real or perceived by building owners). Possible complaints from homeowners.	4	2	1	3	4	48
			Significance Post-Mitigation					
			4	2	1	1	4	36

Project Activity	Blast Induced Damage to Wells		Likelihood		Consequence			Significance Rating
Overburden and midburden blasting with blasting depths between 20 and 30 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of water perceived to be caused by blasting induced vibration	4	2	1	2	4	42
			Significance Post-Mitigation					
			4	2	1	2	4	42

Project Activity	Blast Induced Damage to road surfaces and earth dams		Likelihood		Consequence			Significance Rating
Overburden and midburden blasting with blasting hole depths between 20 and 30 m	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Road substrate and compacted earth dams may suffer desegregation from high ground vibration radiated by blasting.	4	4	3	2	4	72
			Significance Post-Mitigation					
			4	2	1	2	4	42

Project Activity	Damage to structures or injury to people closer than 1000 m from fly rock		Likelihood		Consequence			
All blasting	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Serious to fatal injury or damage to property and infrastructure caused by uncontrolled fly rock	4	4	5	3	4	96
			4	2	2	1	4	42

Project Activity	Damage to structures or complaints from neighbours caused by high air blast		Likelihood		Consequence			
All blasting, but particularly presplit and coal blasting	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Complaints or minor damage to buildings caused by high air blast levels.	4	4	5	4	4	104
			Significance Post- Mitigation					
			4	3	2	1	4	49

Project Activity	Water Pollution from Dissolved Nitrates		Likelihood		Consequence			
All blasting	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative	Significance Pre-Mitigation					
	Resulting Impact from Activity	Accumulation of dissolved nitrates in the water system causing an increase in algal and weed growth in waterways	5	4	4	4	5	117
			Significance Pre-Mitigation					
			1	2	1	1	4	18

Project Activity	Dust and fumes generated by blasting affecting health and wellbeing of surrounding neighbours		Likelihood		Consequence			
All blasting	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative	Significance Pre-Mitigation					
	Resulting Impact from Activity	Dust and fumes are a risk to health of people within a zone of 2 to 3 km from blasting	4	4	4	3	5	96
			Significance Post- Mitigation					
			4	2	2	2	4	48

Project Activity	Damage to ruins, graves and heritage sites caused by vibration		Likelihood		Consequence			
All blasting	Phase of Project	Operational Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative	Significance Pre-Mitigation					
	Resulting Impact from Activity	Vibration may cause damage to structures and graves.	4	4	3	3	4	80
			Significance Post- Mitigation					
			4	2	1	2	4	42

<table>
<tr><td>Project Activity</td><td colspan="2">Damage to ruins, graves and heritage sites caused by fly rock</td><td colspan="2">Likelihood</td><td colspan="3">Consequence</td><td></td></tr>
<tr><td rowspan="5">All blasting</td><td>Phase of Project</td><td>Operational Phase</td><td>Frequency of Activity</td><td>Frequency of Impact</td><td>Severity</td><td>Spatial Scope</td><td>Duration</td><td>Significance Rating</td></tr>
<tr><td>Impact Classification</td><td>Cumulative</td><td colspan="6">Significance Pre-Mitigation</td></tr>
<tr><td rowspan="3">Resulting Impact from Activity</td><td rowspan="3">Fly rock impact will cause damage to structures and graves.</td><td>4</td><td>4</td><td>4</td><td>4</td><td>4</td><td>96</td></tr>
<tr><td colspan="6">Significance Post- Mitigation</td></tr>
<tr><td>4</td><td>2</td><td>2</td><td>2</td><td>4</td><td>48</td></tr>
</table>

Mitigation, Management and Monitoring Measures

Vibration

The impact of vibration on people and buildings will be insignificant, providing the blast design is like the one outlined in Table 1.

However, there is a need to mitigate vibration when mining comes closer than 200 m from the R36 and closer than 1000 m from privately owned homes. Only one hole per delay (instance in time) may be fired to limit ground vibration to the required levels. This is achieved through effective timing designs and using initiation systems that accurately reflect the timing design.

A baseline study of houses within 1000 m of blasting will be needed before blasting commences to determine the current condition of the buildings as a reference. The from surrounding existing mines are unlikely to have caused damage, but houses naturally deteriorate with time, so there will be cracks and other damage that are not blasting related and need to be recorded.

Air blast and fly rock

Air blast control will be important to meet the limit of 125 dB and to avoid complaints regarding the mine activities. At 125 dB limit, air blast will be controlled within the blast and will have low significance at distances beyond 100 m.

Air blast and related noise from blasting need to be controlled by providing adequate stemming in each blasthole as per an effective design. Stemming lengths should not be less than 20 hole-diameters, except in presplit holes. Strict control needs to be applied to prevent the occurrence of over-charged holes.

Stemming length control also applies to fly rock control.

Under-burdened faces are a major source of fly rock and air blast. Burden control on free faces must be applied and face profiling should be applied on faces that are oriented towards receptors that are closer than 1000 m from a blast. Effective burden control implies presplitting of all overburden and mid-burden blasts to create good quality vertical high walls.

As a normal procedure, it will be necessary to temporarily clear people to a safe distance (1000 m) from blasting activities. This control must also apply to people working in the opencast operations immediately adjacent to the mine.

In cases where roads or railway lines (R36 and the railway line to the South East of the mine) come within the zone of influence of fly rock from blasting, traffic must be stopped at a safe distance of a minimum of 1000 m during blasting operations.

Pre-split blasting can generate very high air blast amplitudes. This should be controlled by firing presplit holes one at a time in sequence away from nearby receptors and in an upwind direction.

Monitoring programme

Routine air blast and ground vibration monitoring should be carried out near the closest private home to each blast. Occasional audits should be conducted on blasting practices and mitigation options reconsidered if monitoring shows that levels exceed applicable guidelines.

In areas where the unmitigated significance of fly rock is Medium High, a video must be taken and assessed for fly rock control of each blast as this will provide a form of evidence for potential complaints and will be useful for management improvement.

Fumes

Should any nitrous oxide fumes be observed during a blast, blasting activity should be reviewed and the cause of the fumes identified and corrected if needed. Causes include poor charging practices, incorrect explosives formulation or holes that are too close together in softer formations.

Nitrates dissolved in water

Only waterproof explosives should be used. Bulk emulsions and bulk emulsion blends are suitable, but explosives that can dissolve in water, such as ANFO should never be used.

Sleep times (how long a blast stands after it is charged and before it is fired), should be limited to a maximum value depending on the water quality which can cause break-down of emulsions inside a blasthole. Behaviour of the chosen emulsion product over time when exposed to groundwater (water present in the blastholes) must be tested to determine a safe sleep time.

Any spillages of stored explosives, especially ammonium nitrate prill, must be controlled with adequate bunding and cleaned immediately after a spillage occurs.

Special mitigation measures for structures closer than 500m to blasting

Heritage sites (including graves)

In several cases, there are heritage sites that a located closer than 500 m. These structures are particularly sensitive to fly rock risk. For these structures that are closer than 500 m to a blast, the following measures need to be taken in addition to the fly rock control measures outlined.

1. Stemming lengths must be increased to >25 hole diameters.
2. For each blast, every heritage site within 500 m of a blast must be mapped before the blast and then checked after the blast. If there is any fly rock within 250 m of such site, stemming lengths for the next blast must be increased to 30 hole diameters or specialist advice obtained to curb the risk in future blasts.

A video recording of each blast must be made to determine the effectiveness of the fly rock control.

Sites within the mining area

Ruins that are present within the proposed open cast area are KP4, KP9, KP12. KP13 and KP22. There is also a grave site 2 within the planned opencast mining area. The proposal is to leave remnant pillars around each of these sites that are 50 m in radius. Special care will be needed to minimise the risk of pillar displacement or damage during blasting around the pillar. This will require smaller diameter holes (reduced from 250 mm) long delays, and only one hole firing per delay when blasting closer than 100 m from the pillar. Specialist advice will be needed in working out the mining sequence around the pillars and in designing each blast closer than 100 m from the pillar edges to ensure no pillar displacement occurs and vibration limits are met.

Buildings closer than 500 m from blasting

The village on Kranspan, Portion 1 (Marker Y in Figure 4) will fall within the normally mitigated zone of fly rock and vibration.

The special mitigating measures for fly rock outlined above for heritage sites must apply for this village.

All people and animals must be evacuated from the village when blasting closer than 1000 m from the village.

To curb vibration when blasting closer than 800 m from the village, charge mass per delay will need to be reduced over and above the normal mitigation measures for controlling vibration. This can be achieved by drilling smaller diameter holes and/or by multi-benching using shorter holes. Specialist advice should be obtained to ensure ground vibration at the village is effectively curbed to 7.5 mm/s.

Conclusions and Key Findings

The most important findings of this report are:

1. There will be a negative impact from blast induced ground vibration in four cases (R36 road a nearby community and two farm dwellings all within the boundaries of the operation). This can be achieved through timing designs and initiation systems that ensure only one hole fires per instant in time during a blast.
2. Air blast and fly rock present the highest significance ratings and will need to be controlled by applying blast designs with stemming lengths that will effectively curb fly rock including controlled stemming application of the holes. Atmospheric conditions have a major impact on amplifying air vibration in certain directions, but if effective stemming is applied and presplits are timed with short delays between each hole, air vibration will be low, and amplification will be insignificant.
3. The temporary removal of people and stopping of road/rail traffic will be necessary to a safe distance of a minimum of 1000 m from planned blasting activities at blasting time.
4. A few heritage sites (ruins and one grave) exist within the opencast mining area. These present a challenge that will require specialist involvement in the blast designs and mining sequences when mining approaches closer than 150 m to these sites.

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Appendix 1 – Impact of Blasting on Structures and Humans

Influence of Blasting Practice on Vibration and Air blast

A few basic factors influence ground vibration[1] amplitudes. These are:

1. **The charge mass fired per instance in time.** The larger the charge mass, the higher the amplitude of the ground vibration. The charge mass can be limited by timing blasts so that holes fire one at a time or by reducing the blasthole diameters. These practical measures have a marked influence on vibration amplitudes.
2. **The distance from the blast.** Vibration energy is attenuated in the rock through friction, reflections and increased distribution of the wave front as distance increases from a blast. Normally, structures that are farther from blasting experience lower amplitudes than those closer to blasting. This phenomenon is discussed in more detail in the Section entitled Attenuation and Prediction of Peak Amplitudes.

Air blast is the air pressure wave generated by a detonation. Air blast amplitudes are strongly influenced by the following factors:

1. Unconfined charges produce very high air pressure waves. Unconfined charges are those that are not confined in a hole that is properly stemmed. Examples are lay-on charges used for secondary blasting purposes and detonating cord that is sometimes used for connecting holes on surface. The amplitude of the air blast is proportional to the mass and the surface area of the exposed charge. Limiting the use of unconfined charges is important to controlling air blast amplitudes.
2. Ineffective stemming material, un-stemmed holes (often used in presplit blasts) and overcharged holes all create high air blast amplitudes and increase the risk of fly rock. Blast designs and control during application are the two important factors in helping to combat excessive air blast levels from these sources. Blasts that are the noisiest are usually presplit blasts that are normally fired un-stemmed. Control of air blast in this case could be achieved by firing presplit holes sequentially away from a sensitive receptor with short delays between each presplit hole.
3. Atmospheric conditions can amplify air blast amplitudes to damaging levels. High wind velocities, thick cloud cover or temperature inversions are the main amplifying factors. Normally, well-designed and controlled blasts where all holes are properly stemmed and the blast is correctly timed, amplification effects are insignificant. However, these effects become very significant with poor control and air blast related damage, such as broken windowpanes or loosened ceilings, can occur as far as 10 km from a blast under certain atmospheric conditions.

Air blast is more commonly a problem to nearby homeowners than vibration, because it is felt through response of large surfaces such as ceilings and windows. Homeowners usually confuse these effects as being caused by ground vibration. The result is that complaints are more frequent for noisy blasts that may be small than large well-controlled blasts.

[1] Ground vibration is the vibration that is measured close to the surface of the ground. It does not include any structural resonance effects.

Attenuation and Prediction of Peak Amplitudes

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 (Dowding, 1984):

Equation 1

$$C = a\left(\frac{R}{\sqrt{W}}\right)^{-b}$$

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 *a* and *b* are site-specific constants that are a function of the transmission properties of the rock mass. The constants *a* and *b* are usually determined from vibration measurements at a specific site. There is no historical vibration data measured from the area and global constants have been applied for Equation 1:

a = 1143

b = -1.65

Air Blast Prediction

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

$$p = 7\times10^{4}\left(\frac{W^{\frac{1}{3}}}{R}\right)$$

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 <u>only relevant for exposed charge masses</u>. 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 **125 dB** at any receptor.

Ground Vibration Limits

Building response to ground vibration

Although there are no formalized limits to vibration, the US Bureau of Mines (USBM) limits are commonly applied in Africa. The limiting curve is shown in Figure 8 and has been developed from empirical studies (Siskind *et.al.* 1980).

The limiting curve in Figure 8 represents the limit for potential cosmetic damage to a house. The maximum ground vibration amplitudes are frequency dependent with higher frequencies allowing higher peak amplitudes. Most modern blasting seismographs will display the vibration data in terms of the USBM limiting criterion. In general, at lower frequencies, the ground vibration should not exceed 12.7 mm/s, but at higher frequencies, the limit can increase to 50 mm/s.

Because of human response to vibration (see below) and the need to limit complaints from neighbours, the limits for this study are recommended at a maximum PPV of 7.5 mm/s. At levels above 7.5 mm/s, people find ground vibration very disturbing.

Human response to ground vibration

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 levels. Table 1 provides typical human response to ground vibration

Ground vibration levels received at a structure of 0.76 to 2.54 mm/s are quite perceptible, but the probability of damage is almost 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 unpleasant, although permanent damage to a structure is unlikely.

Human perception is also affected by frequency. The approximate human response curves are combined with the USBM limiting curve for damage in Figure 9. These curves slope in the opposite direction. In other words, humans are more tolerant to low frequency vibrations.

To avoid damaging buildings, the USBM limiting curve should be applied. However, to avoid constant complaints and possible litigation from neighbours, the vibration should preferably be kept beneath the *unpleasant* curve and be kept beneath the *intolerable* curve.

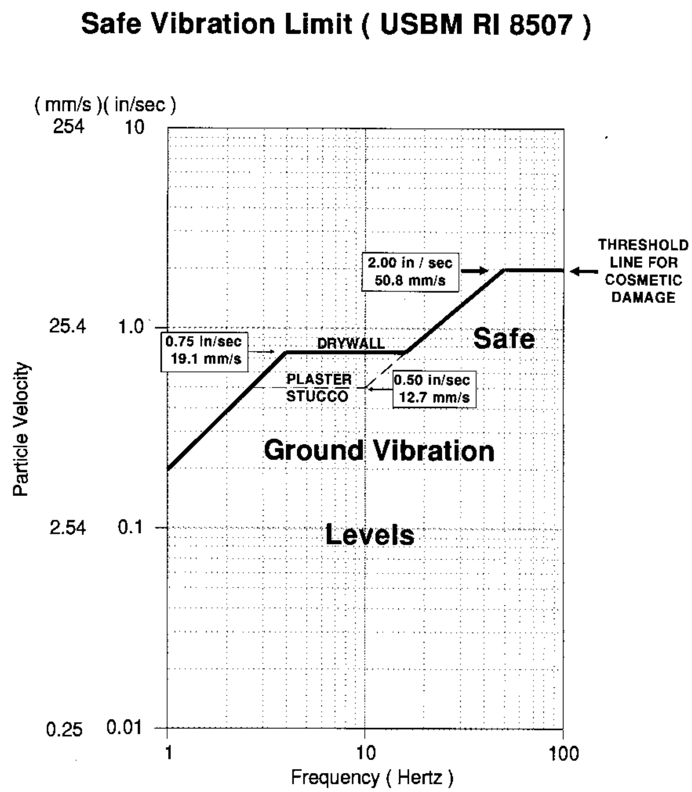

Figure 8. USBM curve that is generally used in Africa. (After Chiappetta, March 2000). This is a very conservative limit as it applies to structures build with timber frames and dry walls. Concrete block and mortar buildings are much stronger and will withstand much higher vibration amplitudes without damage.

Table 5. Human response to 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	0.062 – 2.540
Disturbing	2.540 – 7.620
Very disturbing	7.620 – 25.400

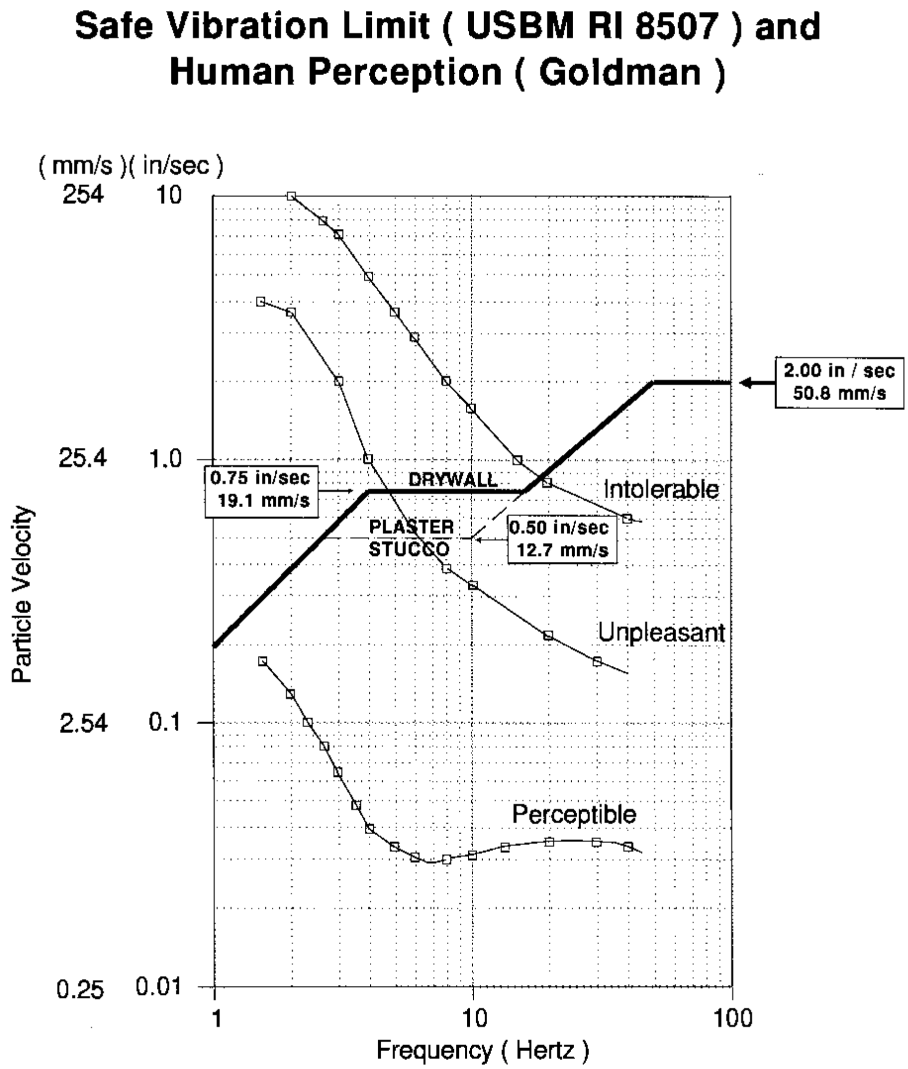

Figure 9. Human response curves compared with potential damaging limits. (After Chiappetta, 2000)

Mud buildings and Heritage Structures

There are no published vibration limits on these kinds of structures, because they are so variable in shape, size and strength. Mud houses can vary significantly and will be more sensitive to low frequency vibration if they have heavy roofs. They can also be weakened significantly by water erosion (rain) and walls that are not vertically constructed.

However, studies reported by Oriard (2005, Chapter 10) indicate that such structures including mounds and derelict buildings are quite resilient to vibration and compare with modern dry wall structures. The limits in Figure 8 would therefore apply. A conservative limit of 19.5 mm/s should be applied to the ruin sites, but a stricter 7.5 mm/s should apply for the mud-build houses, especially as there is a risk of partial collapse due to dilapidation from water ingression and temperature fluctuations and possibly poor foundations.

The main risk to heritage sites (including graves) is from fly rock impact.

Graves

Being in the ground, high vibrations would be needed to desegregate the ground. PPV values of 150 mm/s or more would increase the risk of desegregation. The main risk to graves is of fly rock either damaging headstones or impacting grave sites.

Vibration on other Structures

Vibration limits have been published in the literature for different types of equipment and structures. Although these may differ slightly from application to application, the guidelines by Bauer and Calder (1977) are based on empirical information. These limits are provided in Table 6.

Table 6. Vibration amplitudes for structures and equipment other than buildings.

Type of Structure	Type of Damage	PPV at which Damage starts (mm/s)
Rigidly mounted mercury switches	Trip-out	12.7
Compacted soil	Segregation from the vertical component of vibration	150
Concrete blocks (e.g. floor slabs)	Hairline cracks in concrete	203
Cased drill holes	Horizontal offset	381
Mechanical equipment (e.g. pumps and compressors)	Shaft misalignment	1016
Prefabricated metal buildings on concrete pads	Cracked floor, building twisted and distorted	1524

Segregation of compacted materials occurs at PPV values above 150 mm/s.

Impact of Blasting on Wells and Aquifers

A literature review of blasting induced vibration impact is very unlikely to result in damage to any boreholes or aquifers surrounding the two mines. It has been established that vibration of earthquake magnitude and frequency of vibration is needed for damage to become apparent. The ground vibrations generated by blasting will be orders lower than earthquake magnitude vibration.

Water oscillation

The information provided in this Section is based on work Published by Oriard (2005).

It is possible for water in open wells to respond to seismic waves caused primarily by dilatation that occurs in the aquifer as a result of a passing vibration wave. The factors that have an impact are:

a. The dimension of the well and its construction detail
b. The rock/soil formation (porosity and transmission properties)
c. The period and amplitude of the seismic wave and its type

In measurements during some earthquakes, the water level fluctuated in response to the passage of the different wave forms but did not produce long term or permanent changes. However, in a few cases strong earthquakes appeared to result in some permanent changes in the aquifers, but the physical effect responsible is not understood.

Oriard is not aware of any such effects for lower level elastic vibrations that would be associated with blasting. He notes that the strain levels from earthquakes are far greater and transmitted to far greater distances than blasting vibrations. He notes that the effects aquifers seen from strong ground motion caused by earthquakes is not present where vibration particle velocities are lower than 20 mm/s

The oscillation of the water is strongly dependent on the frequency of the vibration wave. In earthquakes, very low frequencies are generated (periods greater than 10 seconds) which are like the resonant frequencies of aquifer systems, thus causing the water level fluctuations. Blasting generates much higher frequencies (periods of a fraction of a second), and thus would not cause the water system in an aquifer to respond to the vibration.

Damage to rock

The pressure induced in an aquifer by the passage of a seismic wave can be determined as follows:

Equation 3

$$P = \rho c V$$

P is the pressure in KPa, ρ is the density of the medium (soil or rock) in kg/m^3, V is the particle velocity in mm/s.

Based on this relationship, the induced pressures for different particle velocities are provided in *Table 7.*

Rock begins to fail at particle velocities above 600 mm/s which are equivalent to a pressure of about 5000 KPa (Table 7). With reference to Table 3, which provides an estimate of likely particle velocity amplitudes as a function of distance from blasting, particle velocity will exceed 600 mm/s at distances closer than 100 m from blasting. Therefore, damage to the aquifer host-rock by blasting vibration is very unlikely at distances greater than 100 m from blasting.

Air Blast Limits

Based on work carried out by Siskind *et.al.* (1980), monitored air blast amplitudes up to 135 dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies (down to 1 Hz). Persson *et.al.* (1994) have published the following estimates of damage thresholds based on empirical data (Table 8).

Table 7. Induced pressure in an aquifer as a function of particle velocity (vibration). This is based on a wave propagation velocity of 3000 m/s and a rock density of 2650 kg/m³.

Particle Velocity (mm/s)	Induced Pressure (KPa)
1	7.95
5	39.75
10	79.50
15	119.25
20	159.00
100	795.00
200	1590.00
300	2385.00
400	3180.00
500	3975.00
600	4770.00
700	5565.00
800	6360.00
900	7155.00
1000	7950.00

Table 8. Damage limits for air blast.

120 dB	Threshold of pain for **continuous** sound
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

Appendix 2 – A J Rorke Resume

Introduction

I have specialized in the consulting and development fields of blasting technology since 1985.

My knowledge and capabilities include blast optimisation for mining and wall control, blasting related environmental studies, management of the development of technologies for blasting (examples being blasting software and precise electronic detonators) and blasting consultancy.

Until 2017 I was employed by BME as a Director Blasting Technology and was responsible for managing a group of mining engineers, software engineers, scientists and technicians.

I have had numerous papers on blasting technology published at local and international blasting conferences.

I live in Johannesburg, South Africa.

Experience

2005-2017

Director of Blasting Science, BME. Management role for a team of software engineers developing blasting design software, electronics engineers developing electronic delay detonators and blast optimisation engineers providing advanced consulting services to mining and civils operations.

Also acted directly as a consultant to operations and BME clients when needed.

1995–2005

Blasting Consultant

Supplied a blasting consultancy services to surface and underground mining operations. This work has included blast auditing, blast monitoring and optimisation, designs for complex blasting problems and wall control. Modern blast monitoring equipment and software tools were used for monitoring of blast performance and vibration.

Carried out environmental impact studies related to blast induced vibration, noise and dust.

Generated blast design software for surface and underground blasting operations. Several blasting codes have been developed that are being used by the mining industry. Main achievement: The development of the BlastMap blast design software that is used by most BME clients. This work was later passed onto software programming specialists

Supervise and carry out blasting research projects for underground mines, surface hard rock mines and coalmine operations.

Develop and provided training courses in underground and surface blasting

Manage a team of Explosives Engineers who provide monitoring and consulting services to BME clients

Direct the development, testing and application of BME's newest electronic delay detonator system, AXXIS.

During this period, I have consulted to many of the mining and civil contracting operations in South Africa, Namibia, Zimbabwe, Zambia, Tanzania, Mali, Botswana, Malawi, Ethiopia, Ghana, Mauritania and Guinea. I have also provided advice for operations in the Philippines, China, the UAE and Australia.

1990–1995

Blasting Consultant, Blastech

In the early 90's, I formed a private consultancy company, Blastech (Blasting and Geotechnologies (Pty) Ltd), that provided a high-tech consultancy and monitoring service in blasting technology to South African mining and civil engineering operations. This company stopped functioning when I joined BME in 1995.

1987 - 1990

Chamber of Mines Research Organization, Johannesburg

Research Project Manager

Planned and managed a rock de-stressing project for deep level gold mines.

Applied sophisticated drill and blast methods and fluid injection methods to relieve stress in rock burst prone areas.

1985–1986

AECI Ltd, Johannesburg

Blasting Physicist

Provided blasting consultancy service mainly to open cast mines.

Involved in blast simulations and numerical modelling of blasts.

Set up a rock testing lab and rock testing procedures for input into blast models.

1979–1985

Chamber of Mines Research Organization, Johannesburg

Research Engineer

Conducted research in rock burst source mechanisms.

Managed several seismic projects on different deep-level gold mines for measuring rock burst phenomena.

Involved with computer coding to analyse seismic data.

1976–1978

Kloof Gold Mining Company, Johannesburg

Learner Miner

Production miner and shift boss in tunnelling and stoping projects

Learner miner.

Education

1982-1983 Rand Afrikaans University, Johannesburg

MSc degree in Geology focusing in Seismology (With distinction)

1970-1975 University of the Witwatersrand, Johannesburg

BSc (Mining Geology) degree in Engineering.

Examples of Publications

A J Rorke, 2007, An evaluation of precise short delay periods on fragmentation in blasting, EFEE Conference, Vienna, Austria.

A J Rorke, 2005, Wave interference patterns: predicting vibration concentrations from blasting using precise detonators, EFEE Conference, Brighton, UK

A J Rorke, S Thabethe. 2004, Large-hole blasting next to a pillar supporting a public road. 23rd ISEE Symposium, New Orleans, USA

A J Rorke, 2002, Strict Blasting Control in a High Production Hard Rock Mine, Seventh International Symposium for Rock Fragmentation by Blasting, Beijing, China

A J Rorke. 2000, The effectiveness of electronic detonators in surface blasting. BAI 2000 International High-Tech Blasting Seminar, Orlando, USA.

A J Rorke and J Botes. 2000, Highwall control measures at Optimum Colliery. BAI 2000 International High-Tech Blasting Seminar, Orlando, USA.

A. M. Milev S. M. Spottiswoode M. W. Hildyard A. J. Rorke and G. J. Finnie. 2000, Simulated rockburst – source design, seismic effect and damage. ISRM Symposium, Seattle, USA.

A. J. Rorke and A. M. Milev. 1999, Near field vibration monitoring and associated rock damage. Sixth International Symposium for Rock Fragmentation by Blasting, Johannesburg, South Africa.

Affiliations

Associate Member of the International Society of Explosives Engineers

Fellow of the Institute of Quarrying

Organising Committee, Fragblast 6

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Appendix 3 – Risk Assessment Methodology

The ABS risk assessment methodology has been applied as outlined in the three Tables in this Appendix.

Table 9. Consequence and likelihood

EPOCH ANALOGY	SEVERITY OF IMPACT	RATING
	Insignificant / non-harmful	1
	Small / potentially harmful	2
	Significant / slightly harmful	3
	Great / harmful	4
	Disastrous / extremely harmful	5

	SPATIAL SCOPE OF IMPACT (Extent)	RATING
Within Site	Activity specific	1
Activity/ Site Boundary	Area specific	2
Incl adjacant area	Whole project site / local area	3
Province	Regional	4
Countrywide/ International	National	5

	DURATION OF IMPACT	RATING
	One day to one month	1
	One month to one year	2
	One year to ten years	3
	Life of operation	4
	Post closure / permanent	5

CONSEQUENCE

	FREQUENCY OF ACTIVITY / DURATION OF ASPECT	RATING
	Annually or less / low	1
	6 monthly / temporary	2
	Monthly / infrequent	3
	Weekly / life of operation / regularly / likely	4
	Daily / permanent / high	5

	FREQUENCY OF IMPACT	RATING
	Almost never / almost impossible	1
	Very seldom / highly unlikely	2
	Infrequent / unlikely / seldom	3
	Often / regularly / likely / possible	4
	Daily / highly likely / definitely	5

LIKELIHOOD

Table 10. Significance matrix

LIKELIHOOD (Frequency of activity + Frequency of impact)	CONSEQUENCE (Severity + Spatial Scope + Duration)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 11. Significance rating

Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
VERY HIGH	126-150	Improve current management	Maintain current management
HIGH	101-125	Improve current management	Maintain current management
MEDIUM-HIGH	76-100	Improve current management	Maintain current management
LOW-MEDIUM	51-75	Maintain current management	Improve current management
LOW	26-50	Maintain current management	Improve current management
VERY LOW	0-25	Maintain current management	Improve current management

Appendix 4 - Glossary

Air blast

Air blast is the common technical term for the air pressure waves that travel through are from a blast. It is caused by uncontrolled high-pressure gas ejections from a blast. It is often sub-audible and can be felt for many kilometres from a blast dependent on atmospheric conditions. Air blast is inconvenient and seldom causes damage. It mainly is a cause of complaint from neighbours who usually believe it is ground vibration. However, air blast can be effectively controlled.

Free Face

Free faces are the sides of a blast block that are not confined by broken material from a previous blast. Free faces can cause dangerous fly rock if the burdens of the holes along free faces are too small.

Under-burdened

The burden is defined as the amount of rock that each blasthole must break in the direction towards the face of a blast. If a hole is under-burdened, it means the hole has been drilled too close to the face of the blast and there is not enough rock to effectively contain the explosion and expanding gasses thus generate dangerous fly rock and excessive air blast.

PPV

PPV is the acronym for Peak Particle Velocity. This relates to vibration measured in the ground. PPV is measured in mm/s and represents the highest amplitude of the ground vibration trace.

ANFO

ANFO is the acronym for Ammonium Nitrate and Fuel Oil. ANFO is made from porous ammonium nitrate prills with a small percentage of fuel oil added to it. The fuel oil is normally diesel. ANFO is water soluble and is not suitable for use in blastholes containing water. Because it is water soluble, it also presents a higher negative impact risk on dissolved salts in the water system.

Emulsion

Emulsion is a water-proof mix of ammonium nitrate in solution with fuel oil. Emulsion is non-detonable when using primers until it is sensitised during the charging operation. Because it is water-proof, it presents a low negative impact significance to the water system.

Holes per Delay

Each blast is timed to fire the blastholes in a certain pre-designed sequence. The sequence is defined by introducing delay periods between holes or groups of holes. The number of holes designed to fire at the same time is referred to as holes per delay.

Stemming

Stemming is an inert material used to plug the top portion of each hole to contain the energy in the rock. Stemming material can comprise drill cuttings, sand or aggregate. Generally stemming performance improves as the particle size of the stemming increases.

Ground vibration amplitude

Ground vibration amplitude is the amplitude of the particle velocity in a vibration wave travelling through the ground. The maximum value is the same as the peak particle velocity.

Charge mass

The charge mass per hole is usually specified in kilograms and is the major impact source on ground vibration amplitudes. This is the critical value that needs to be limited when designing blasts from a vibration control point of view.

Presplit blasts

Presplit blasts are fired along the perimeter of a blast to create a safe and stable final wall. These blasts are usually characterized by unstemmed, lightly charged holes that are fired at very short intervals apart. Because of the lack of stemming and the short inter-hole delays, presplit blasts tend to generate high air blast levels.

Stemming shear strength

To contain the high-pressure gases in a hole for as long as possible during detonation, stemming material must contain a level of shear strength that will prevent rapid ejection from the hole. Amongst the stemming materials typically used, screened aggregate has the highest shear strength and powdery drill cuttings the lowest shear strength.

Ilima Coal Company (Pty) Ltd

Kranspan Project - Framework for Rehabilitation and Closure

ABS Africa
Sustainability Advisors

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ILIMA COAL COMPANY (PTY) LTD

KRANSPAN PROJECT - FRAMEWORK FOR REHABILITATION AND CLOSURE

1 INTRODUCTION AND BACKGROUND

Ilima Coal Company (Pty) Ltd. is applying for a mining right over nine (9) portions of the Farm Kranspan 49IT. The farm Kranspan is situated approximately 13 km South-West of Carolina and approximately 12 km North of Breyten in the Gert Sibande District of the Mpumalanga Province. The farm falls within the authority of the Chief Albert Luthuli Local Municipality.

The applicant is the holder of prospecting right MP30/5/1/2/2/102PR and plans to mine the E Seam of the Ermelo Coalfield. To proceed with the planned mining activity the applicant is applying for a Mining Right. The main activity being applied for in terms of the EIA Regulations, 2014 (as amended) is thus Listed Activity 17 in Listing Notice 2.

Two coal products are expected to be produced from the mining. Approximately 70% of the mined coal is planned to be beneficiated and then exported via the Richards Bay Coal Terminal (RBCT). The remaining 30% will be thermal coal, supplied to Eskom for power generation.

The planned operations would comprise of surface and underground mining.

2 BRIEF PROJECT DESCRIPTION

The mine planning and detailed engineering is ongoing and the surface area extent of the planned infrastructure may change.

Based on the mine planning studies completed to date, the following is proposed:

- Surface (open pit) mining focusing on extraction of the E Seam via the roll over mining method;
- Follow-up phases of mining focused on extraction of the E Seam will be achieved through underground mining via the bord and pillar method;
- Establishment and maintenance of topsoil, overburden and a discard stockpile;
- Following extraction, the coal product will be dry crushed and screened on-site. To meet the export coal quality specifications, 70% of the coal will be beneficiated on site through an on-site coal washing plant with filter press;
- Coal discard from the wash plant will be disposed of in-pit as part of the rehabilitation of the surface mining. Alternatively, the discard will be disposed of in an engineered stockpile on surface. Both disposal options will be investigated and assessed in the S&EIR process;
- Dewatering of seepage water will be required for both the surface and underground mining over the Life of Mine (LOM). Water removed from pits and the underground workings will be retained in pollution control dams; and
- Establishment and maintenance of various ancillary mine support infrastructure will be required.

Following is a summarised list of the proposed mining activities to be undertaken.

- Exploration geophysical surveying, drilling, pit sampling and trenching;
- Clearing and grubbing (surface mining areas and surface infrastructure footprint);
- Topsoil removal and stockpiling (surface mining areas and surface infrastructure footprint);
- Overburden removal and stockpiling;
- Drilling and blasting (when necessary, surface and underground mining);
- Excavation of coal and material transfer to a coal stockpile area (surface and underground mining);
- Dry crushing and screening at the product loading area;
- Beneficiation of the export coal product; and
- Loading, hauling and transport of coal product (surface and underground mining).

2.1 Open Pit Design

A conventional strip mining (roll-over) method will be employed for each of the opencast pits. Material from the boxcut phase will be stored per overburden classification, with the bulk of the material placed in a position alongside the final strip, to facilitate filling of the final void.

Each of the steps in the open cast mining method is discussed below.

2.1.1 Topsoil

Topsoil will be removed two strips in advance of the current working strip and will be either stockpiled separately or placed directly on the rehabilitated area behind the advancing strip. Topsoil will be removed using excavators and hauled with Articulated Dump Trucks (ADTs).

2.1.2 Softs Removal

Soft subsoil will be removed one strip in advance of the current working strip and will be either stockpiled separately or placed directly on the rehabilitated area behind the advancing strip. Softs will be removed using excavators and hauled with Articulated Dump Trucks (ADTs).

2.1.3 Overburden Drill And Blast

Drilling of the overburden will be done using a mobile drill rig drilling a 110 mm diameter hole and with a planned burden and spacing of 4 m x 5 m. This may be adjusted once mining has commenced.

2.1.4 Overburden Dozing

The first overburden removal process will be to doze overburden material to the spoil side. For modelling purposes, it is assumed that 30% of the overburden can be dozed. The assumption is based on current mining practices at similar sites.

2.1.5 Overburden Load And Haul

After dozing, remaining overburden will be loaded and hauled and dumped on the spoil side of the current strip. The load and haul will be conducted using excavators and ADTs.

2.1.6 Coal Drill And Blast

Drilling of the overburden will be done using a mobile drill rig drilling a 110 mm diameter hole and with a planned burden and spacing of 7 m x 8 m. This may be adjusted once mining has commenced.

2.1.7 Coal Load And Haul

Permanent haul roads will be constructed in line with relevant safety requirements. The coal be loaded and hauled to the Run of Mine Stockpile using excavators and ADTs.

2.1.8 Rehabilitation

Rehabilitation of the open pit will be done concurrently with the opencast mining using the recognised roll over method of mining and the stated mining sequence.

Materials are placed back into the void in the former stratigraphic sequence i.e. topsoil on the surface, subsoil directly below the topsoil, while all hard material (sandstone and shale) is deposited in the bottom of the void. It is envisaged that the final reinstated surface level will be approximately 0.52 m above the original surface level. However, the existing surface drainage pattern will remain unchanged and the total disturbed area will be free draining. On completion of surface reinstatement, the area will be re-vegetated with suitable pasture grass species.

2.2 Underground Mining

The underground mining method will be a conventional bord and pillar mining operation deploying continuous miners with shuttle cars, supported by roof bolters for roof support and load haul dumpers for sweeping. The mine will be designed for the maximum extraction on the advance with no pillar extraction on retreat. The safety factors applied for main developments is 2.0 and for secondary production panels 1.6.

It is planned to establish three continuous miner production sections producing between 120,000 and 130,000 tpm. A stone development section will be established for developing through dykes and faults. This will ensure that the continuous miner sections focus on coal production only.

The mine design will allow for the introduction of additional production sections, if required in the future.

2.2.1 Underground Material Handling Systems

Broken ore will be transported from the production faces by means of an LHD and tipped into underground dump trucks for transporting to the underground crushing circuit.

Ore will be tipped directly onto a grizzly. The undersize will pass through the grizzly screen onto an apron feeder and vibrating grizzly, which will convey the ore to the underground crusher. Oversize will undergo secondary breakage using a hydraulic rock breaker. Ore will be transferred to adit via underground conveyor. From the surface stockpile it will be transported to plant via tipper trucks.

2.3 Dry Crushing And Screening Plant

Certain areas will be mined to produce a high Ash, medium Volatile, thermal coal product for power station consumption by screening and crushing the run of mine (ROM) coal. The crushing and screening plant will be situated at the plant area.

At the crushing and screening plant, the raw coal is fed into the crushing plant by a FEL. The coal is crushed mechanically in the plant by jaw crushers. This reduces the size of the raw coal so that it can be more easily handled. The crushed coal then moves into the screening plant where vibrating screens separate the crushed coal into different sizes or grades of coal.

This coal product is then loaded onto trucks for delivery to the Eskom market.

2.4 Overburden Stockpiles

Several overburden stockpiles will be established during the LOM. These overburden stockpiles comprise of the hards and softs sub-soil material removed in order to gain access to the coal seam. The stockpiles have been placed as close to the pits as possible but outside of areas identified as environmentally sensitive.

The stockpiles are temporary in that they are only on surface for as long as it takes to extract the coal from the relevant pit. After the coal has been removed, the overburden material is placed back into the pit in the same order as it was removed, typically hards, softs and then topsoil. Whilst on surface, the overburden stockpiles are managed as part of the dirty water management area. Runoff from the stockpile areas thus drains and is contained in the PCDs.

2.5 ROM and Product Stockpiles

Several ROM stockpiles will be established at the open cast mine areas. Raw coal extracted from the pits is temporarily stockpiled at these locations before being transported to the coal processing area either for dry crushing and screening or washing.

Following processing, the coal is placed on the product stockpile. The latter is situated adjacent to the processing plant. From here, the product is transported to the customer. The product stockpile will be in place for the LOM.

The ROM and product stockpile areas are managed as part of the dirty water management system. Runoff from the stockpile areas thus drains and is contained in the PCDs.

2.6 Beneficiation

Washing of the raw coal is required for approximately 70% of the coal product over the LOM. The purpose of washing is primarily to reduce the ash content of the coal so that it meets the quality requirements of the export market.

The raw coal handling facilities, coal preparation plant (wash plant) and product out-loading facilities are designed to receive and process coal from both opencast and underground mining operations and to produce 3.0 Mt/a of saleable product at 5,500 kcal/kg net as received which is to be out-loaded on rail for delivery to the Richards Bay Coal Terminal (RBCT). Ilima indicates that the beneficiation plant will not be established during the first three years of mining.

2.7 Discard Management

Two discard management alternatives were assessed as part of the S&EIR Process, namely surface and in-pit discard disposal. These are discussed in the relevant specialist studies, summarised in Section 17 of the EIR. The alternatives analysis is presented in Section 6 of the EIR.

Based on the mine planning undertaken to date and informed by the findings of the geochemical modelling, approximately 5 384 455 m3 of discard material is proposed to be backfilled in Pit 5 as part of the rehabilitation of this pit. This comprises of a surface area of approximately 143 ha and is based on backfilling of the discard into the mined pit up to the average height of the roof of the coal seam. Should additional discard disposal capacity be required and the material be backfilled to above the pre-mining coal seam depth, geochemical and groundwater modelling will be undertaken to estimate this impact prior to the implementation of this management option.

There are several design options for in-pit disposal of mine wastes which have been used successfully in the world.

Current forecasts indicate that there will be enough capacity in Pit 5 for the in-pit disposal of all discard material that will be generated over the LOM. Should this change, Ilima will establish an engineered surface discard stockpile. This stockpile will be situated in proximity to the coal preparation plant and will be designed in compliance with the Regulations regarding the Planning and Management of Residue Stockpiles and Residue Deposits, 2015 (as amended).

2.8 Workforce And Housing

The total number of employees and subcontractors are estimated to be between 350 and 400 and the water supply capacity has therefore been calculated at 40 kilolitres (kL) per day. Provision is made for a contractors camp on site.

3 FRAMEWORK FOR REHABILITATION AND CLOSURE

In the planning and implementation stages of the project, the focus of reclamation and closure planning is to ensure that:

- The proposed post-closure land use(s) for the site are defined and agreed with the regulatory authorities and local communities.
- The nature, scale and cost of the works required to return the site to a condition consistent with the requirements of the post-closure land use(s) are defined and understood.
- The necessary financial provisions are made for closure and that these are included in the assessment of the project's economic viability.
- A plan is developed for the implementation of the reclamation and closure works to ensure that the process proceeds concurrently with mining operations wherever possible.
- The build-up in reclamation and closure liabilities over the life of mine is limited through appropriate mine planning and concurrent reclamation to mitigate as far as possible the impacts of premature or unplanned closure.

The framework within which the conceptual reclamation and closure plan has been developed is described below in terms of the expected life of mine, post closure land use objectives legislative requirements and policy guidelines.

3.1 Life Of Mine Plan

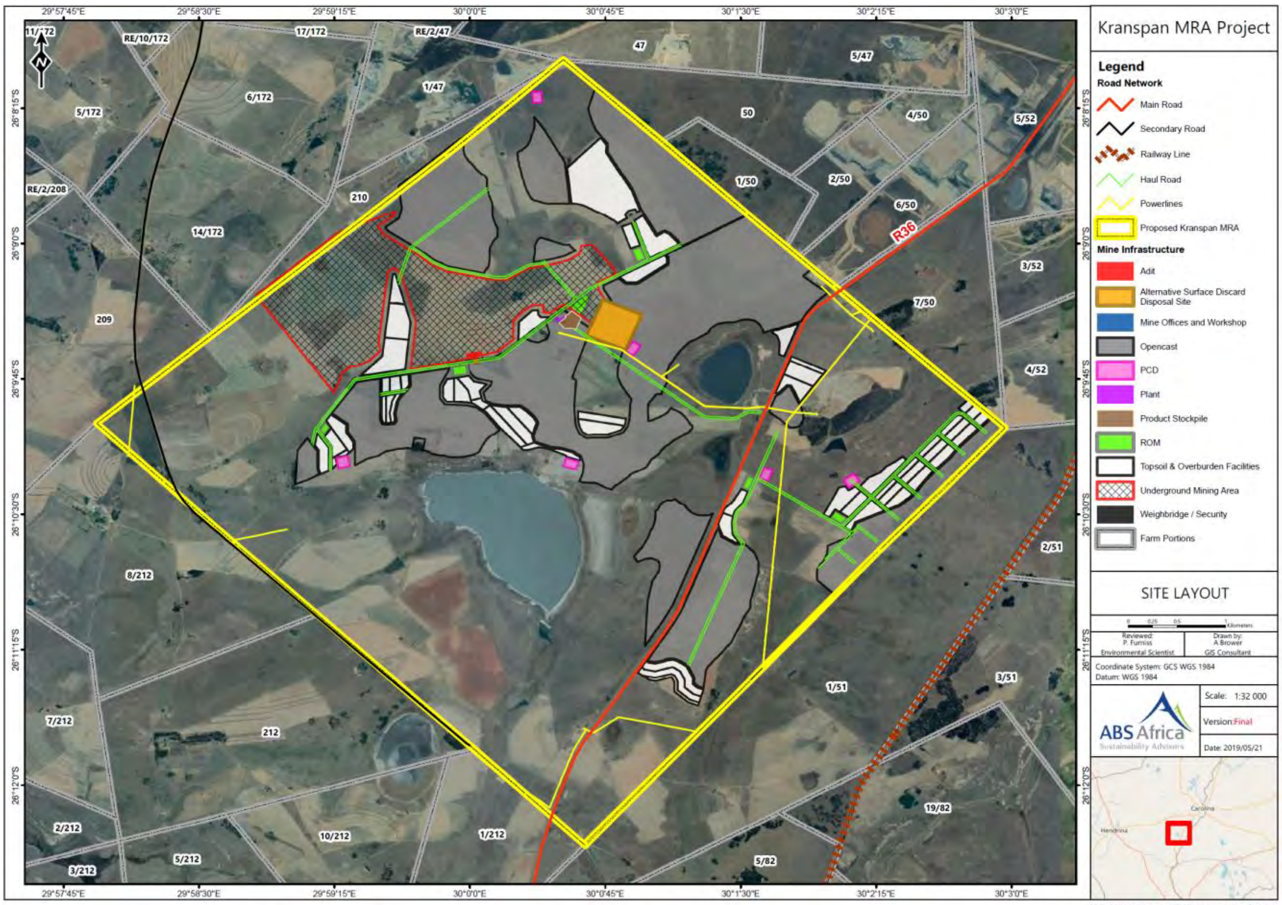
The project consists of the following key components:

- A mine contractors camp;
- Overhead powerlines and related electrical infrastructure from the nearest Eskom take-off position;
- Back-up power supply (generators);
- Bunded fuel storage area;
- Potable water supply infrastructure;
- Mine haul roads and associated stormwater control structures;
- Explosives storage area;
- Mine offices, parking area, first aid station, stores, laboratory, workshop, change house and lamp room (pre-fabricated structures);
- Overland conveyor;

- Wash plant;
- Surface discard stockpile facility (if needed in addition to in-pit disposal of discard);
- Product stockpiles and loading area;
- Weighbridges;
- Brake test ramps;
- Crushing and screening plant;
- Underground mine access shaft and associated equipment;
- Upcast ventilation shaft and fans (underground mine), and
- Wastewater (sewage) treatment infrastructure for the contractor's camp and mine office block area.

The mine will operate on a 2-shift system 6 days per week and the coal preparation plant operates on a 3-shift system 7 days per week. Coal is out-loaded to rail 7 days per week. The raw coal handling, stockpiling, processing, and out-loading facilities are designed to cater for the differences between mining, coal preparation, and product handling operations.

FIGURE 3-1: GENERAL SURFACE LAYOUT MAP



3.2 POLICY GUIDELINES AND LEGISLATIVE REQUIREMENTS

Historically, financial provision was regulated under the Mineral and Petroleum Resources Development Act, 2002 (MPRDA), and the Mineral and Petroleum Resources Development Regulations. This system has been repealed and replaced through amendments to the MPRDA and the National Environmental Management Act, 1998 (NEMA), and through the publication of Financial Provisioning Regulations under NEMA in 2015 (the 2015 FP Regulations).

Section 24R of the NEMA deals with mine closure and includes references to section 24P of NEMA, which covers the financial provision required for mine closure. Section 24R (3) of the NEMA requires the holder of a mining right to plan, manage and implement such procedures and measures in respect of the closure of a mine as may be prescribed.

In terms of section 43 (1) of the MPRDA, the holder of a mining right remains responsible for any environmental liability until the Minister has issued a closure certificate in terms of the MPRDA to the holder of the right.

Legislation require inter alia that an applicant or holder of right or permit 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.

An applicant 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:

- annual rehabilitation, as reflected in an annual rehabilitation plan;
- final rehabilitation, decommissioning and closure of the prospecting, exploration, mining or production operations at the end of the life of operations, as reflected in a final rehabilitation, decommissioning and mine closure plan; and
- remediation of latent or residual environmental impacts which may become known in the future, including the pumping and treatment of polluted or extraneous water, as reflected in an environmental risk assessment report.

The closure planning process has been developed to conform to the requirements of best Practice Guidelines which requires that the concurrent and decommissioning rehabilitation as well as describe the unit costs and provide a detailed cost estimate. The estimates of rehabilitation, closure and aftercare costs have been structured to distinguish between rehabilitation and closure costs incurred during the life of mine and those that will be incurred at closure.

Rehabilitation funding guarantees would be provided to the regulatory authorities based on the expected extent of surface disturbances at selected stages throughout the life of mine and the success of ongoing rehabilitation and closure works. Rehabilitation activities will be designed to achieve a post-mining land use as close as possible to the level of productivity and biodiversity present at pre-mining levels.

A closure plan forms part of the environmental management programme or environmental management plan 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 showing the land or area under closure.
- A summary of the regulatory requirements and conditions for closure negotiated and documented in the environmental management programme or environmental management plan.

- A summary of the results of the environmental risk report and details of identified residual and latent impacts;
- A summary of the results of progressive rehabilitation undertaken;
- 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;
- 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.

The requirements of South Africa's legislation relating to financial provisioning for mine closure and decommissioning further require the following:

- The determination, review and assessment must be undertaken by a specialist or specialists.
- The financial provision liability associated with annual rehabilitation, final closure or latent or residual environmental impacts may not be deferred against assets at mine closure or mine infrastructure salvage value.
- The proof of making or adjusting the financial provision provided by the applicant or holder of a right or permit must identify the manner in which the financial provision will be apportioned through the use of appropriate financial vehicles.
- The proof of making or adjusting the financial provision must be accompanied by a verification of registration of the financial institution contemplated in those sub-regulations.
- Where an applicant or holder of a right or permit makes use of the financial vehicle any interest earned on the deposit shall first be used to defray bank charges in respect of that account and thereafter accumulate and form part of the financial provision.
- Where financial provision is made for remediation of latent or residual environmental impacts which may become known in the future, including the pumping and treatment of polluted or extraneous water the financial vehicle used for that purpose must, on issuance of a closure certificate in terms of the MPRDA, be ceded to the Minister responsible for mineral resources, or, if the financial vehicle contemplated in regulation 8(1)(c) is used, the trustees must authorise payment to the Minister responsible for mineral resources.

In addition to the above environmental legal obligations provided for in the NEMA and the MPRDA there may be other potential statutory obligations which may be relevant and include inter alia:

- The Mine Health and Safety Act 29 of 1996
- The Regulations on use of water for mining and related activities published in terms of GN R704 under the NWA
- The National Heritage Resources Act 25 of 1999
- The National Building Regulations and Building Standards Act 103 of 1977
- The Labour Relations Act 66 of 1995

3.3 Post Closure Land Use Objectives

Ilima's objective for the rehabilitation and closure of the mine is to ensure that the site is left in a condition that is safe and stable where long-term environmental impacts are minimised and any future liability to the community and future land use restrictions are minimised. The final post-mining land use will be determined in consultation with the local communities, Ministry of Mines and Geology as well as other departments responsible for environmental and social aspects. The land uses to be identified during this process are likely to include the following:

- Livestock grazing;
- Cultivation; and
- Wildlife habitat.

For health and safety reasons as well as the protection of specific rehabilitation works, specific areas within the license area may be designated as exclusion zones. Natural soil covers and vegetation will as far as possible be re-established over these areas but access by humans and / or livestock will be prohibited.

The following closure objectives form part of the conceptual closure plan:

- All structures established by Ilima and not desirable or usable post closure will be demolished and building material removed or disposed of;
- Hazardous material, equipment and contaminated soils and steel structures will be disposed of safely and in an environmentally acceptable manner;
- The coal wash plant and other areas used for the handling and storage of hazardous materials will be decontaminated;
- Rehabilitation of disturbed areas to a final land use capability that is practical and best suited for the final landform, taking into consideration the socio-economic activities of the receiving communities.

At the end of the mine life, the residual facilities will include surface water diversion structures and supporting infrastructure. If a Surface Discard Facility is required during the Life of Mine, this facility will be rehabilitated and form part of the post-closure landscape.

The ultimate end-use of the rehabilitated areas is considered to have three major objectives. The first is the re-establishment to the greatest feasible degree of vegetation on the disturbed areas within the concession. The second is the re-integration of the disturbed areas outside the project footprint into the agricultural and other prevalent economies. Thirdly, by working with and involving local people in the re-development of the disturbed land to assist them in working towards a more sustainable form of livelihood.

3.4 Reclamation And Closure Completion Criteria

The objective of the rehabilitation closure process is to restore as much as possible of the area disturbed during the operation of the development and mine to a land use as close as possible to that previously practiced before mining operations. While the total area disturbed may ultimately be different to that surveyed, the objective would be to maintain the balance of land use and return as much of the area disturbed to productive use.

Rehabilitation and closure of areas disturbed in mining and related operations will be considered to be complete when:

- All structures, equipment and infrastructure not consistent with the post closure land use have been decommissioned, demolished and removed from site;

- Ownership of all remaining infrastructure and services required to support the proposed post closure land use have been formally transferred to the local authority responsible for the administration of the area;
- The area has been made safe for all post closure land users and livestock;
- All surface disturbances and remaining landforms are structurally and ecologically stable and have sustainable soil and vegetation covers where applicable; and
- Surface water management structures are in place and are not susceptible to erosion.

3.5 Conceptual Rehabilitation And Closure Plan

As various facilities reach the end of their period of use, Ilima will initiate rehabilitation activities concurrent with on-going mining operations. Rehabilitation activities will be undertaken during all phases of the project in order to restore the land back to a c sustainable usable condition.

Ilima will implement progressive rehabilitation measures, beginning during the construction phase. The key factors that will be considered during the construction phase include –

- The greenfield or natural areas affected by the Project will be minimised; and
- The potential future contact of contaminating materials with the environment will be minimised.
- Design and construction will be carried out with the closure objectives in mind.

3.5.1 General Reclamation And Closure Activities

3.5.1.1 Protection and Harvesting of Resources to Be Used During Rehabilitation

Construction activities will be undertaken with a view to ensuring the following:

- Optimising the layout to ensure that the area occupied by mine infrastructure is limited to a minimum.
- Ensure that construction crews restrict their activities to areas earmarked for development only.
- Pre-stripping of topsoil and overburden material from development areas with a view to using the material during concurrent as well as decommissioning and closure phases.
- Establishing seed banks and a nursery with a view to be used during rehabilitation activities.

3.5.1.2 Rehabilitation Trials

- Concurrent reclamation activities should be used to experiment with different rehabilitation and revegetation options, determining the optimal subsoil and topsoil placement requirements, vegetation to be used as well as maximum slope angles to be used. Early revegetation trials will determine the species to be included in the seed bank and nursery.

3.5.1.3 Preparation and Placement of Topsoil

The following activities will be undertaken as part of the soil placement process:

- The utilizable soil (500mm) removed during the construction phase or while opening up of decline adit entrance, shall be redistributed in a manner that achieves an approximate uniform stable thickness consistent with the approved postmining land use (Low intensity grazing), and will attain a free draining surface profile. A minimum layer of 300mm of soil will be replaced.
- A representative sampling of the stripped soils will be analysed to determine the nutrient status of the utilizable materials. As a minimum the following elements will be tested for: EC, CEC, pH, Ca, Mg, K, Na, P, Zn, Clay% and Organic Carbon. These elements provide the basis for determining the fertility of soil. based on the analysis, fertilisers will be applied if necessary.

- Erosion control measures will be implemented to ensure that the soil is not washed away and that erosion gulleys do not develop prior to vegetation establishment.
- If soil (whether stockpiled or in its undisturbed natural state) is polluted, the first management priority is to treat the pollution by means of in situ bioremediation. If in situ treatment is not possible or acceptable then the polluted soil must be classified and disposed at an appropriate, permitted, off-site waste facility.
- Disturbed areas will be graded and ripped to ensure the area is ready for the placement of overburden and topsoil material, where viable.
- Compaction will be avoided through the use of suitable equipment and methods and the placement of subsoil and topsoil to a suitable depth. Where multi-layer soil profiles are re-created, running over the lower layers with heavy equipment should be minimised.
- Following placement, all soils should be ripped to full rooting depth.
- Where natural revegetation is not possible, the soils should be tilled to produce a seed-bed suitable for the plant species selected for seeding.

3.5.1.4 Re-Vegetation

Prior to initiating the proposed rehabilitation vegetation plan, ILIMA will evaluate growth media replacement depths for various exposures by conducting re-vegetation trials to arrive at a specification that accounts for location and soil type.

- Where possible, self-succession of vegetation will be allowed to occur and if this does not happen, then suitable indigenous vegetation will be replaced.
- Species selected for rehabilitation must meet the biodiversity objectives.
- Rehabilitation species selection will be based on practical considerations.
- Appropriate methods will be used for vegetation establishment.
- Planting should be done when climatic conditions are most likely to ensure success.
- No specialized biodiversity objectives have been set but should these be identified during the detailed closure planning process the necessary expertise will be acquired to ensure the successful implementation of the rehabilitation plan.
- The revegetation objectives should be set to meet the post-closure land uses that have been agreed for the site. These could be the re-establishment of the native vegetation, erosion control for the protection of water resources, establishment of high-quality grazing or the preparation of lands for arable use.

3.5.1.5 RoM Stockpiles

- It is expected that RoM stockpiles will be removed by the end of mine life and stockpile areas would be reclaimed by grading and re-vegetating to blend with the natural landscape.

3.5.1.6 Contaminated Soils

Contaminated soil from solvents and lubricant and other hydrocarbon sources will be removed and placed in an approved disposal facility. Alternatively, the soils will be treated and when considered rehabilitated it can be used as part of the reclamation process.

3.5.2 Rehabilitation And Closure Activities Applicable To Specific Infrastructure Areas

3.5.2.1 Crushing and Screening Facility and Coal Wash Plant (if established)

- Infrastructure will be removed to a depth of 0.5m below ground level, alternatively foundations will be covered to a depth of 0.5m, provided this does not affect surface water runoff. Sub-surface structures will be backfilled or sealed off.
- Structures will be toppled or dropped and then loaded for removal using mechanical equipment.
- Inert rubble will be removed to a licensed landfill facility.
- Contaminated rubble will be assessed for degree of contamination and disposed of in the appropriate hazardous waste disposal sites.
- All infrastructure (including civil concrete) which cannot be used by alternative land users will be demolished and the following options can be considered for their viability:
- Remove and/or bury all rubble and waste, at approved sites.
- The final site will be contoured so as to return the rehabilitated area to as close to the pre-mining environment as possible. This will be undertaken by carrying out the following rehabilitation activities:
  - Excavation and suitable offsite disposal of contaminated soils to the depth of contamination.
  - Contouring to allow for a free draining landscape.
  - self-succession of vegetation will be allowed to occur and if this does not happen, then suitable indigenous vegetation will be replaced.
  - If necessary, erosion control and floodwater run-off control measures will be implemented.
  - If necessary, erosion will be repaired if and when it occurs.

3.5.2.2 In-Pit Discard Disposal

Coal discard generated at the wash plant generally comprises of larger coal particle sizes and less moisture. Discard from the coal preparation plant is planned to be deposited back into the open pits, after extraction of the target coal seam has been completed. In accordance with the recommendations from the geochemical characterisation testwork, geochemical modelling and groundwater study, only Pit 5 is proposed to be used for the in-pit disposal of the discard material.

The volume of discard material which will be generated over the LOM is dependent on several factors including the tonnage of coal processed through the wash plant. Based on the mine planning undertaken to date and informed by the findings of the geochemical modelling, approximately 5 384 455 m^3 of discard material is proposed to be backfilled in Pit 5 as part of the rehabilitation of this pit. This comprises of a surface area of approximately 143 ha and is based on backfilling of the discard into the mined pit up to the average height of the roof of the coal seam.

Should additional discard disposal capacity be required and the material be backfilled to above the pre-mining coal seam depth, geochemical and groundwater modelling will be undertaken to estimate this impact prior to the implementation of this management option.

3.5.2.3 Surface Discard Facility and Associated Water Management Structures

In the event that a surface discard stockpile is established, the primary considerations for closure design of this facility include:

- geotechnical considerations;

- dust and surface water control;
- long term management of residual seepage and groundwater elevations; and
- contaminated Sites requirements.

At closure, the Surface Discard Facility will remain a permanent feature on the landscape. The rehabilitation and closure of the facility will include activities that take place concurrently with its development and operation as well as those associated with its final decommissioning and closure. Rehabilitation of the side slopes will be carried out concurrently. Sufficient drying time will be allowed before rehabilitation activities will start on the top of the Surface Discard Facility (est. 2-3 years).

As such, a cover system should be constructed on closure to isolate the discard material from the environment. Based on the proposed environmental control measures (i.e. low permeability soil liner and underdrainage system), seepages through the base of the facility should not have a negative effect on shallow surface water or groundwater.

Post closure, the Surface Discard Facility area will be a zone of restricted access for safety reasons, as well as to protect established vegetation. The Surface Discard Facility will be rehabilitated to ensure they are safe and stable. Where appropriate rehabilitation materials or cover material are available, revegetation will be encouraged.

3.5.2.4 Sealing of Shafts, Adits and Inclines

The most important aspect in sealing adit shafts is to ensure that the safety considerations associated with such a shaft are met. For the shaft to be sealed adequately, inert building rubble may be backfilled into the shaft, thereby partially plugging the shaft. The sealant is reinforced by a concrete cap, dimensions of which are governed by the size and nature of the shaft. After sealing the adit, the final void will then be filled with rubble and covered with, sub-soil and 300mm to 500mm of topsoil and vegetated. The possible formation of methane underground once the shaft has been sealed needs to be taken into account by placing venting boreholes strategically in the area.

3.5.2.5 Workshop Area

All steel and concrete structures need to be demolished to 1 m below ground level. The remaining rubble may be buried adjacent to the building sites. Once the infrastructure is demolished, the area needs to be covered with 300mm of topsoil and vegetated.

3.5.2.6 Opencast Rehabilitation

All the voids will be filled with the adjacent overburden. The overburden will be loaded, trucked and placed into the voids, and the topography in the area adjacent to these voids shaped to ensure that a free draining landscape is achieved. Once all the voids have been backfilled, 300mm thick topsoil or soft overburden in place of soil will be spread on rehabilitated areas. Once placed, the "growth medium" should then be fertilised, ripped and revegetated. A small topsoil stockpile should be left for remedial work.

3.5.2.7 Land Use

Final land uses will be a combination of:

- Future mining resource area, both formal and informal;
- Rehabilitated landforms with modified natural ecosystems;
- Zones with restricted access for safety; and

- Community facilities and structures.

Consultation with key stakeholders to develop and define the post mining land use options will be facilitated by Ilima. Environmental and socio-economic assessments will be undertaken to ensure the selected land use options are consistent with regulatory constraints and are sustainable into the future.

3.5.3 POST CLOSURE WATER MANAGEMENT

During the decommissioning phase it is anticipated that the quality of the water in the PCDs will not be suitable for discharge. The water will therefore be contained in the PCDs and allowed to evaporate until such time that the rehabilitation of the site is completed and the seep water becomes suitable for release.

The geohydrological assessment identified the potential for decant to occur from the rehabilitated opencast areas. Decant is possible from the pits as the rate of recharge to the backfilled pits are expected to be higher compared to natural conditions. If this is the case at closure, a total of 20 potential decant points were identified as part of this assessment. The timing of decant varies according to the rate at which groundwater and rainfall recharge may flood the pits and may occur between 6 and 39 years after mining ceases, depending on the prevailing conditions.

The volume of decant will be mainly driven by the rate of recharge to the backfilled pits. These volumes may vary between 1 160 and 21 900 m^3/a, depending on the size of the pit and the success of the rehabilitation process. The static test results indicate that there is an acid generating potential for some of the material that will be handled on site, specifically the coal and discard material. For this reason, the quality of decant is not expected to be good. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

Due to the anticipated poor quality of decant water, provision was made for a series of PCDs to capture the seepage and allow for evaporation. The PCDs will remain post-closure to allow for the capture of runoff and seepage from the mined areas and seep zones identified during the geohydrological assessment.

It is recommended that the geohydrological study and associated post closure water quality modelling assessment be updated once the kinetic test work is finalised to confirm the post closure water management requirements.

3.5.3.1 REHABILITATION MONITORING, AFTERCARE AND MAINTENANCE

Provision has been made for ongoing monitoring and maintenance following the completion of the final rehabilitation and closure activities. The monitoring typically includes the following aspects:

- Alignment of the actual final topography to the agreed planned landform that is free draining
- The actual depth of topsoil placing as well as the chemical, physical and biological status of replaced soil.
- Presence of erosion and the actual cause of the erosion
- Surface water quality as well as the presence of ponding in low-lying area, resulting in breeding areas for mosquitos.
- Groundwater quality at agreed monitoring locations.
- Vegetation basal cover.
- Vegetation species diversity.
- Crop growth and yield (on sites rehabilitated to agricultural end-uses).

Provision has been made for the collection and analysis of environmental monitoring data (surface and ground water, air quality) and the compilation of monitoring reports for a period of:

- 18 months after closure to coincide with the decommissioning and rehabilitation phase of the project; and
- An additional 5 years after completion of the decommissioning and closure phase.

3.5.4 Potentially Acid Generating Material And Post Closure Water Quality Risk

Sampling was conducted in two phases. The first phase involved the analysis of discard samples generated during small-scale washing experiments. The material selected for the wash tests was based on the analysis of information for 24 reject samples provided by the project geologist. Six samples were selected that covered the range of total sulphur, ash content and calorific value.

The second phase involved the analysis of 20 samples, selected from drill core material from four newly drilled monitoring holes.

In summary, the reject coal material has a probability of becoming acid generating if stored in a surface impoundment for a significant amount of time. The contradiction between the ABA and NAG data for these samples introduces a degree of uncertainty around the magnitude of the acid generating potential. Greater clarity should be provided by the on-going kinetic test.

The environmental risk associated with the waste rock material (drill cores) is lower, with only one of the 20 samples demonstrating significant acid generating potential. The static tests provide an often unrealistic, worst case scenario as a result of the sample preparation. Milling the material to -75 µm creates a reactive surface area and degree of mineral liberation that is very significantly greater than is likely on an actual waste rock dump. As such, while the tests may be indicative of acid generating and metal leaching potential, the magnitude is often overestimated.

The tests conducted during this phase of the project indicated that the material did exceed the TCT and LCT0 values for a number of elements, but in these cases the measured values were significantly below the relevant TCT1 and LCT1 values, so the material should be classified accordingly.

The following proven control measures for avoiding or preventing acid mine drainage have been incorporated into the mine design and environmental management plan:

- Land reclamation, which includes management of overburden stockpiles and rehabilitation of mined areas in a manner which facilitates the quick movement of surface water flow off mined areas;
- Alkaline amendment to active disturbances. This includes managing stockpiles by blending acid-generating material with material with a high acid neutralising potential as well as the use of limestone to increase alkalinity;
- Alkaline recharge trenches comprising of or surface trenches filled with alkaline material to add alkalinity to water prior to infiltration. The increased alkalinity buffers the formation of acid;
- Oxygen barriers. These involve the installation of technologies like impervious membranes, dry seals, hydraulic mine seals, grout curtains/walls to restrict the extent to which material which may acid-generating comes in contact with oxygen or water;
- Water covers, involving the placement of material which may be acid-generating beneath a pond or lake, either natural or artificial;

- Alkaline amendment to abandoned mines. Measures include the removal of surface stockpiles known to be a source of acid mine drainage and backfilling of underground voids with impermeable material; and
- Remining and reclamation. This involves returning to a previously mined area to decrease the recharge, cover acid-producing materials and/or remove the remaining coal, which is the source of most of the pyrite.

Avoidance measures implemented for the potential acid mine drainage impact associated with the proposed mining activities include:

- Revision of the mine plan to avoid the extent to which environmentally sensitive areas are directly impacted upon;
- Implementation of strip mining and concurrent rehabilitation measures to minimise the surface area extent potentially exposed to oxidation;
- After mining, reinstatement of the overburden material in the same stratigraphic sequence in which it was removed. This prevents mixing of the different soils and limits the extent to which carbonaceous material may be exposed to oxidative conditions;
- Design of clean and dirty water storm water systems to minimise the flow of surface water into areas where acid may be generated, including the pits and overburden stockpile areas. In addition, the stormwater management plan provides for six HDPE-lined pollution control dams for containing dirty water runoff, seepage into mine workings and decant from rehabilitated pits;
- Prevention of dirty surface water runoff and decant into sensitive environmental features like wetland and pans;
- If the surface discard stockpile is necessary, it is recommended that at least a compacted clay liner be considered in order to reduce long-term adverse impacts on groundwater and decant quality;
- In-pit disposal of discard:
  - Must be limited to Pit 5;
  - The discard material must not be backfilled beyond the level of the pre-mining coal seam depth;
  - Should additional discard disposal capacity be required and the material be backfilled to above the pre-mining coal seam depth, that geochemical and groundwater modelling is undertaken to estimate this impact prior to the implementation of this management option. The outcome of these simulations must guide the extent to which discard can be placed above the coal seam depth;
  - The full extent of the discard material must be placed below the regional rest (pre-mining) groundwater table; and
- Additional mitigation measures must be implemented to further reduce the risk of in-pit disposal of discard to groundwater resources. This must be informed by the outcome of updates to the groundwater model inclusive of the kinetic leach testwork.
- The EMPr must be updated to include the detailed engineering design for the surface discard facility, should it be required;
- Prior to the construction of the wash plant, the groundwater model must be updated with the findings of the kinetic leach testwork and the detailed design of the in-pit disposal; and

- Additional mitigation measures must be implemented to further reduce the risk of in-pit disposal of discard to groundwater resources. This must be informed by the outcome of updates to the groundwater model inclusive of the kinetic leach testwork.

3.5.5 MEASURES THAT WILL BE PUT IN PLACE TO REMEDY ANY RESIDUAL OR CUMULATIVE IMPACT THAT MAY RESULT FROM ACID MINE DRAINAGE

Groundwater monitoring will continue throughout the LOM to detect changes in water quality and this will be used to inform the need for any additional control measures, including post-closure water treatment.

Decant will be contained in an HDPE-lined, engineered facility, appropriately designed for the volume water required to be managed.

Poor quality water will not be released into the environment.

Various technologies can be employed for treating acid mine drainage should this be necessary. The choice of the technology is dependent on several factors including the volume of water, level of acidity, water oxidation status and concentrations of metals (Skousen et al., 2018). Without knowing these variables, it is not possible to accurately design and cost a water treatment system.

In general, water treatment can be undertaken:

- Actively, typically through the establishment of a water treatment plant and the use of chemicals; and
- Passively, by, for example, the construction of wetlands which make use of natural chemical and biological processes to improve the quality of water. Passive water treatment systems are suitable for conditions of low to moderate flow and acidity.

Should the monitoring programme indicate that water treatment of acid mine drainage is likely to be necessary, a treatment plan will be developed based on the quality and flow of water requiring treatment. The preference will be on using passive water treatment technologies.

The treatment plan will include the cost for the treatment of water for as long as this may be needed. This cost will be included in the annual update to the mine's financial provisioning for rehabilitation and closure, as required by legislation.

4 ESTIMATE OF COSTS ASSOCIATED WITH THE IMPLEMENTATION OF THE CLOSURE PLAN

The estimate for rehabilitation and closure for the Kranspan project is based on the principles and closure activities as set out in the report. The closure plan is considered conceptual and therefore certain uncertainties relating to the actual activities to be implemented as part of the decommissioning and closure phases of the project will only be confirmed once a detailed closure plan has been developed.

The costing is based on the DMR methodology, as described earlier in the report.

It is worth noting that a significant portion of the closure activities can be completed concurrently with the mining operations, thus significantly reducing the works required at the end of the life of mine.

The quantum for closure summarized in Table 4-1 and reflects the environmental closure liability associated with the first 6 months of mining. Based on the mine plan it is anticipated that a steady sate will then be achieved after 6 months and that the roll-over mining plan can be implemented after that. This allows for concurrent reclamation to be undertaken from the 1st year of mining, thereby limiting the liability associated with the closure of the mine towards the end of its life. The increase in closure liability is reflected in Table 4-2 and Table 4-3. Which reflects months 6 to 18 of mining.

TABLE 4-1: KRANSPAN QUANTUM FOR CLOSURE: MONTHS 0-6

CALCULATION OF THE QUANTUM							
	KRANSPAN	Location:	Ilima Coal Company				
	0 - 6 Months	Date:	June 2019 - Rev00				
	Description: Class A (Medium Risk)	Unit:	A Quantity	B Master rate (2019 Inflated)	C Multiplication factor	D Weighting factor 1	E=A*B*C*D Amount (Rands)
Component			Step 4.5	Step 4.3	Step 4.3	Step 4.4	
1	Dismantling of processing plant & related structures (incl. overland conveyors & Power lines)	m^3	1467.00	R16.13	1.00	1.10	R 26 036
2 (A)	Demolition of steel buildings & Structures	m^2	0.00	R224.74	1.00	1.10	R 0
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	1081.00	R331.20	1.00	1.10	R 393 827
3	Rehabilitation of access roads	m^2	64710.00	R40.22	1.00	1.10	R 2 862 679
4(A)	Demolition & rehabilitation of electrified railway lines	m	0.00	R390.34	1.00	1.10	R 0
4(B)	Demolition & rehabilitation of non electrified railway lines	m	0.00	R212.91	1.00	1.10	R 0
5	Demolition of housing &/or administration facilities	m^2	0.00	R449.48	1.00	1.10	R 0
6	Opencast rehabilitation including final voids & ramps	ha	18.18	R228 763.15	0.52	1.10	R 2 378 899
7	Sealing of shafts, adits & inclines	m^3	0.00	R120.65	1.00	1.10	R 0
8(A)	Rehabilitation of overburden & spoils	ha	43.50	R157 082.45	1.00	1.10	R 7 516 395
8(B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	0.00	R195 643.36	1.00	1.10	R 0
8(C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	2.00	R568 241.05	0.80	1.10	R 1 000 104
9	Rehabilitation of subsidised areas	ha	0.00	R131 532.90	1.00	1.10	R 0
10	General surface rehabilitation	ha	6.05	R124 435.80	1.00	1.10	R 828 120
11	River diversions	ha	0.00	R124 435.80	1.00	1.10	R 0
12	Fencing	m	1500.00	R141.94	1.00	1.10	R 234 204
13	Water management	ha	18.18	R47 313.99	0.67	1.10	R 633 944
14	2 to 3 years of maintenance & aftercare	ha	18.18	R16 559.90	1.00	1.10	R 331 165
	Specialist study (Hydrogeological study)	SUM	1.00	R149 181.56	1.00	1.10	R 164 100
	Specialist study (Auditing)	SUM	1.00	R74 102.19	1.00	1.10	R 81 512
							R 16 450 986
	Weighting Factor 2 (step 4.4)			1.05		Sub Total 1	**R 17 273 535**
	Preliminary and General			12% of Sub Total 1			**R 1 974 118**
	Administration and supervision costs			6% of Sub Total 1			**R 987 059**
	Engineering Drawings and specifications			2% of Sub Total 1			**R 329 020**
	Engineering and Procurement of specialist work			2.5% of Sub Total 1			**R 411 275**
	Development of a closure plan Final Groundwater modelling			2.5% of Sub Total 1			**R 411 275**
	Contingency			10% of Sub Total 1			**R 1 645 099**
						Sub Total 2	**R 23 031 380**
	VAT (15%)						**R 3 454 707.02**
	GRAND TOTAL						**R 26 486 087**

TABLE 4-2: KRANSPAN QUANTUM FOR CLOSURE: MONTHS 6-12

CALCULATION OF THE QUANTUM								
	KRANSPAN	Location:	Ilima Coal Company					
	6 - 12 Months	Date:	June 2019 - Rev00					
	Description: Class A (Medium Risk)	Unit:	A Quantity	B Master rate (2019 Inflated)	C Multiplication factor	D Weighting factor 1	E=A*B*C*D Amount (Rands)
Component			Step 4.5	Step 4.3	Step 4.3	Step 4.4	
1	Dismantling of processing plant & related structures (incl. overland conveyors & Power lines)	m^3	1467.00	R16.13	1.00	1.10	R 26 036
2 (A)	Demolition of steel buildings & Structures	m^2	0.00	R224.74	1.00	1.10	R 0
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	1081.00	R331.20	1.00	1.10	R 393 827
3	Rehabilitation of access roads	m^2	64710.00	R40.22	1.00	1.10	R 2 862 679
4(A)	Demolition & rehabilitation of electrified railway lines	m	0.00	R390.34	1.00	1.10	R 0
4(B)	Demolition & rehabilitation of non electrified railway lines	m	0.00	R212.91	1.00	1.10	R 0
5	Demolition of housing &/or administration facilities	m^2	0.00	R449.48	1.00	1.10	R 0
6	Opencast rehabilitation including final voids & ramps	ha	14.98	R228 763.15	0.52	1.10	R 1 960 171
7	Sealing of shafts, adits & inclines	m^3	0.00	R120.65	1.00	1.10	R 0
8(A)	Rehabilitation of overburden & spoils	ha	49.88	R157 082.45	1.00	1.10	R 8 618 800
8(B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	0.00	R195 643.36	1.00	1.10	R 0
8(C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	3.00	R568 241.05	0.80	1.10	R 1 500 156
9	Rehabilitation of subsidised areas	ha	0.00	R131 532.90	1.00	1.10	R 0
10	General surface rehabilitation	ha	6.05	R124 435.80	1.00	1.10	R 828 120
11	River diversions	ha	0.00	R124 435.80	1.00	1.10	R 0
12	Fencing	m	1500.00	R141.94	1.00	1.10	R 234 204
13	Water management	ha	14.98	R47 313.99	0.67	1.10	R 522 359
14	2 to 3 years of maintenance & aftercare	ha	44.66	R16 559.90	1.00	1.10	R 813 522
	Specialist study (Hydrogeological study)	SUM	1.00	R149 181.56	1.00	1.10	R 164 100
	Specialist study (Auditing)	SUM	1.00	R74 102.19	1.00	1.10	R 81 512
							R 18 005 486
	Weighting Factor 2 (step 4.4)			1.05		Sub Total 1	R 18 905 760
	Preliminary and General			12% of Sub Total 1			R 2 160 658
	Administration and supervision costs			6% of Sub Total 1			R 1 080 329
	Engineering Drawings and specifications			2% of Sub Total 1			R 360 110
	Engineering and Procurement of specialist work			2.5% of Sub Total 1			R 450 137
	Development of a closure plan Final Groundwater modelling			2.5% of Sub Total 1			R 450 137
	Contingency			10% of Sub Total 1			R 1 800 549
						Sub Total 2	R 25 207 680
	VAT (15%)						R 3 781 152.04
	GRAND TOTAL						**R 28 988 832**

TABLE 4-3: KRANSPAN QUANTUM FOR CLOSURE: MONTHS 12-18

CALCULATION OF THE QUANTUM							
	KRANSPAN	**Location:**	**Ilima Coal Company**				
	12 - 18 Months	**Date:**	**June 2019 - Rev00**				
	Description: Class A (Medium Risk)	**Unit:**	**A Quantity**	**B Master rate (2019 Inflated 6%)**	**C Multiplication factor**	**D Weighting factor 1**	**E=A*B*C*D Amount (Rands)**
Component			**Step 4.5**	**Step 4.3**	**Step 4.3**	**Step 4.4**	
1	Dismantling of processing plant & related structures (incl. overland conveyors & Power lines)	m^3	1467.00	R16.13	1.00	1.10	R 26 036
2 (A)	Demolition of steel buildings & Structures	m^2	0.00	R224.74	1.00	1.10	R 0
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	1081.00	R331.20	1.00	1.10	R 393 827
3	Rehabilitation of access roads	m^2	64710.00	R40.22	1.00	1.10	R 2 862 679
4(A)	Demolition & rehabilitation of electrified railway lines	m	0.00	R390.34	1.00	1.10	R 0
4(B)	Demolition & rehabilitation of non electrified railway lines	m	0.00	R212.91	1.00	1.10	R 0
5	Demolition of housing &/or administration facilities	m^2	0.00	R449.48	1.00	1.10	R 0
6	Opencast rehabilitation including final voids & ramps	ha	8.21	R228 763.15	0.52	1.10	R 1 074 299
7	Sealing of shafts, adits & inclines	m^3	0.00	R120.65	1.00	1.10	R 0
8(A)	Rehabilitation of overburden & spoils	ha	49.88	R157 082.45	1.00	1.10	R 8 618 800
8(B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	0.00	R195 643.36	1.00	1.10	R 0
8(C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	3.00	R568 241.05	0.80	1.10	R 1 500 156
9	Rehabilitation of subsidised areas	ha	0.00	R131 532.90	1.00	1.10	R 0
10	General surface rehabilitation	ha	6.05	R124 435.80	1.00	1.10	R 828 120
11	River diversions	ha	0.00	R124 435.80	1.00	1.10	R 0
12	Fencing	m	1500.00	R141.94	1.00	1.10	R 234 204
13	Water management	ha	8.21	R47 313.99	0.67	1.10	R 286 286
14	2 to 3 years of maintenance & aftercare	ha	75.10	R16 559.90	1.00	1.10	R 1 368 013
	Specialist study (Hydrogeological study)	SUM	1.00	**R149 181.56**	1.00	1.10	R 164 100
	Specialist study (Auditing)	SUM	1.00	**R74 102.19**	1.00	1.10	R 81 512
							R 17 438 033
	Weighting Factor 2 (step 4.4)			**1.05**		**Sub Total 1**	**R 18 309 935**
	Preliminary and General			12% of Sub Total 1			**R 2 092 564**
	Administration and supervision costs			6% of Sub Total 1			**R 1 046 282**
	Engineering Drawings and specifications			2% of Sub Total 1			**R 348 761**
	Engineering and Procurement of specialist work			2.5% of Sub Total 1			**R 435 951**
	Development of a closure plan			2.5% of Sub Total 1			**R 435 951**
	Final Groundwater modelling						
	Contingency			10% of Sub Total 1			**R 1 743 803**
						Sub Total 2	**R 24 413 247**
	VAT (15%)						**R 3 661 986.98**
	GRAND TOTAL						**R 28 075 233**

The following assumptions apply to the calculation of the quantum for closure associated with the Kranspan Project:

- It is assumed that concurrent rehabilitation will be undertaken as soon as steady state is achieved and the roll-over mining method is employed and that the surface disturbances that the calculations are based on will not change significantly.
- The establishment of a coal wash plant will not be undertaken during the first three years of mining at Kranspan and the financial provision for the closure of these facilities is therefore not presented in the Quantum.
- No underground mining is planned during the first 18 months of mining.
- All structures established for the project will be removed and the affected areas rehabilitated.
- All access roads will be rehabilitated as soon as the roads are no longer required

- It is assumed that no water treatment will be required following the closure of the mine and that the pollution control facilities will be adequate to contain any seeps from these areas.
- The conceptual closure plan and associated quantum for closure will be reviewed on an annual basis, as per the requirements of South African legislation and updated accordingly. Any changes to the mine plan or infrastructure requirements will be captured in the annual review and the quantum updated accordingly.

The assumptions will be reviewed on an annual basis based on the monitoring information generated as well as the various specialist studies to be undertaken as part of the calibration of the geohydrological model as well as the refinement of the closure plan.

5 PUBLIC CONSULTATION AND DISCLOSURE

The manner in which I&APs were identified and engaged with as part of the Public Participation Process (PPP), including the type of engagement followed, communication method and languages used, was informed by the requirements of the EIA Regulations (2014), applicable guideline documents, review of population data available for the area and feedback from I&APs during the S&EIR Process.

5.1 PRIOR CONSULTATION AND EXISTING AGREEMENTS

Prior to the commencement of the S&EIR Process, several Interested and Affected Parties (I&APs), including landowners, land users and surrounding landowners/land users, have been consulted with as part of the original prospecting right application and in advance of the exploration work undertaken by Ilima.

5.2 SCOPING PHASE

As part of project notification, a Draft Scoping Report was made available for public review and comment for a period of 30 days from 7 December 2018 to 28 January 2018.

Registered I&APs were notified of the application and the availability of the Draft Scoping Report (DSR) through letters sent by e-mail and where no e-mail address was provided, through registered mail. The application and availability of the DSR was also announced through messaging applications (SMS and WhatsApp). . Notices were also made available in isiZulu at the container shop on Portion 1 of Kranspan.

Newspaper advertisements were placed in a local and regional newspaper in two languages (isiZulu and English). Letter notifications were distributed in Afrikaans and English and sms notifications were sent in Afrikaans. Site notices were placed in English and Afrikaans.

Key stakeholder meetings undertaken as part of the Notification Phase of the Project are summarised in the EIR.

5.2.1 COMMUNITY SURVEY

A local community is situated on Portion 1 of the Farm Kranspan, within the mining right area. . A community survey was undertaken on the 27th of February 2019 to engage with the community as well as adjacent communities to the proposed mining right area, to establish the socio-economic dynamics of the community and record the concerns of the community in terms of the proposed mining project. In accordance with the requirements of Regulation 41(2)(e), the survey was also used to determine levels of literacy, and preferred language and communication methods.

From the survey, it was noted that the community consists of approximately 12 families, residing in approximately 50 informal structures.

The findings of the consultative survey are discussed in the Social Impact Report.

It is understood that the community is in negotiations with Msobo Coal (Pty) Ltd. regarding the potential relocation of the community. This relocation is independent of the planned activities by Ilima and will thus proceed regardless of the outcome of the Ilima application for a mining right. Although the potential impacts of the proposed Ilima mining activities on this community have been assessed in the S&EIR Process, it is understood that the community is likely to be relocated before the proposed Ilima mining activities proceed.

5.3 EIA PHASE

This Draft EIR will be made available for a 30-day comment period. Notification of the availability of the draft report will be advertised (newspaper notices and site notices) and sent (e-mail and/or registered mail and messaging applications) in the same manner as the Draft Scoping Report. The Draft EIR will also be made available in the same way as was done for the Scoping Report.

6 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations apply to the assessment.

- The closure plan is conceptual in nature and it is recommended that a detailed closure plan be developed as part of the detail design phase of the project.
- No treatment of seepage water from the Surface Discard Facility or mined areas will be required.
- The assessment is based on rates associated with the works, as per 2019.
- The final land uses are to be established in consultation with the community and local authorities.
- Monitoring will continue for a period of 3 years after the start of the decommissioning phase.

7 CONCLUSION

The estimate for rehabilitation and closure associated with the Kranspan Project was based on the measured works as per the design reports and proposed development of the mine. The Closure objectives were determine taking into consideration site observations, legislative requirements as well as best practice guidelines available for mining projects.

The risk items to be addressed as part of the closure plan were based on a number of third-party reports and assessments, many of which are based on certain assumptions and limitations. These assumptions and limitations would need to be addressed during the operation phase of the mine and the closure objectives and risk assessment updated accordingly.

It is further recommended that a detailed closure plan be developed during the detail design phase of the project to ensure that the closure objectives are incorporated into the design, and that concurrent rehabilitation will be implemented whenever possible.

End of Report

DISCLAIMER

Advisory on Business and Sustainability Africa (Pty) Ltd. (ABS Africa) has prepared this report specifically for the client.

The contents of this report:

- Are based on the legal requirements for undertaking an Environmental Impact Assessment, as defined in the relevant legislation and the scope of services as defined within the contractual undertakings between the client and ABS Africa.

- Are specific to the intended development at the proposed site. The report shall not be used nor relied upon neither by any other party nor for any other purpose without the written consent of ABS Africa. ABS Africa accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

- Reflect the best judgement of ABS Africa in light of the information available at the time of preparation. The analyses contained in this report has been developed from information provided by the client and other parties. This information is not within the control of ABS Africa and ABS Africa has not audited such information and makes no representations as to the validity or accuracy thereof.

APPENDIX A: - FINANCIAL PROVISIONING FOR CLOSURE – DMR METHODOLOGY APPLIED

8 INTRODUCTION

The section provides an overview of the approach and methodology used for the determination of the financial provisioning required for the closure plan associated with the Kranspan Project.

9 DMR METHODOLOGY

The methodology followed the guidelines as required in terms of the "Guideline Document for the Evaluation of the Quantum of Closure-related Financial Provision Provided by a Mine",

The Guideline format makes use of a set template for which defined rates and weighted factors are used. The factors which ultimately define the rate to be used are determined by amongst others the type/classification of the mining that is being undertaken (the mineral being mined), the risk class of the mine and its proximity to built-up or urban areas and the weighting factor that is prescribed.

The rates are predetermined and specified by the DMR, the quantities being measured and applied to a template issued by the authority.

The cost for closure is calculated using these variables. Contingencies and VAT are applied to the cost.

The DMR's "Guideline Document for the Evaluation of the Quantum of Closure-related Financial Provision Provided by a Mine", the Master Rates for the DMR spreadsheet have been updated based on new rates released by the DMR in 2012 with an inflation factor applied based on the CPI for the applicable period.

It was assumed that the mine infrastructure has no salvage value, as per the guideline requirements.

Surface disturbances and infrastructure areas were measured by ABS Africa based on the mine layout and mine plan map provided by Ilima.

9.1 MINE CLASSIFICATION

The DMR Guideline Document for the Evaluation of the Quantum of Closure Related Financial Provision provided by a Mine (DME, 2005), classifies a mine according to a number of factors which include:

- The mineral mined;
- The risk class of the mine;
- Environmental sensitivity of the mining area;
- Type of mining operation; and
- Geographic location.

Once the mining type (mineral), the risk class (Class A, B or C) and the sensitivity of the area (Low, Medium or High) have been determined the unit rates for the applicable closure components are identified (Refer to Table 9-1 and Table 9-2.

TABLE 9-1: PRIMARY RISK CLASS FOR TYPE OF MINERAL MINED (ICC'S RISK CLASS HIGHLIGHTED)

Mineral	Ore	Size: large if > than (tpm)	Primary Risk Class			
			Large Mine		Small Mine	
			Mine and Mine Waste	Mine, Mine Waste, Plant and Plant Waste	Mine and Mine Waste	Mine, Mine Waste, Plant and Plant Waste
Antimony		1000	A	A	C	C
Asbestos		0	A	A	A	A
Base metals (Copper, Cadmium, Cobalt, Iron ore, Molybdenum, Nickel, Tin, Vanadium)	Sulphide	10 000	A	A	C	A
	Oxide	10 0000	C	A	C	A
Coal		0	A	A	A	A
Chrome		10 000	C	A	C	C
Diamonds and precious stones		10 000	C	B	C	C
Gold, silver, uranium		10 000	B	A	B	A
Phosphate		10 000	C	B	C	C
Platinum		10 000	C	B	C	B
Mineral sands (Ilmenite, Titanium, Rutile, Zircon)		10 000	C	B	C	C
Zinc and Lead		10 000	C	A	C	A
Industrial Minerals (Andalusite, Barite, Bauxite, Cryolite, Fluor- spar)		10 000	C	A	C	C
Note: Underground mines have a minimum risk ranking of B (Medium risk						

TABLE 9-2: CRITERIA USED TO DETERMINE THE SITE SENSITIVITY

Sensitivity	Sensitivity criteria		
	Biophysical	Social	Economic
Low	▪ Largely disturbed from natural state.	▪ The local com- munities are not within	▪ The area is insensitive to development.

	▪ Limited natural fauna and flora remains. ▪ Exotic plant species evident. ▪ Unplanned development. ▪ Water resources disturbed and impaired.	sighting distance of the mining operation. ▪ Lightly inhabited area (rural).	▪ The area is not a major source of income to the local communities.
Medium	▪ Mix of natural and exotic fauna and flora. ▪ Development is a mix of disturbed and undisturbed areas, within an overall planned framework. ▪ Water resources are well controlled	▪ The local communities are in the proximity of the mining operation (within sighting distance). ▪ Peri-urban area with density aligned with a development framework. ▪ Area developed with an established infrastructure.	▪ The area has a balanced economic development where a degree of income for the local communities is derived from the area. ▪ The economic activity could be influenced by indiscriminate development.
High	▪ Largely in natural state. ▪ Vibrant fauna and flora, with species diversity and abundance matching the nature of the area. ▪ Well planned development. ▪ Area forms part of an overall ecological regime of conservation value. ▪ Water resources emulate their original state.	▪ The local communities are in close proximity of the mining operation (on the boundary of the mine). ▪ Densely inhabited area (urban/dense settlements). ▪ Developed and well-established communities.	▪ The local com-munities derive the bulk of their income directly from the area. ▪ The area is sensitive to development that could compromise the existing economic activity.

TABLE 9-3: WEIGHTING FACTOR 1- NATURE OF TERRAIN

Description			
Weighting Factor 1	**Flat**	**Undulating**	**Rugged**
Weighting factor 1: Nature of the terrain/ accessibility	1	1.05	1.1
Weighting factor 2:	**Urban**	**Peri-Urban**	**Remote**
Proximity to urban area where goods and services are to be supplied	1	1.05	1.1

Table 9-4: Mine Classification Summary

Mine	Risk Class	Sensitivity	Terrain	Proximity to Urban Area
Kranspan Project	A	Medium	Undulating	Peri-Urban

APPENDIX B: HIGH RISK ASPECTS RELATING TO CLOSURE

The following aspects have been rated as the most significant potential closure risks that need to be managed during the decommissioning, closure and post closure phases of the project. Each issue generally reflects more than one of the higher rated hazards in the risk assessment matrix.

- Safety during rehabilitation and decommissioning
- Changing stakeholder expectations over life of project
- Inadequate financial provision for closure and lack of project controls
- Poor or inadequate rehabilitation designs and implementation
- Geotechnical instability of pit walls
- Erosional stability of mine waste landforms
- Geochemical stability of mine wastes
- Public access and safety

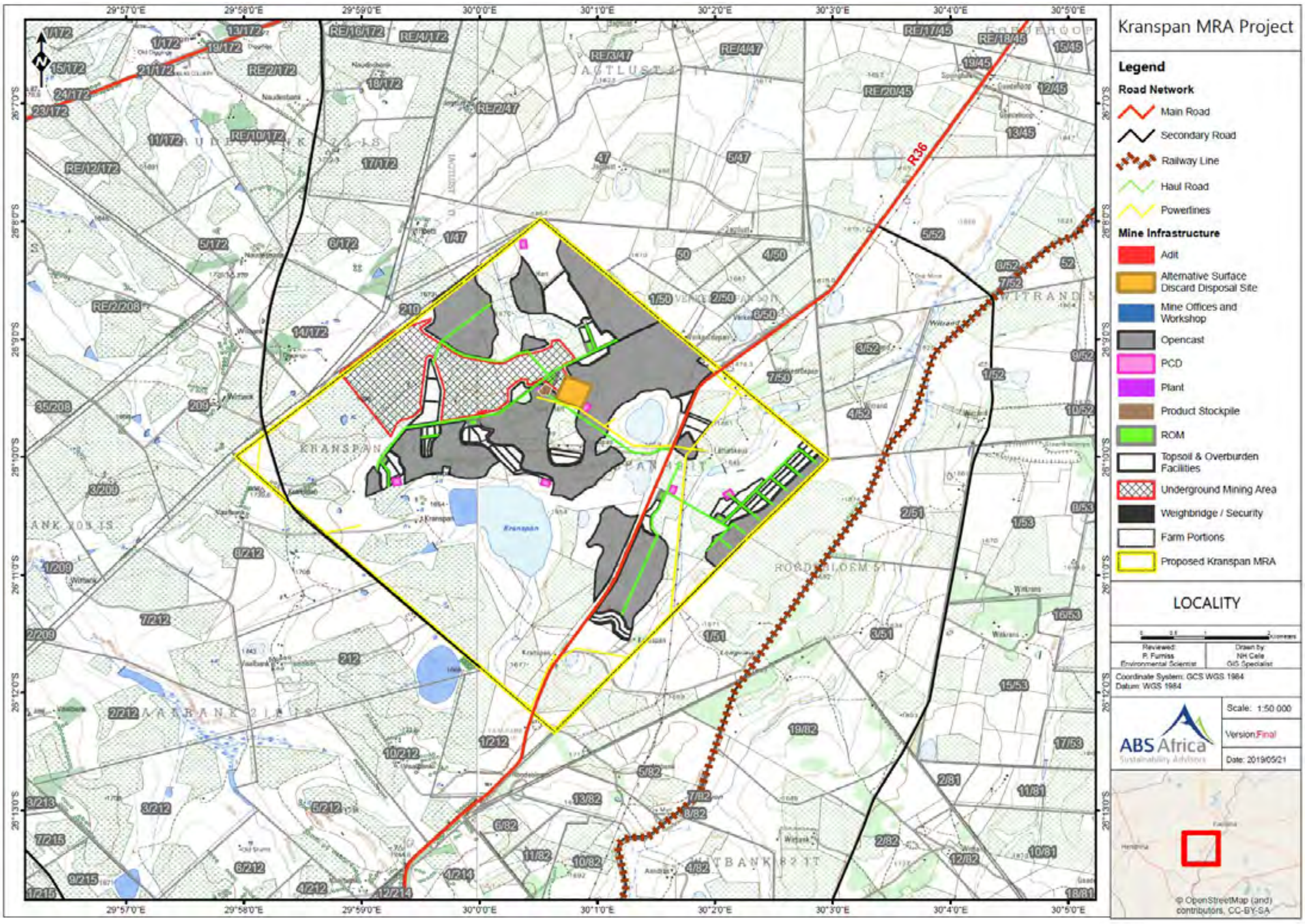
Table 9-5 provides an overview of the risks identified as well as the ratings of the various aspects identified, together with management measures that can be implemented to mitigate the risks.

TABLE 9-5: RISK ASSESSMENT MATRIX

Area/Aspect	Description of Risk	Potential Cause	Consequence	Control Measures	Risk Rating (pre-mitigation)	Risk Rating (post mitigation)
Demolition	Personnel injury during decommissioning and closure	Ineffective implementation of risk management and safety plans Ineffective decontamination of plant/equipment/buildings prior to dismantling/demolition activities commencing Fall from height Electrical isolation not implemented correctly	Injury or fatality Legal, financial and reputational damage	Continue to use operational safety systems during decommissioning and demolition e.g. risk assessments, Job Hazard Analysis, engineering controls etc. Use of suitable qualified and experienced demolition company with trained and experienced staff	Hight	High
Stakeholders	Unrealistic expectations or a change in expectations from originally agreed objectives	Political changes or elections Change in best practice over time	Increased closure period and costs	Ongoing consultation Regulatory approval of closure plan	High	High
Decommissioning and closure	Extended closure period or unplanned delays Underestimation of costing of closure Closure project controls not implemented	Inadequate design or implementation unable to meet closure objectives Delay in obtaining approval from regulator Unforeseen post closure conditions.	Increased closure period and costs	Conservative costing Annual Closure Provision review Trials and planning to increase certainty around closure	High	High
Mine Residue Disposal Facilities	Rehabilitation designs not suited to site materials Poor implementation of design Unsuccessful rehabilitation (active erosion, inadequate vegetation cover, weeds)	Poor quality rehabilitation materials Inadequate design or design implementation Ineffectual past rehabilitation strategies Poor seed selection or seed collection practices	Erosion, inadequate water control and/or poor vegetative growth Contamination Inability to meet closure criteria Increased costs.	Classification of rehabilitation materials Materials balance based on material classification Re-optimisation of rehabilitation design and deployment of materials available	High	Medium

				Robust planning including site specific appropriate designs Implementation procedures and quality control/ supervision		
Shafts and declines	Uncontrolled access leading to injury or death	Poor access control or no sealing of access	Injury or death	Access control Security Sealing of shafts	High	Low
Water	Contamination of water resources	Geochemical risk of material due to AMD and metal leaching	Contamination of limited water resources	Design features to ensure risk is identified and managed	High	Low

APPENDIX C: MINING RIGHT APPLICATION AREA PLAN



APPENDIX D: DETAILS OF THE EAP WHO PREPARED THE CLOSURE PLAN; AND THE EXPERTISE OF THAT EAP

Details of The EAP Who Prepared The Report

NAME OF THE PRACTITIONER:	ABS Africa (Pty) Ltd.
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Academic Qualifications

- B.Sc (Geography, Environmental Studies), Potchefstroom University for CHE, SA (1995)
- B.Sc (Hons) Environmental Management, Potchefstroom University for CHE, SA (1996)

Professional Registration

Pr.Sci.Nat. Professional Natural Scientist (Environmental Science): The South African Council for Natural Scientific Professions, 2004

Summary of the EAP's Past Experience

ABS Africa (Pty) Ltd is a professional environmental advisory company with a focus on the mining environment. The ABS Africa personnel included in the project team structure for the independent environmental assessment have collectively completed more than 100 EIAs across the African continent.

Much of this experience has been gained in undertaking complex and challenging EIAs involving the management of specialist teams, conducting public participation processes, aligning international standards with in-country legislation and interfacing with project engineering teams.

The EAP responsible for this submission has 18 years environmental assessment and management experience in the energy, water, mining and infrastructure sectors. His project experience includes conducting environmental assessment studies in South Africa, Mali, Guinea, Tanzania, Zambia, Botswana, Zimbabwe, and Mozambique.

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Report on Static Test Data for Discard Coal and Waste Rock Samples - Kranspan

1 Introduction

Ilima Coal Company (Pty) Ltd. is applying for a mining right over nine (9) portions of the Farm Kranspan 49IT. The farm Kranspan is situated approximately 13 km South-West of Carolina and approximately 12 km North of Breyten in the Gert Sibande District of the Mpumalanga Province. The farm falls within the authority of the Chief Albert Luthuli Local Municipality.

This report contains the findings of the geochemical characterisation of selected samples of mine material. The laboratory phase of geochemical characterisation typically includes static and kinetic tests. This report focusses on the static test results.

2 Background to geochemical characterisation

The primary purpose of the geochemical characterisation of mine materials is to guide management decisions. Therefore, it is critical that a phased assessment program is carried out to ensure sufficient data are available at all stages of the project cycle. Best practice environmental management can only be achieved through the early recognition of the potential for acid drainage and metal leaching.

Geochemical characterisation aims to identify the distribution and variability of key geochemical parameters (such as sulphur content, acid neutralising capacity and elemental composition) and acid generating and metal leaching characteristics. A basic screening level investigation is essential and should commence at the earliest possible stage. The necessity and scope for detailed investigations will depend on the findings of initial screening.

2.1 Sample selection

Sample selection is critical and must be given due consideration at all stages of the process. For waste material the samples must represent each geological type that will be mined or exposed and each waste type. The number of samples must be sufficient to adequately cover the variability within each geological unit and waste type. For process tailings, a smaller number of samples are adequate, provided there is confidence that the feed composition will remain consistent over time. If the composition of the ore being processed changes substantially the resulting tailings should be retested.

2.2 Sample number

The number of samples required for the characterisation of each material type depends on a number of factors, including:

- The amount of disturbance (i.e. the volume or mass of material extracted for each material type).
- Compositional variability within the material type.
- The degree of statistical confidence required.

While the number of samples required is likely to be site-specific, country specific guidelines do exist. The GARD guide describes the Australian Government's Department of Industry guidelines. These suggest at least 3-5 representatives of each material type during the prospecting phase, increasing to 5-10 per material type during resource scoping. During the pre-feasibility they recommend several hundred representatives of high and low grade ore, waste rock and tailings, with the number dependent on the complexity of the deposit geology and host rock. This should be followed by kinetic testing of 1-2 representatives of each material type. In reality, this number is often reduced due to time and budget constraints

The goal of waste management is to prevent or reduce environmental impact, so characterisation programmes must provide sufficient information to make sustainable and cost-effective decisions regarding the management and disposal of waste materials. The number of samples needs to be sufficient to meet this minimum requirement.

2.3 Testing programme overview

Laboratory and field-testing are designed to characterise the acid generating and leaching potential of mine and waste materials. Typically, a phased approach is adopted and this is likely to be dynamic, with changes informed by data as they become available.

The laboratory phase of geochemical characterisation typically includes the following analyses:

Static tests

- Whole rock and elemental analysis
- Mineralogical analysis
- Acid base accounting (ABA)
- Net acid generation (NAG)
- Short term leaching tests

Kinetic tests

- Humidity cells
- Laboratory leach columns

This report will focus on the static tests.

3 Materials and methods

3.1 Sample materials

Sampling was conducted in two phases. The first phase involved the analysis of discard samples generated during small-scale washing experiments. The material selected for the wash tests was based on the analysis of information for 24 reject samples provided by the project geologist. Six samples were selected that covered the range of total sulphur, ash content and calorific value.

Table 1: Sample designation, ash content, calorific value and total sulphur of reject coal samples

Designation	Calorific value (MJ/kg)	Ash content (%)	Total sulphur (%)
Ant 3 (2)	11.93	58.54	4.27
Ant 100 (4)	17.73	39.03	2.06
Ant 105 (1)	8.65	61.55	3.45
Ant 105 (3)	13.21	39.77	2.48
Ant 110 (1)	13.59	49.23	2.68
Ant 185 (1)	15.11	45.01	5.83

The second phase involved the analysis of 20 samples, selected from drill core material from four newly drilled monitoring holes. Images of the cores, showing the different lithologies, are presented in Appendix A.

Table 2: Sample designation and basic description of samples selected from drill cores

Sample designation	Description
GC01-2	Unweathered Sandstone (fair amount of silica)
GC01-4	Carbonaceous Shale & Sandstone
GC01-5	Sandstone (roof of coal seam)
GC01-6	Carbonaceous Sandstone
GC02-2	Carbonaceous Clay (roof of B seam)
GC02-3	Sandstone (floor of B-lower)
GC02-5	Mix of sandstone/siltstone and clay (floor of C seam)
GC02-6	Carbonaceous Shale
GC02-7	Sandstone
GC02-9	Sandstone (roof and floor of E seam)
GC03-2	Siltstone/sandstone
GC03-3	Carbonaceous Shale and sandstone mix
GC03-4	Carbonaceous Sandstone
GC03-6	Sandstone & Shale mix
GC03-8	Carbonaceous Shale
GC03-10	Carbonaceous sand stone and Shale mix
GC04-2	Carbonaceous Shale
GC04-3	Shale and Sandstone mix
GC04-4	Sandstone
GC04-6	Sandstone

3.1.1 Whole rock analysis

Major and trace element analysis was performed by X-ray fluorescence. The samples were prepared by first drying the samples at 100˚C for ~3 hours in order to determine loss of moisture content (H2O-), followed by ashing of the sample at 1000˚C until completely ashed, to determine the loss on ignition (LOI). XRF analyses were performed using a PANalytical Epsilon 3 XL ED-XRF spectrometer, equipped with a 50kV Ag-anode X-ray tube, 6 filters, a helium purge facility and a high resolution silicon drift detector, calibrated using a number of international and national certified reference materials (CRMs).

Whole rock analysis data were checked by performing a strong acid (HNO_3:HF) digestion of 0.25 g solid material in 100 ml acid mix and quantifying the components by ICP.

3.1.2 Static tests

3.1.2.1 Deionised water leach

The leach tests were performed at a solids loading of 5% (m/v), equivalent to a solid to liquid ratio of 1:20. Samples were removed and filtered through a 0.45 µm membrane filter ahead of cation and anion analysis by ICP and IC.

3.1.2.2 Toxicity Characteristic Leach Protocol (TCLP)

Samples were subjected to a standard TCLP leach test using a solids loading of 5%, equivalent to a solid to liquid ratio of 1:20.

3.1.2.3 Acid base accounting (ABA)

Acid base accounting utilises information on the maximum potential acidity and acid neutralising capacity of the material in order to classify it as potentially acid forming, non-acid forming or uncertain. The maximum potential acidity was calculated based on the total sulphur content. The acid neutralising capacity was determined using the standard method (Sobek & Modified Sobek (Lawrence) Methods)

3.1.2.4 Net acid generation (NAG) test

The Single Addition NAG test was performed as per the Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials (MEND Report 1.20.1). The sample (5 g) was exposed to 500 ml of 15% hydrogen peroxide and allowed to react until gas evolution ceased. The flask was then heated for a minimum of two hours to ensure the decomposition of any residual peroxide. Once the contents had cooled the volume was made up to 500 ml with deionised water, the pH recorded and the solution titrated to pH 4.5 and pH 7.0. A small subsample of the leachate was used to determine cation and anion concentrations by ICP and IC.

3.1.3 Kinetic test – leach column

The residual reject coal material was combined and used to load a laboratory scale leach column (Figure 1). The column had an internal diameter of 90 mm and when packed with reject material had a bed height of approximately 330 mm.

Figure 1: Photograph of the leach columns used to perform the kinetic tests

The irrigation cycle consisted of three days on and four days off. The irrigation rate will be changed every four weeks to approximate seasonal rainfall. Over the three days of irrigation the leachate was recycled through the column 30 times to simulate percolation through a much larger bed.

3.1.3.1 Leachate sampling and analysis

The recycled leachate was collected at the end of each weekly leach cycle and the volume, pH and electrical conductivity measured immediately. A 15 ml sub-sample was filtered through a 0.45 µm membrane filter to remove any suspended material. A 2 ml fraction of the filtered sample was removed and diluted appropriately in 22 mM sodium hydroxide for anion analysis by ion chromatography (Dionex IC). The remaining 13 ml was preserved by adding two drops of concentrated ultrapure nitric acid (Sigma) and retained for cation analysis by ICP-MS (Agilent 7700 ICP-MS).

If the pH of the sample leachate was above pH 4.5, the alkalinity was determined by titration using the standard potentiometric method (APHA). Where sufficient sample was available, 50 ml was titrated against a standard sulphuric acid solution (0.01 N) to a pH endpoint of pH 4.5. For samples with a pH below pH 8.3 the total acidity was determined by, using the standard method (APHA), by titrating against a standard sodium hydroxide solution (0.02 N) to a pH endpoint of pH 8.3. Where sufficient sample volume was available a 30 ml sample was used. Prior to the titration, 5 drops of 30% hydrogen peroxide was added and the sample heated to oxidise any reduced metals. The sample was allowed to cool and the volume made up with deionised water.

4 Results and discussion

4.1 Whole rock analysis

The whole rock analysis provides an indication of the elemental composition of the material. The major elements are represented in terms of standard mineral types.

4.1.1 Reject coal samples

The data for the major elements are summarised in Table 3. As anticipated for coal the loss on ignition values were high, contributing between 71 and 82% of the total. Of the remaining portion, silica and aluminium were the most significant components, with smaller fractions of iron, titanium and calcium. The sulphur values were lower than anticipated, based on the initial information provided (Table 1), although there was some agreement in terms of ranking from highest to lowest sulphur grade.

Table 3: Summary of major element analysis by XRF for reject coal samples

Major Elements		Major Element Concentration (wt %)[s]					
		Ant 3 (2)	Ant 110 (1)	Ant 100 (4)	Ant 105 (1)	Ant 185 (1)	Ant 105 (3)
Silica	SiO_2	9.16	11.31	12.07	12.65	10.28	8.38
Titanium	TiO_2	0.23	0.29	0.35	0.36	0.22	0.41
Aluminium	Al_2O_3	4.47	5.94	5.26	5.75	5.32	4.88
Iron	Fe_2O_3	0.25	0.43	0.24	0.31	0.3	1.65
Manganese	MnO	0.01	0.02	0.01	0	0.02	<0.01
Magnesium	MgO	0.15	0.17	0.28	0.2	0.41	0.09
Calcium	CaO	0.36	0.63	0.71	0.17	1.13	0.37
Sodium	Na_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	K_2O	0.13	0.19	0.23	0.28	0.19	0.23
Phosphorous	P_2O_5	0	<0.01	<0.01	0.2	<0.01	<0.01
Chromium	Cr_2O_3	0	0	<0.01	<0.01	<0.01	<0.01
Sulphur	SO_3	0.19	0.25	0.18	0.02	0.66	0.33
L o I[1] (1000 ºC)	LOI	82.06	79.05	71.45	76.86	78.89	80.23
Total	Total	99.08	100.29	99.57	99.31	99.49	99.58
L o M (105 ºC)	H_2O-	2.06	2	8.8	2.51	2.07	3.01

[1] Loss on ignition – includes total volatile content (including water contained in lattice of silicate material)

The trace element analysis indicates that for the majority of the elements the concentrations are low (<100 ppm), so the capacity for leaching is low, even if the elements are relatively mobile. The most significant exceptions are zinc, where the concentrations range from 3300 to just below 8400 ppm and strontium, with concentrations of up to 4700 ppm.

The data for the individual elements are compared to the total concentration threshold (TCT) values set out in the Waste Classification Regulations, 2013 published under the National Environmental Management Act of 2008 (Appendix B). For a number of elements the concentrations exceed the TCT0 value and these are highlighted in bold in Table 4. In all cases the concentrations are significantly below the TCT1 threshold. The TCT1 threshold for zinc is 160000 ppm, so the sample with the highest value (Ant 100 (4)) is just over 5% of this value.

Table 4: Summary of trace element data for the reject coal samples. Values in red exceed the TCT0 value

Trace Element		Trace Element Concentration (ppm)					
		Ant 3 (2)	Ant 110 (1)	Ant 100 (4)	Ant 105 (1)	Ant 185 (1)	Ant 105 (3)
Arsenic	As	**16.9**	**18.5**	**25.1**	**26.5**	**27.6**	**13.3**
Barium	Ba	**412**	**236**	**491**	**834**	**206**	70.9
Bismuth	Bi	<0.68	1.17	<0.68	2.37	2.04	1.04
Cadmium	Cd	<3.04	<3.04	<3.04	<3.04	<3.04	4.73
Cerium	Ce	94.6	137	103	115	120	<3.08
Chlorine	Cl	1 645	503	1 577	1 044	479	6 283
Cobalt	Co	**51.1**	40.5	**51.7**	**59.6**	38.6	<0.56
Caesium	Cs	1.14	1.03	1.17	1.19	1.02	<0.49
Copper	Cu	**149**	**154**	**148**	**156**	**172**	**30.3**
Galium	Ga	94.8	77.1	89.7	84.6	93	<3.21
Germanium	Ge	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	14.3	<0.38	5.63	<0.38	<0.38	4.37
Mercury	Hg	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	69.7	65	74.8	75.8	63.8	28.5
Lutetium	Lu	1.83	2.01	2.09	1.77	2.19	<0.61
Molybdenum	Mo	4.85	3.79	0.91	<0.51	4.75	13.5
Niobium	Nb	63.2	53.2	71.7	42.9	48.3	19.9
Neodymium	Nd	39.6	40.4	30.9	13.8	40.2	35
Nickel	Ni	**159**	**175**	**258**	**242**	**147**	**135**
Lead	Pb	**108**	**67.5**	**64.7**	<2.03	**73.3**	**41.7**
Rubidium	Rb	45.8	52.7	78.4	119	59.2	8.38
Antimony	Sb	**40.6**	**21**	**41.3**	**29.3**	**36.8**	<1.48
Scandium	Sc	11.9	<2.63	14.2	15.5	9.03	15.8
Selenium	Se	2.89	2.04	3.89	12.5	2.89	0.55
Samarium	Sm	11.6	11.9	10.9	10.3	9.3	12.2
Tin	Sn	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Strontium	Sr	1 178	1 070	2 462	4 746	1 072	196
Tantalum	Ta	1.62	0.15	1.24	<0.07	<0.07	2.65
Tellurium	Te	8.36	23.3	8.07	2.35	17.2	7.88
Thorium	Th	71.6	57	55.3	45.6	60.7	20.2
Thallium	Tl	0.82	0.16	1.49	0.96	1.21	0.5
Uranium	U	9.99	8.19	16.8	27	9.01	6.65
Vanadium	V	**184**	**166**	**183**	**173**	**161**	**204**
Tungsten	W	<0.29	<0.29	<0.29	<0.29	<0.29	5.43
Yttrium	Y	157	154	181	208	162	26.3
Ytterbium	Yb	10.5	10.4	14.6	10.7	7.96	30.6
Zinc	Zn	**8 309**	**3 954**	**8 382**	**6 342**	**3 986**	**3 303**

Zirconium	Zr	828	665	838	795	663	249

There are no threshold concentration values for a number of elements which are relatively abundant, such as strontium, suggesting that these do not pose a significant environmental risk.

4.1.2 Drill core samples

The data for the drill core samples are presented separately for each core. The data for GC01 are presented in Table 5.

Table 5: Summary of major element analysis by XRF for drill core GC01

Major Elements		Major Element Concentration (wt %)[s]			
		GC01-2	GC01-4	GC01-5	GC01-6
Silica	SiO_2	79.82	54.11	73.53	78.11
Titanium	TiO_2	0.59	0.94	0.58	0.96
Aluminium	Al_2O_3	10.52	20.29	11.7	9.92
Iron	Fe_2O_3	1.34	3.13	4.72	3.36
Manganese	MnO	0.01	0.02	0.05	<0.01
Magnesium	MgO	0.3	0.75	0.43	0.09
Calcium	CaO	0.1	0.13	0.07	0.02
Sodium	Na_2O	0.22	<0.01	<0.01	<0.01
Potassium	K_2O	3.67	2.2	2.41	0.34
Phosphorous	P_2O_5	0.06	0.11	0.06	0.03
Chromium	Cr_2O_3	0.03	0.02	0.03	0.03
Sulphur	SO_3	0.02	0.02	0.02	0.01
L o I[1] (1000°C)	LOI	2.33	18.83	5.5	7.77
Total	Total	99.1	100.73	99.84	100.29
L o M (105°C)	H_2O-	0.08	0.62	0.99	0.18

The major elements present in the four selected layers from drill core GC01 are silica, aluminium and potassium, which are consistent with quartz and feldspar. This is in agreement with the description of the material as predominantly sandstone.

The iron concentration varies from 1.3 to 4.7%, but the sulphur grades are all very low (0.02% or lower), so the iron is not present as acid generating pyrite or pyrrhotite. This suggests that the material is unlikely to be acid generating.

The data for the six samples from drill core GC02 are summarised in Table 6. Five of the six samples have a similar composition to the sandstone in GC01, dominated by silica, aluminium and potassium. The exception is GC02-2, which is described as carbonaceous clay forming the roof of the B seam. The significantly high loss on ignition value accounts for the higher carbon content.

The sulphur grades for five of the fractions are very low (< 0.11) indicating that the acid generating potential should be low. The exception is GC2-09, which reported a sulphur grade of 3.18%. This sample had the highest iron concentration (7.08%), suggesting that some of the iron could be present in the form of acid-generating sulphide phases.

Table 6: Summary of major element analysis by XRF for drill core GC02

Major Elements		Major Element Concentration (wt %)[s]					
		GC02-2	GC02-3	GC02-5	GC02-6	GC02-7	GC02-9
Silica	SiO_2	36.14	69.95	61.9	51.71	73.48	45.07
Titanium	TiO_2	0.77	0.77	1.23	1.00	0.56	0.47
Aluminium	Al_2O_3	13.46	15.56	20.96	22.95	13.55	10.98
Iron	Fe_2O_3	1.24	2.42	0.93	3.00	2.28	7.08
Manganese	MnO	<0.01	0.01	<0.01	<0.01	0.02	0.06
Magnesium	MgO	0.57	0.65	0.28	0.91	0.67	1.16
Calcium	CaO	1.67	0.69	0.04	0.2	0.75	10.69
Sodium	Na_2O	<0.01	<0.01	<0.01	<0.01	0.14	<0.01
Potassium	K_2O	0.64	3.37	2.48	2.77	3.56	1.93
Phosphorous	P_2O_5	0.08	0.06	0.04	0.12	0.06	0.24
Chromium	Cr_2O_3	0.01	0.02	0.01	0.01	0.03	0.01
Sulphur	SO_3	0.01	0.11	0.01	0.02	0.11	3.18
L o I[1] (1000 °C)	LOI	41.66	7.03	11.3	17.52	4.34	18.68
Total	Total	99.15	100.26	99.39	100.29	99.7	99.23
L o M (105 °C)	H_2O-	3.06	0.2	0.56	0.57	0.16	0.21

The data for the six fractions selected from drill core GC03 are summarised in Table 7. The major elements are again silica and aluminium, consistent with shale and sandstone.

The loss on ignition values are highest for GC03-3, 4 and 8, which is consistent with their description as carbonaceous.

The iron content varies fairly substantially across the six fractions, from 0.88% to as high as 7.49%, but the sulphur grades are again low. This suggests that the iron is present as oxide inclusions within the shale and sandstone, rather than as sulphide phases.

The low sulphur grades (< 0.12%) indicate that the material is unlikely to be acid generating.

Table 7: Summary of major element analysis by XRF for drill core GC03

Major Elements		Major Element Concentration (wt %)[s]					
		GC03-2	GC03-3	GC03-4	GC03-6	GC03-8	GC03-10
Silica	SiO_2	57.47	49.1	60.54	53.11	67.46	77.3
Titanium	TiO_2	1.23	0.85	0.83	1.08	0.41	0.85
Aluminium	Al_2O_3	25.82	18.06	16.84	24.47	6.93	10.49
Iron	Fe_2O_3	0.88	4.24	2.34	7.49	2.99	1.42
Manganese	MnO	<0.01	0.04	0.01	0.14	0.01	<0.01
Magnesium	MgO	0.49	0.72	0.59	1.4	0.23	0.26
Calcium	CaO	0.1	0.17	0.59	0.51	0.35	0.17
Sodium	Na_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	K_2O	2.28	2.22	2.8	2.7	1.38	1.12
Phosphorous	P_2O_5	0.04	0.14	0.07	0.11	0.04	<0.01
Chromium	Cr_2O_3	0.01	0.02	0.01	0.01	0.03	0.04
Sulphur	SO_3	0.02	0.02	0.12	0.03	0.10	0.01
L o I[1] (1000 ^oC)	LOI	11.82	23.07	16.24	9.48	19.35	6.76
Total	Total	100.35	99.57	100.89	100.62	100.34	99.72
L o M (105 ^oC)	H_2O-	0.3	1.26	0.37	0.24	1.51	1.46

The data from the four fractions selected from GC04 are summarised in Table 8. The results are consistent with the description of the samples. GC04-2 and GC04-3 have relatively high loss on ignition values, consistent with the description as carbonaceous shale and shale.

The GC04-4 and GC04-5 samples are have very high silica values and relatively lower aluminium values, indicating they are composed primarily of quartz, with smaller amounts of feldspar.

The iron grades are higher for the first two fractions, again consistent with shale and are lower in the quartz-dominated fractions. The sulphur grades are low for all four fractions, suggesting that the acid generation potential will be low.

The calcium and magnesium fractions across all four of the drill cores are low, with the only exception GC02-9, which has a calcium fraction just over 10%. The relatively low calcium and magnesium levels suggest that the acid neutralising capacity of most of the samples is likely to be low.

Table 8: Summary of major element analysis by XRF for drill core GC04

Major Elements		Major Element Concentration (wt %)[s]			
		GC04-2	GC04-3	GC04-4	GC04-5
Silica	SiO_2	46.32	57.5	85.03	86.17
Titanium	TiO_2	0.89	1.04	0.3	0.33
Aluminium	Al_2O_3	20.96	20.34	7.18	7.53
Iron	Fe_2O_3	5.33	2.41	2.54	1.38
Manganese	MnO	0.11	<0.01	0.01	<0.01
Magnesium	MgO	0.87	0.6	0.13	0.01
Calcium	CaO	0.17	0.23	0.04	0.01
Sodium	Na_2O	<0.01	<0.01	<0.01	<0.01
Potassium	K_2O	2.12	2.67	2.36	0.97
Phosphorous	P_2O_5	0.08	0.08	0.05	0.01
Chromium	Cr_2O_3	0.01	0.02	0.03	0.04
Sulphur	SO_3	0.09	0.02	0.03	<0.01
L o I[1] (1000 ^{o}C)	LOI	22.37	15.63	2.9	3.69
Total	Total	99.54	100.65	100.16	99.88
L o M (105 ^{o}C)	H_2O-	0.74	0.61	0.15	0.18

The trace element data for the drill core samples are summarised in Table 9 for GC01 and GC02 and Table 10 for GC03 and GC04.

All 20 of the drill core samples exceed the TCT0 threshold for at least two of the elements, but the concentrations are well below the TCT1 thresholds in all cases.

The elements for which the values most frequently exceed the TCT0 thresholds are barium (all 20 samples), copper (all 20 samples), antimony (17 of 20 samples), lead (12 of 20 samples) and arsenic (7 of 20 samples). In addition, a smaller number of the samples exceeded the TCT0 thresholds for vanadium and zinc.

The concentration of mercury was below the detection limit for all 20 of the samples.

Table 9: Trace element concentrations for GC01 and GC02 samples against TCT values. Values in red exceed the TCT0 threshold

Sample Element	TCT0 mg/kg	TCT1 mg/kg	GC01-2 mg/kg	GC01-4 mg/kg	GC01-5 mg/kg	GC01-6 mg/kg	GC02-2 mg/kg	GC02-3 mg/kg	GC02-5 mg/kg	GC02-6 mg/kg	GC02-7 mg/kg	GC02-9 mg/kg
As	5.8	500	2.75	2.6	2.6	**8.43**	**8.59**	2.23	2.32	**6.08**	2.25	**8.55**
Ba	62.5	6250	**657**	**587**	**516**	**92.9**	**1475**	**732**	**934**	**779**	**657**	**318**
Bi			1.01	1.26	1.39	1.61	1.14	1.01	0.94	2.12	1.47	1.3
Cd	7.5	260	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04
Ce			<3.08	165	99.3	18	64.8	3.39	35.1	229	<3.08	36.2
Co	50	5000	15.3	5.6	<0.56	4.44	21.9	2.29	13.6	8.92	1.97	5.34
Cs			0.92	1.28	0.99	1.32	1.31	1.11	1.56	1.3	0.93	0.86
Cu	16	19500	**32.9**	**72.7**	**40.2**	**40.7**	**85.3**	**38.4**	**52.1**	**74.3**	**33.4**	**37.2**
Ga			13.8	37.7	20.2	17	49.1	24.2	34.7	47.3	20	12.9
Hg	0.93	160	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
La			47.4	75.7	49.5	81.4	77.7	57.5	96.2	76.9	48.4	43.2
Mo	40	1000	6.39	3.77	6.46	7.55	3.44	4.64	3.8	2.23	5.69	8.02
Nb			17.8	34.1	18.5	29.1	51.5	25.1	40.2	35.5	22.1	9.92
Nd			29.7	30.7	11.5	21.9	21.2	33.5	31.1	48.1	21.8	26.9
Ni	91	10600	<5.14	53.3	25.5	36.8	127	16.9	22.3	82.5	<5.14	28.9
Pb	20	19000	**21.7**	**28.3**	16.8	18	7.66	**20.6**	**20.8**	**43.1**	19.4	**20.5**
Rb			200	210	172	18.2	136	213	149	291	189	115
Sb	10	75	**13.3**	**10.4**	**12.5**	8.8	**15.1**	**10.5**	**12.2**	**22.6**	7.52	6.36
Sc			14.4	18.2	13.7	8.25	19.3	20.6	15.7	14.6	17.6	15.9
Se	10	50	0.55	2.05	0.64	<0.36	9.85	0.45	<0.36	3.07	<0.36	<0.36
Sm			4.57	13.5	7.45	5.78	8.32	7.08	11.8	13.1	5.28	6.86
Sr			145	146	143	25	3.44	4.64	3.8	2.23	185	116
Ta			1.29	0.6	0.68	0.46	51.5	25.1	40.2	35.5	0.91	0.49
Te			0.54	<0.16	0.34	3.46	21.2	33.5	31.1	48.1	<0.16	<0.16
Th			16.3	40.4	12.5	11.1	127	16.9	22.3	82.5	8.29	4.81
Tl			1.71	1.26	1.69	1.54	7.66	20.6	20.8	43.1	1.76	1.64
U			3.62	6.1	4.23	3.12	136	213	149	291	3.26	3.49
V	150	2680	112	**204**	139	148	15.1	10.5	12.2	22.6	122	119
W			0.96	0.92	1.4	0.84	19.3	20.6	15.7	14.6	1.01	1.21
Y			32	92.1	19.2	27.1	165	24.4	48.2	112	21.3	16.5
Zn	240	16000	<5.49	**264**	88	<5.49	118	83	194	**302**	<5.49	7.5
Zr			495	516	334	831	1407	448	816	533	271	266

Table 10: Trace element concentrations for GC03 and GC04 samples against TCT values. Values in red exceed the TCT0 threshold

Sample Element	TCT0 mg/kg	TCT1 mg/kg	GC03-2 mg/kg	GC03-3 mg/kg	GC03-4 mg/kg	GC03-6 mg/kg	GC03-8 mg/kg	GC03-10 mg/kg	GC04-2 mg/kg	GC04-3 mg/kg	GC04-4 mg/kg	GC04-5 mg/kg
As	5.8	500	**8.4**	5.44	**6.15**	3.68	<0.43	5.15	<0.43	3.63	2.88	**6.42**
Ba	62.5	6250	**654**	**674**	**815**	**857**	**939**	**322**	**606**	**914**	**562**	**134**
Bi			<0.68	1.34	1.78	1.62	<0.68	1.15	1.9	1.19	1.06	1.9
Cd	7.5	260	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04
Ce			13.6	139	115	28.1	178	73.9	187	101	<3.08	<3.08
Co	50	5000	28.9	21.2	8.92	10.3	7.97	11.4	6.34	15.1	<0.56	11.3
Cs			0.85	1.42	1.25	1.17	1.22	1.12	1.23	1.33	0.72	0.73
Cu	16	19500	**39.5**	**88**	**71.4**	**51.1**	**81.5**	**47.5**	**85.2**	**60.6**	**36.8**	**35.6**
Ga			23	50.9	44.7	33.1	46.5	18.8	50.5	38.4	12.1	15.5
Hg	0.93	160	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
La			36.7	90.5	68.2	66.5	62.2	69.5	67.5	80.1	32.8	40.2
Mo	40	1000	3.62	1.73	4.12	4.79	2.94	9.18	2.27	5.28	6.97	9.53
Nb			20.4	45.4	42	37	43.1	30.3	38	42.8	10.9	11.4
Nd			31	22.4	52.7	14.5	40.9	16.1	27.7	17.2	11.4	23.5
Ni	91	10600	38	62.8	72.7	39.4	89.3	21.5	90.1	60	8.87	7.7
Pb	20	19000	**36.4**	17.7	**46**	**38.4**	**60.9**	3.75	**55.9**	**42.4**	12.9	7.49
Rb			154	197	253	254	258	85	260	250	161	42.4
Sb	10	75	**14**	**12.6**	**22.2**	**14.8**	**13.6**	**10.1**	**12**	**17**	**10.5**	**15**
Sc			16.1	15.4	14.9	16.1	13.6	13.9	16	12.8	11.3	9.59
Se	10	50	<0.36	2.31	<0.36	0.95	1.83	<0.36	2.36	1.07	0.39	<0.36
Sm			2.48	12	12.6	7.65	13.3	2.73	11.9	10.7	5.93	3.21
Sr			360	176	500	168	541	160	173	154	110	34.5
Ta			1.3	0.38	0.45	0.28	0.66	1.39	0.52	0.83	1.15	1.18
Te			22.2	1.23	<0.16	<0.16	<0.16	2.11	0.49	0.59	1.26	2.48
Th			9.53	58.7	35.4	26.5	49.1	14.5	55.6	34.8	6.05	3.65
Tl			0.82	1.42	1.46	1.66	0.9	1.37	1.29	1.36	1.66	1.65
U			3.28	5.65	5.1	4.67	5.99	3.28	7.54	4.78	4.06	2.95
V	150	2680	120	**226**	**177**	132	**180**	147	**181**	**193**	100	93.2
W			1.92	0.66	1.07	0.8	1.55	0.8	1.38	0.89	1.16	0.85
Y			42.3	124	84.6	52.3	116	34.7	132	86.2	10.7	13
Zn	240	16000	30.4	**292**	**321**	192	**299**	<5.49	**312**	**384**	9.56	<5.49
Zr			449	666	583	916	445	682	429	787	222	385

4.2 Acid base accounting

Acid base accounting (ABA) uses a calculated maximum potential acidity value, based on sulphur grade, and a measured acid neutralising capacity value to estimate the likelihood of the material being acid generating and the theoretical quantum of the acid. The ABA data do not provide any indication of rate of acid generation. The data for the reject coal samples are summarised in Table 11.

Table 11: Total sulphur and acid base accounting data for the six reject coal samples

Sample	Total S (%)	Paste pH	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC:MPA
Ant 3 (2)	0.64	6.7	20	10	9.96	0.50
Ant 100 (4)	0.59	6.5	19	15	3.53	0.81
Ant 105 (1)	0.76	4.7	24	1	23	0.04
Ant 105 (3)	0.52	5.2	16	0.25	16	0.015
Ant 110 (1)	0.89	6.8	28	15	13	0.52
Ant 185 (1)	0.59	7.3	18	30	-12	1.64

The sulphur grades for all six samples are relatively similar, falling between 0.5 and 0.9%. These are generally lower than the values provided by the site geologist, but higher than the sulphur determined by XRF during the whole rock analysis. It is interesting that the relative trend is not consistent across the three data sets. The highest sulphur grades, by XRF were Ant 185 (1), at 0.66% and Ant 105 (3), at 0.33%, while these returned two of the lowest values by LECO analysis.

The sulphur values presented above are determined by combusting the material and measuring the resulting SO_2 gas by infra red analysis (LECO analyser). This technique can lead to an overestimation of acid generating potential, as some non-acid generating sulphur species are able to contribute to the measured value.

The paste pH values are near-neutral for most of the samples, but acidic for the two Ant 105 samples. An acidic paste pH is normally indicative of some weathering, with the release of some iron and acidity from soluble, acid-generating salts on the surface.

The acid neutralising capacity values are low in all cases, with the exception of the Ant 185 sample, which is moderate. The low ANC values are typical of coal, which is not typically associated with carbonate minerals.

The net acid producing potential of five of the six samples is positive, indicating the likelihood that the material could be acid generating, although the magnitude of the acid generating potential is relatively low.

The ABA data from the 20 drill core samples is summarised in Table 12. The total sulphur grades for the majority of samples is low (< 0.5%), with the exceptions being GC01-6 (2.05%), GC03-2 (0.82%), GC03-3 (1.38%), GC03-6 (0.58%), GC04-4 (0.55%) and GC04-6 (0.54%). As with the reject coal material, these values are not consistent with the XRF data, which showed very low sulphur grades for all but GC02-9 (3.18%). The LECO value for that sample was only 0.18% S.

Table 12: Total sulphur and acid base accounting data for the 20 drill core samples

Sample	Total S (%)	Paste pH	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	ANC:MPA
GC01-2	0.09	7.2	2.9	1.2	1.7	0.43
GC01-4	0.17	6.9	5.4	1.2	4.2	0.23
GC01-5	0.45	9.4	14.0	2.5	12.0	0.17
GC01-6	2.05	4.1	64.0	-1.2	65.0	0.02
GC02-2	0.12	5.4	3.6	-9.7	13.0	2.69
GC02-3	0.24	7.8	7.6	18.0	-10.0	2.33
GC02-5	0.18	6.8	5.8	1.2	4.5	0.21
GC02-6	0.11	7.3	3.6	3.2	0.4	0.89
GC02-7	0.18	8.3	5.5	18.0	-13.0	3.30
GC02-9	0.82	7.5	26.0	8.6	17.0	0.34
GC03-2	1.38	7.8	43.0	154.0	-111.0	3.60
GC03-3	0.28	6.8	8.8	0.5	8.3	0.06
GC03-4	0.58	7.0	18.0	2.2	16.0	0.12
GC03-6	0.38	7.6	12.0	14.0	-2.5	1.20
GC03-8	0.12	8.5	3.6	4.0	-0.4	1.12
GC03-10	0.31	8.3	9.5	2.0	7.5	0.21
GC04-2	0.12	6.9	3.7	2.7	0.9	0.74
GC04-3	0.55	7.5	17.0	4.9	12.0	0.29
GC04-4	0.34	6.6	11.0	0.01	11.0	0.00
GC04-6	0.10	5.3	3.0	-0.5	3.5	0.17

The paste pH values were for the most part within a fairly narrow range (pH 6.8-8.3), suggesting that there had not been significant liberation of either acidic or alkaline components. The exceptions to this were GC01-6 (pH 4.1) and GC02-2 (pH 5.4), which yielded acidic pH values and GC01-5 (pH 9.4) and GC03-8 (pH 8.5), which yielded more alkaline values.

GC01-6 has the highest sulphur grade so the acidic paste pH was not unexpected. The GC02-2 sample did not have a high sulphur grade, but did yield a negative value on the ANC test, indicating that there must have been the release of acid generating salts when the sample was placed in the acid solution, although there is little evidence from the deionised water leach data to support this.

The more alkaline paste pH values suggest that the samples contain some water-soluble alkaline minerals, most likely carbonates. However, the two samples with the highest paste pH values have very low ANC values, which is unexpected.

The acid neutralising capacity values are generally low, with all but one sample having an ANC value below 18 kg/t. This is consistent with the XRF data, which showed very low calcium and magnesium values for almost all samples. Calcium and magnesium are often present as carbonate minerals. The exception is GC03-2, which had an ANC value of 154 kg/t, despite not having elevated calcium and magnesium concentrations.

The ABA results suggest that 14 of the 20 samples have some acid generating potential, although the magnitude of the acid generating potential is low (< 15 kg H_2SO_4/t) for 11 of those, with two more marginally above that value. The only sample predicted to have substantial acid generating potential is GC01-6, with a NAPP of 65 kg H_2SO_4/t. Similarly, of the six samples with negative NAPP values, only one (GC03-2) has a neutralising potential greater than 15 kg H_2SO_4/t.

ABA results, like all the static tests are indicative and may provide a most extreme case scenario due to the fact that the material is milled to -75 µm, resulting in a degree of mineral liberation substantially higher than for typical waste rock or discards.

4.3 Net acid generation

The net acid generation test relies on the addition of hydrogen peroxide to accelerate the oxidation of reduced sulphur minerals, generating acidity. Where samples have acid neutralising capacity, some or all of the acid generated may be neutralised. Once the reactions are complete and the residual peroxide has been decomposed the NAG pH is measured. Thereafter, a standard hydroxide solution is used to titrate to specific end points (pH 4.5 and pH 7).

A low NAG pH value is indicative of material that has an acid generating capacity in excess of the acid neutralising capacity. The results of the assay show that five of the six samples yielded NAG pH values significantly below pH 4.5, suggesting acid generation, despite the low sulphur values.

The NAG pH for the remaining sample was pH 5.5. This is consistent with the ABA data that suggested Ant 185 (1) had a negative acid generating potential.

Table 13: Summary of NAG data for the reject coal samples. Total acid generation is the sum of the NAG 4.5 and NAG 7 values. Data presented relative to the NAPP value derived during the ABA tests

Sample	NAG pH	NAG 4.5 (kg H_2SO_4/t)	NAG 7 (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)
Ant 3 (2)	2.7	81	54	9.96
Ant 100 (4)	2.8	79	59	3.53
Ant 105 (1)	2.6	70	49	23
Ant 105 (3)	2.6	53	40	16
Ant 110 (1)	2.7	79	59	13
Ant 185 (1)	5.5	<0.01	1.37	-12

There is a significant discrepancy between the ABA data and the NAG data, with the measured acid production between 5 and 40 times higher than predicted by ABA. This could be due to the underestimation of the total S values or an error in the NAG test.

The NAG data for the drill core samples are summarised in Table 14. There is a greater degree of agreement between the NAG data and ABA data for the drill core samples, with measured acid generation values of over 15 kg H_2SO_4/t for four of the samples. These include the three samples with the highest predicted NAPP values. All the samples predicted to have a negative NAPP value had NAG pH values above pH 6.2 and total NAG values below 0.5 kg H_2SO_4/t.

Table 14: Summary of NAG data for the drill core samples. Total acid generation is the sum of the NAG 4.5 and NAG 7 values. Data presented relative to the NAPP value derived during the ABA tests

Sample	NAG pH	NAG 4.5 (kg H_2SO_4/t)	NAG 7 (kg H_2SO_4/t)	NAPP (kg $H_2SO_{4/t}$)
GC01-2	6.1	<0.01	<0.01	1.7
GC01-4	4.3	0.2	10	4.2
GC01-5	2.7	8.2	5.5	12.0
GC01-6	2.2	43	6.9	65.0
GC02-2	7.6	<0.01	<0.01	13.0
GC02-3	8.0	<0.01	<0.01	-10.0
GC02-5	4.9	<0.01	2.0	4.5
GC02-6	5.9	<0.01	0.4	0.4
GC02-7	8.3	<0.01	<0.01	-13.0
GC02-9	2.5	18	7.3	17.0
GC03-2	9.7	<0.01	<0.01	-111.0
GC03-3	6.1	<0.01	0.4	8.3
GC03-4	3.6	2.0	13.9	16.0
GC03-6	6.9	<0.01	<0.01	-2.5
GC03-8	6.2	<0.01	0.4	-0.4
GC03-10	4.5	<0.01	1.8	7.5
GC04-2	4.6	<0.01	8.4	0.9
GC04-3	3.0	3.9	11.0	12.0
GC04-4	3.0	3.1	1.8	11.0
GC04-6	2.5	14.0	4.5	3.5

The analysis of the final leachate from the NAG tests complemented the acid generation data. There was good agreement between the total sulphur grade and the sulphate concentration in the leachate, with the highest value (542 mg/l) recorded for GC01-6. The data for iron in solution also corresponded well with the sulphur grade and sulphate data, confirming that acid generating iron sulphide minerals contributed significantly to the measured sulphur grade.

The GC03-2 sample, which yielded a NAG pH of 9.7, had an elevated calcium concentration in the leachate (81 mg/l), consistent with the high acid neutralising capacity. The remaining samples all had calcium concentrations in the leachate below 35 mg/l.

4.4 Leach data

Three sets of leach data were generated during the static tests, a deionised water leach, a standard TCLP test and the leachate from the NAG test. The section below presents the data for these three tests in parallel to provide information on the enhanced mobility of certain elements under increasingly acidic and oxidising conditions.

4.4.1 Reject coal samples

The pH, TDS and anion data from the deionised water leach on the reject coal samples are presented in Table 15. The values for nitrate, fluoride, phosphate and cyanide were all below the detection limit, so are not included.

The Ant 3 (2) and Ant 105 (3) samples showed leachate pH values in the acidic range, with the Ant 3 (2) sample being particularly low. These values are not consistent with the paste pH values presented as part of the ABA, which may be related to the relative solid to liquid ratios. The acidic pH suggests some oxidative weathering of the material, with the formation of soluble acid generating salts on the surface. The elevated TDS and sulphate concentration in the leachate from the deionised water leach for Ant 3 (2) is consistent with this.

The pH values for the remaining four samples are between pH 6.0 and 7.1, indicating limited leaching of readily soluble components. This is supported by the relatively low TDS values, for all but Ant 3 (2). The TDS value reported for Ant 105 (3) is most likely an analytical error, based on the values for chloride and sulphate.

The chloride concentrations are relatively low for all six samples, which is consistent with the information on the mineralogy. Similarly, the sulphate concentrations for all but Ant 3 (2) are low in the deionised water test leachate. This indicates that for the majority of the samples significant weathering has not occurred. The TDS, chloride and sulphate values for the deionised water leach are below the TCT0 values in all cases.

The pH and TDS data for the TCLP tests are not presented as they are affected by the acetic acid used in the test. The anion concentrations (Appendix X) are similar to the deionised water leach.

Table 15: Summary of deionised water leach data for reject coal samples and NAG leachate sulphate value. All data normalised to a solid to liquid ratio of 1:20

	Deionised water leach				NAG leach
	pH	TDS	Cl^-	SO_4^{2-}	SO_4^{2-}
Sample		mg/l	mg/l	mg/l	mg/l
LCT0		1000	300	250	250
LCT1		12500	15000	12500	12500
Ant 3 (2)	2.8	424	63	249	**590**
Ant 100	7.1	122	28	12	**730**
Ant 105 (1)	6.0	80	38	25	**935**
Ant 105 (3)	4.7	18	34	21	**720**
Ant 110 (1)	6.9	268	48	52	**1050**
Ant 185 (1)	7.1	166	20	39	**435**

The anion data for the leachate from the NAG tests is similar to the deionised water and TCLP data, with the exception of sulphate. The sulphate concentrations in the NAG leachate are significantly higher in all cases, indicating the oxidation of reduced sulphur compounds to sulphuric acid. This is consistent with the NAG pH values (Table 13). The trend in sulphate concentration across the samples is generally consistent with the sulphur grades determined during the ABA analysis, with Ant 110 (1) having the highest sulphur grade (0.89%) and Ant 105 (3), Ant 100 (4) and Ant 185 (1) the three lowest. A material balance calculation, assuming 100% oxidation of sulphur to sulphate, predicted sulphate concentrations higher than the measured concentrations in the NAG leachate for all six samples, suggesting that not all the reduced sulphur was present in acid generating phases. The biggest difference was for the Ant 185 (1) sample, which is consistent with the higher NAG pH value and lack of acid generating potential.

The cation concentrations in the leachate from the three tests are summarised in Tables 16-18. The values are compared to the LCT0 and LCT1 thresholds.

Table 16: Comparison of cation concentration in leachate from deionised water, TCLP and NAG tests. All data normalised to a solid to liquid ratio of 1:20. Values in red exceed LCT0 threshold

Sample	**Limits**		**Ant 3 (2)**			**Ant 100 (4)**		
	LCT0	LCT1	Deionised	TCLP	NAG	Deionised	TCLP	NAG
Element	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Aluminium			0.54	0.72	18.77	<0.100	0.38	24.63
Arsenic	0.01	0.5	**0.03**	**0.04**	**0.05**	<0.001	<0.001	**0.05**
Boron	0.5	25	<0.001	0.00	0.42	<0.001	0.00	**0.62**
Barium	0.7	35	0.09	0.18	**6.13**	0.47	**2.56**	**6.58**
Calcium			11.00	12.00	130.00	22.00	372.00	200.00
Cadmium	0.003	0.15	0.00	0.00	**0.01**	<0.001	<0.001	<0.001
Cobalt	0.5	25	0.24	0.18	0.26	0.00	0.01	0.38
$Chromium_{Total}$	0.1	5	0.00	0.00	**1.65**	<0.001	0.01	**1.25**
Chromium (VI)	0.05	2.5	<0.010	<0.010		<0.010	<0.010	0.00
Copper	2.0	100	0.02	0.03	0.43	<0.001	<0.001	0.50
Iron			114.00	78.00	75.00	<0.025	7.35	55.00
Mercury	0.006	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium			1.65	<0.5	<0.001	0.61	<0.5	2.69
Magnesium			4.00	3.00	30.00	3.00	79.00	55.00
Manganese	0.5	25	0.28	0.30	**2.00**	0.10	**3.30**	**1.86**
Molybdenum	0.07	3.5	<0.001	0.00	0.06	<0.001	<0.001	0.07
Soduim			1.00	<1	<1	2.00	<1	<1
Nickel	0.07	3.5	**0.19**	**0.17**	**0.33**	0.00	0.03	**0.64**
Lead	0.01	0.5	**0.04**	**0.12**	**0.39**	<0.001	**0.05**	**0.14**
Antimony	0.02	1.0	<0.001	0.00	0.01	<0.001	<0.001	0.01
Selenium	0.01	0.5	<0.001	0.01	**0.03**	<0.001	<0.001	**0.02**
Silicon			0.67	0.53	16.55	0.25	0.20	19.48
Strontium			0.10	0.15	4.20	0.51	4.08	5.13
Uranium			0.01	0.00	0.08	<0.001	0.00	0.10
Vanadium	0.2	10	0.00	<0.001	**1.66**	<0.001	0.00	**1.74**
Zinc	5	250	**79.00**	**51.00**	**24.46**	1.19	**17.00**	**25.40**

The cation data support the assertion that the Ant 3 (2) sample has undergone oxidative weathering. The iron concentration in the deionised water leach was high (114 mg/l), confirming that iron and sulphate were the primary contributors to the measured TDS. The iron values were elevated, but not as high in the TCLP and NAG leachates, suggesting some precipitation of ferric iron due to the higher pH (TCLP) and heating (NAG). The Ant 3 (2) sample generated an acidic leachate in the deionised water leach, so the metals concentrations across the three tests are relatively similar, as all three are leaching under acidic conditions. The concentrations of arsenic, nickel, lead and zinc exceeded the

LCT0 threshold in all cases, while a number of other elements saw enhanced leaching under the oxidising conditions of the NAG test.

The Ant 100 (4) sample showed very little reactivity in the deionised water wash, with all elements below the TCT0 threshold. Under the acidic conditions of the TCLP leach the barium, manganese, lead and zinc concentrations exceeded the TCT0 threshold. The calcium concentration in the leachate increased from 22 mg/l (deionised water) to 372 mg/l (TCLP), most likely due to the dissolution of calcium carbonate (ANC of 15 kg/t) and some leaching of calcium by the acetate anion. The calcium concentration in the NAG leachate was elevated, but not as high, most likely due to the absence of acetate complexation.

Table 17: Comparison of cation concentration in leachate from deionised water, TCLP and NAG tests. All data normalised to a solid to liquid ratio of 1:20. Values in red exceed LCT0 threshold

Sample	Limits		Ant 105 (1)			Ant 105 (3)		
	LCT0	LCT1	Deionised	TCLP	NAG	Deionised	TCLP	NAG
Element	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Aluminium			<0.100	0.56	29.40	<0.100	0.28	42.40
Arsenic	0.01	0.5	<0.001	<0.001	**0.06**	<0.001	0.00	**0.03**
Boron	0.5	25	<0.001	0.00	**0.82**	<0.001	<0.001	0.31
Barium	0.7	35	0.17	0.59	**2.80**	0.12	0.30	**2.90**
Calcium			11.00	24.00	35.00	7.00	13.00	15.00
Cadmium	0.003	0.15	<0.001	0.00	**0.01**	<0.001	<0.001	<0.001
Cobalt	0.5	25	0.04	0.07	0.29	0.02	0.02	0.09
$Chromium_{Total}$	0.1	5	<0.001	0.00	**0.84**	<0.001	0.01	**1.46**
Chromium (VI)	0.05	2.5	<0.010	<0.010	0.00	<0.010	<0.010	0.00
Copper	2.0	100	0.00	0.00	0.46	0.00	<0.001	0.62
Iron			<0.025	1.88	80.00	0.13	2.81	95.00
Mercury	0.006	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium			2.39	2.04	3.73	0.95	<0.5	4.99
Magnesium			5.00	8.00	10.00	3.00	3.00	5.00
Manganese	0.5	25	0.15	0.37	0.25	0.11	0.25	0.16
Molybdenum	0.07	3.5	<0.001	<0.001	0.05	<0.001	<0.001	0.05
Soduim			2.00	<1	<1	<1	<1	<1
Nickel	0.07	3.5	0.04	0.07	**0.56**	0.04	0.04	**0.46**
Lead	0.01	0.5	<0.001	**0.02**	<0.001	0.00	**0.11**	**0.40**
Antimony	0.02	1.0	<0.001	<0.001	0.01	<0.001	<0.001	<0.001
Selenium	0.01	0.5	0.00	0.00	0.03	<0.001	0.00	**0.04**
Silicon			1.13	1.81	17.89	0.37	0.38	43.83
Strontium			0.08	0.21	6.55	0.06	0.11	1.35
Uranium			<0.001	0.01	0.09	<0.001	0.00	0.08
Vanadium	0.2	10	<0.001	<0.001	**1.17**	<0.001	<0.001	**0.75**
Zinc	5	250	**19.00**	**30.00**	**23.78**	**24.00**	**21.00**	**39.06**

The Ant 105 (1) and (3) samples behaved in a similar fashion, with very little reactivity in deionised water, with the exception of some zinc leaching. Under the more acidic conditions of the TCLP test the lead concentration increased marginally, to exceed the LCT0 threshold. Under the oxidising