conditions of the NAG test, the arsenic, nickel, chrome, barium and vanadium concentrations increased to exceed the LCT0 threshold.

Table 18: 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				**Ant 110 (1)**			**Ant 185 (1)**	
	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	0.63	25.58	<0.100	0.30	0.41
Arsenic	0.01	0.5	<0.001	0.01	**0.08**	0.00	0.00	0.00
Boron	0.5	25	<0.001	0.00	**0.56**	<0.001	<0.001	0.19
Barium	0.7	35	0.28	**2.02**	**4.90**	0.15	**1.15**	0.46
Calcium			48.00	618.00	195.00	30.00	566.00	170.00
Cadmium	0.003	0.15	<0.001	0.00	0.00	<0.001	<0.001	<0.001
Cobalt	0.5	25	0.03	0.15	0.36	0.01	0.03	0.02
$Chromium_{Total}$	0.1	5	<0.001	0.01	**2.37**	<0.001	0.01	**0.15**
Chromium (VI)	0.05	2.5	<0.010	<0.010	0.00	<0.010	<0.010	0.00
Copper	2.0	100	<0.001	<0.001	0.52	<0.001	<0.001	0.02
Iron			0.03	10.00	105.00	<0.025	14.00	<0.025
Mercury	0.006	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium			0.98	<0.5	2.82	0.77	<0.5	<0.5
Magnesium			6.00	142.00	50.00	5.00	56.00	70.00
Manganese	0.5	25	0.41	**10.00**	**3.43**	0.16	**4.11**	**0.62**
Molybdenum	0.07	3.5	<0.001	<0.001	0.11	0.00	<0.001	0.03
Soduim			<1	<1	<1	<1	<1	<1
Nickel	0.07	3.5	0.02	**0.18**	**0.50**	0.01	0.07	0.06
Lead	0.01	0.5	<0.001	**0.09**	**0.30**	<0.001	**0.06**	**0.06**
Antimony	0.02	1.0	<0.001	0.00	0.01	<0.001	<0.001	<0.001
Selenium	0.01	0.5	<0.001	<0.001	**0.02**	0.00	0.00	0.00
Silicon			0.32	0.28	22.21	0.31	0.25	4.37
Strontium			0.41	6.15	5.51	0.33	3.93	1.93
Uranium			<0.001	0.00	0.10	<0.001	0.00	0.00
Vanadium	0.2	10	<0.001	0.00	**2.50**	0.00	<0.001	**0.49**
Zinc	5	250	3.38	**30.00**	**20.34**	0.63	**12.00**	2.36

4.4.2 Drill core material

The drill core samples showed significantly less reactivity than the reject coal, particularly when leached with deionised water, so only samples that showed some reactivity are discussed in detail. The results for the non-reactive samples are detailed in the Appendices.

4.4.2.1 Deionised water leach

The deionised water leach data for the 20 drill core samples showed that the majority of the material could be considered inert. Only 2 of the 20 samples showed registered leachate pH values below pH 5.5, indicating the release of some acidity. These were GC01-6 (pH 3.3) and GC04-6 (pH 3.5). The GC01-6 sample had the highest sulphur grade (2.05%) and highest NAPP values (65 kg/t) so the data are consistent with the composition and indicate that some oxidative weathering had occurred. The sulphate concentration (46 mg/l) was also higher than most of the other samples, further supporting the assessment.

The GC04-6 sample did not have a high sulphur grade (0.1%), but registered a negative value for the ANC test, indicating no significant neutralising capacity. The concentration of iron in solution (2.6 mg/l) was second only to GC01-6, so the low pH could be accounted for by iron hydrolysis in the absence of neutralising capacity. This would also explain the negative ANC value.

The measured TDS values were below 100 mg/l for all but two of the samples, which is consistent with largely inert material. The two samples with higher TDS values, GC02-2 (170 mg/l) and GC03-8 (138 mg/l) are difficult to interpret as none of the measured cations or anions (Appendix X) were present at elevated concentrations, so the higher TDS values could represent analytical error.

From a metal leaching perspective, the measured concentrations were very low, with values below the LCT0 thresholds in almost all cases. The three exceptions were GC01-6, where the nickel concentration (0.139 mg/l) exceeded the LCT0 threshold (0.07 mg/l), GC03-8, where the arsenic concentration (0.016) marginally exceeded the threshold (0.01 mg/l) and GC04-6, where the manganese concentration was marginally higher than the threshold (0.5 mg/l).

The anion concentrations for all samples were substantially below the LCT0 threshold.

4.4.2.2 TCLP leach

The general trend for the drill core samples was similar to that for the reject coal, with a greater number of samples showing metal concentrations in the leachate that exceeded the LCT0 threshold compared to the deionised water leach. Where the values exceeded the threshold this was by a small amount and all values were substantially below the LCT1 thresholds. The elements that most frequently exceeded the LCT0 threshold were barium, manganese and lead, which is consistent with the reject coal material. The key difference between the two sample sets was the absence of zinc in the drill core samples, while the reject coal showed fairly significant zinc mobility. The TCLP data, for elements where the LCT0 threshold was exceeded for any sample, are summarised in Table 19, along with results for iron and calcium.

The TLCP test exposes the material to a lower pH so is likely to leach out acid labile components. In addition, it uses acetic acid, which can act as an organic ligand and leach out certain elements, by complexation, that may not be mobile if exposed to a mineral acid at a similar pH. This accounts for some of the differences between the TCLP and NAG data for acid generating material.

Table 19: Summary of leachate data from the TCLP tests. Values in red exceed the LCT0 threshold. Concentrations for all other elements were consistently below the LCT0 threshold

Sample	Barium mg/l	Manganese mg/l	Lead mg/l	Calcium mg/l	Iron mg/l
LCT0	0.7	0.5	0.01	-	-
GC01-2	0.397	**0.756**	**0.018**	4	2.65
GC01-4	**0.863**	0.348	0.009	20	0.58
GC01-5	0.553	**0.520**	**0.034**	11	2.81
GC01-6	0.361	**0.559**	**0.014**	6	0.28
GC02-2	**1.650**	0.234	<0.001	97	<0.025
GC02-3	**1.194**	**1.922**	**0.023**	113	23.00
GC02-5	**1.679**	0.345	**0.027**	13	0.50
GC02-6	**0.803**	0.176	**0.030**	22	0.96
GC02-7	0.450	**2.828**	**0.020**	133	38.00
GC02-9	0.453	**1.538**	**0.023**	154	0.58
GC03-2	**0.942**	**4.601**	0.001	3249	23.00
GC03-3	**0.714**	0.279	0.005	21	0.11
GC03-4	**1.022**	**0.570**	**0.013**	18	1.96
GC03-6	**1.096**	**2.116**	**0.019**	130	12.00
GC03-8	**1.956**	0.374	**0.069**	36	0.62
GC03-10	**1.220**	**0.520**	**0.035**	18	0.97
GC04-2	**0.850**	**0.710**	**0.020**	19	2.70
GC04-3	**1.152**	**0.771**	**0.038**	48	3.06
GC04-4	0.371	**0.759**	**0.020**	6	2.53
GC04-6	0.213	**0.656**	**0.027**	10	0.58

The calcium values are consistent with the acid neutralising capacity data, with the five samples with calcium concentrations above 100 mg/l being the five with the highest ANC values. The GC03-2 sample showed the highest calcium value by some margin.

The iron data are interesting and suggests that some of the samples have iron in the oxide or carbonate form, rather than as sulphide minerals. This is clearer when comparing the TCLP and NAG leachate data.

4.4.2.3 NAG leachate

The NAG test exposes the material to a strongly oxidising environment by adding hydrogen peroxide and heating the mixture. Where the sample contains reduced sulphur species these are oxidised to generate sulphuric acid. If the acid generated exceeds the neutralising capacity of the material the leachate will remain acidic and this can liberate metals from acid labile minerals. The NAG test can also result in the liberation of certain base metals and metalloids, such as copper, nickel, zinc, lead and arsenic if they are present as sulphide minerals.

The NAG data are presented in a similar format to the TCLP results.

Table 20: Summary of NAG leachate data. The values have been multiplied by five to normalise the solid to liquid ratio to 1:20. Values in red exceed the LCT0 threshold. Concentrations for all other elements were consistently below the LCT0 threshold

	NAG pH	Ba	Co	Cr_{total}	Mn	Pb	Ni	V	Fe
Sample		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
LCT0		0.7	0.5	0.1	0.5	0.01	0.07	0.2	-
GC01-2	6.1	0.065	<0.001	**0.21**	<0.025	<0.001	<0.001	0.010	<0.025
GC01-4	4.3	**0.830**	0.300	**0.90**	**4.97**	**0.015**	**0.42**	0.180	85.00
GC01-5	2.7	0.380	0.340	**0.72**	**18.60**	**0.065**	**0.69**	0.010	80.00
GC01-6	2.2	0.210	0.180	**3.59**	**0.99**	**0.425**	**1.27**	0.090	225.00
GC02-2	7.6	**9.750**	<0.001	**2.22**	<0.025	<0.001	<0.001	**1.085**	0.31
GC02-3	8.0	0.270	<0.001	**0.17**	<0.025	0.005	<0.001	0.025	<0.025
GC02-5	4.9	0.225	0.065	**0.45**	**0.98**	0.005	0.07	**0.440**	0.24
GC02-6	5.9	0.545	0.020	**0.77**	0.18	<0.001	0.02	**0.915**	<0.025
GC02-7	8.3	0.060	<0.001	**0.26**	<0.025	<0.001	<0.001	0.075	<0.025
GC02-9	2.5	0.395	**0.600**	**2.78**	**8.20**	**0.350**	**0.91**	0.025	105.00
GC03-2	9.7	0.355	<0.001	<0.001	<0.025	<0.001	<0.001	0.005	<0.025
GC03-3	6.1	0.540	0.005	**1.47**	0.17	<0.001	0.01	**2.200**	0.18
GC03-4	3.6	0.185	0.380	**1.30**	**13.75**	0.005	**0.50**	0.070	195.00
GC03-6	6.9	0.280	<0.001	<0.001	0.16	<0.001	<0.001	<0.001	0.23
GC03-8	6.2	0.365	0.025	0.02	**1.70**	<0.001	0.03	0.005	1.16
GC03-10	4.5	0.560	0.065	**0.25**	**2.37**	<0.001	**0.22**	0.100	0.46
GC04-2	4.6	**0.860**	**0.635**	**0.53**	**21.15**	0.005	**0.91**	0.025	60.00
GC04-3	3.0	0.185	0.400	**0.50**	**2.84**	**0.050**	**1.83**	0.155	145.00
GC04-4	3.0	0.290	0.210	**0.83**	**8.40**	**0.015**	**0.29**	**0.245**	0.77
GC04-6	2.5	0.455	0.180	**2.19**	**1.21**	**0.425**	**0.70**	0.025	55.00

The NAG data show that a greater number of elements exceed the LCT0 threshold. The barium, manganese and lead are consistent with the TCLP data, although the trend and the magnitude of the concentrations provide some insight into the mechanism.

There is a clear relationship between iron concentration in the leachate and the NAG pH value. This is expected for two reasons, the first is that iron sulphides are the most abundant sulphide minerals, so iron liberation is expected where acid generation is high. The second factor relates to pH and the solubility of ferric iron, with significant precipitation of ferric iron above pH 3.

The majority of the samples showed total chromium concentrations in the leachate that exceeded the LCT0 threshold. This can most likely be attributed to the oxidising environment as elevated chromium was not detected during any of the other tests.

As with the other static tests the NAG test should be considered indicative, rather than definitive. The material is milled to a fine powder, increasing the reactive surface area, a significant excess of peroxide is used and the samples are heated, all of which can increase metal liberation.

5 Conclusions

The interpretation of the data generated during the static test programme allows a number of conclusions to be drawn:

1. The XRF analysis for major elements is consistent with the description of the dominant lithologies for both the reject coal samples and the drill core material.
2. The XRF data for the reject samples identified zinc as the most significant trace element, with the concentration exceeding the TCT0 threshold (240 mg/kg) by a significant amount for all six samples, although the values were substantially below the TCT1 value of 160 000.
3. A number of the samples showed trace element concentrations for arsenic, barium, cobalt, copper, nickel, lead, antimony and vanadium that marginally exceeded the TCT0 threshold.
4. The XRF analysis of the drill core samples showed that the calcium and magnesium concentrations were relatively low, suggesting limited acid neutralising capacity. The zinc concentrations were only a fraction of those measured for the reject coal. A number of the samples contained barium, copper, lead, antimony and zinc at concentrations that exceeded the TCT0 threshold, but not by a substantial amount.
5. The acid base accounting analysis of the reject coal indicated that five of the six samples could be considered acid generating, with Ant 185 (1) the exception.
6. The sulphur grade was relatively consistent across the six samples (0.52-0.89%). This differed significantly from the sulphur grade values provided by the project geologist.
7. The acid neutralising capacity was low (<15 kg H_2SO_4/t) for all but Ant 185 (1) (30 kg H_2SO_4/t), resulting in NAPP values of between 3.5 and 23 kg/t.
8. The NAG tests performed on the reject coal confirmed that five of the six samples could be considered acid generating, but the magnitude of acid generation was significantly higher than predicted in all cases. This discrepancy is difficult to explain, particularly as the sulphate concentrations measured in the NAG leachate are more consistent with the acidity predicted by ABA.
9. The residues from the six reject coal samples were pooled and used to load a flow-through leach column for confirmatory kinetic testing. The leach column has been operating for almost two months. The leachate is still alkaline at this stage.
10. Fourteen of the 20 drill core samples could be considered acid generating based on the ABA analysis. The magnitude of the predicted acid generation is relatively low (< 17 kg H_2SO_4/t) for all but GC01-6 (65 kg H_2SO_4/t).
11. The remaining six samples were predicted to be acid consuming, although the magnitude of the neutralising capacity was again low (< 13 kg H_2SO_4/t) for all but GC03-2 (111 kg H_2SO_4/t). The ABA data were consistent for the whole rock characterisation.
12. The relationship between the ABA and NAG results was far more consistent for the drill core material.
13. Leachate was generated by three different tests, a deionised water leach, TCLP test and NAG test. For the reject coal samples, the concentrations of zinc and manganese in the leachate from all three tests generally exceeded the LCT0 threshold. While the concentrations of zinc in particular exceeded the LCT0 by some margin, they were consistently below the LCT1 value.
14. In addition to zinc and manganese, nickel and lead concentrations in particular from the TCLP and NAG tests exceeded the LCT0 value in several cases, but only marginally.

15. The drill core samples were essentially inert under deionised water leach conditions, with only three instances of individual elements exceeding the LCT0 thresholds.
16. The TCLP leach resulted in concentrations of barium, manganese and lead that exceeded the LCT0 threshold for several of the samples. While the TCLP test is typically a legislative requirement it does not provide particularly useful data as the acetic acid used is more relevant where putrifiable waste is present, which is typically not the case with mine waste.
17. The leachate from the NAG tests showed elevated concentrations of chromium, manganese, lead and nickel in several cases, with values exceeding the LCT0 threshold, but significantly lower than the LCT1 value.
18. There was a strong positive correlation between the dominant trace elements identified by XRF and the elements that were detected in the leach tests.
19. With the exception of the NAG data for the reject coal samples the various tests provided confirmatory data.

In summary, the reject coal material has a high 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 TCT0and 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.

6 References

AMIRA International (2002). ARD Test Handbook: Prediction and kinetic control of acid mine drainage, Ian Wark Research Institute

Hageman, P.L., Briggs, P.H., Desborough, G.A., Lamothe, P.J. and Theodorakos, P.J., (2000). Synthetic Precipitation Leaching Procedure (SPLP) Leachate Chemistry Data for Solid Mine-waste Composite Samples from Southwestern New Mexico, and Leadville, Colorado. U.S. Department of Interior USGS, Denver, CO, 22 pp.

Paktunc, A.D. (1999). Mineralogical constraints on the determination of neutralising potential and prediction of acid mine drainage. *Environmental Geology* **39:** 103–112.

Parbharkar-Fox, A. and Lottermoser, B.G. (2015). A critical review of acid rock drainage prediction methods and practices. *Minerals Engineering* **82:** 107-124.

7 Appendices

Appendix A – Drill core samples

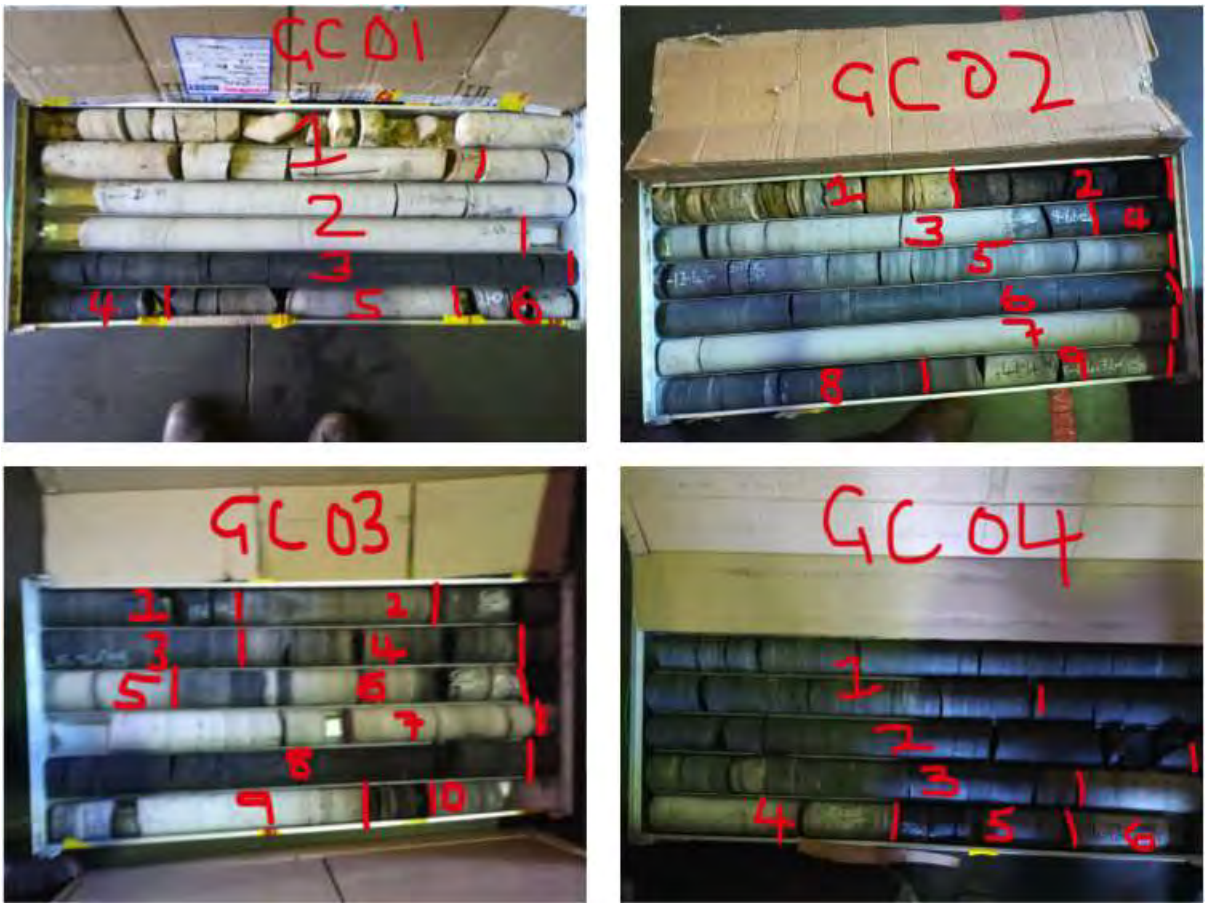


Figure A2: Photographs showing the four drill core samples, identifying the lithologically distinct regions which were used to select the 20 samples tested

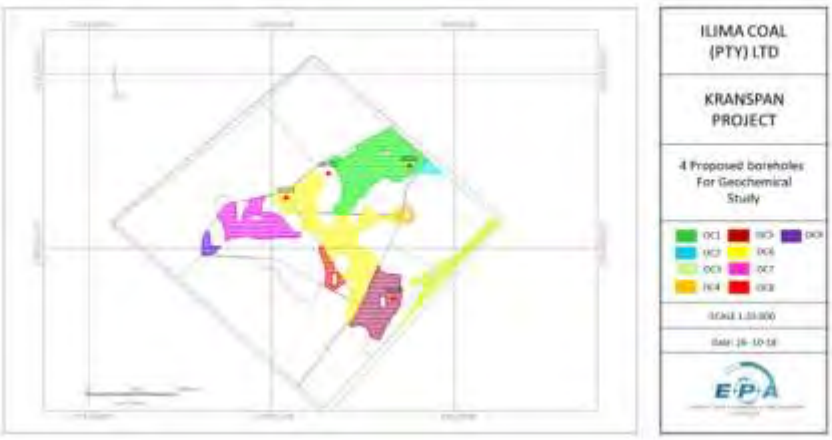


Figure A3: Location of drill core samples

Appendix B

Total Concentration Threshold values for waste materials in mg/kg (Norms and Standards for the assessment of waste for landfill disposal – published in terms of NEMA 2008)

Elements & Chemical Substances in Waste	TCT0	TCT1	TCT2
Metal Ions			
As, Arsenic	5.8	500	2000
B, Boron	150	15000	60000
Ba, Barium	62.5	6250	25000
Cd, Cadmium	7.5	260	1040
Co, Cobalt	50	5000	20000
Cr_{Total}, Chromium Total	46000	800000	N/A
Cr(VI), Chromium (VI)	6.5	500	2000
Cu, Copper	16	19500	78000
Hg, Mercury	0.93	160	640
Mn, Manganese	1000	25000	100000
Mo, Molybdenum	40	1000	4000
Ni, Nickel	91	10600	42400
Pb, Lead	20	1900	7600
Sb, Antimony	10	75	300
Se, Selenium	10	50	200
V, Vanadium	150	2680	10720
Zn, Zinc	240	160000	640000

Appendix C – Laboratory Certificates of Analysis

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES

EXTRACTIONS AS 4439.3

Date received:	**30-01-19**		**Date completed:**	**12-03-19**
Project number:	**1000**	**Report number: 80505**	**Order number:**	**---**

Client name:	**ABS Africa (Pty) Ltd.**	**Contact person:**	**Paul Furniss**
Address:	**PO Box 14003, Vorna Valley, 1686**	**Email:**	**paul@abs-africa.com**
Telephone:	**011 805 0061**	**Contact person:**	**Rob van Hille**
		Email:	**rob@mossgroup.co.za**

Analyses	**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)**				
Sample Number	**53621**	**53622**	**53623**	**53624**	**53625**				
TCLP / Borax / Distilled Water	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	<0.100	0.363	0.105	<0.100	0.639				
As, Arsenic	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	0.5	1	4
B, Boron	0.004	0.007	0.006	0.007	0.033	0.5	25	50	200
Ba, Barium	0.055	0.026	0.046	0.159	0.084	0.7	35	70	280
Ca, Calcium	2	1	3	7	2				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.003	<0.001	0.004	0.053	<0.001	0.5	25	50	200
Cr_{Total}, Chromium Total	<0.001	<0.001	<0.001	<0.001	0.005	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.001	<0.001	<0.001	0.030	0.001	2.0	100	200	800
Fe, Iron	<0.025	0.095	<0.025	4.48	0.197				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	1.4	2.3	2.0	1.6	3.2				
Mg, Magnesium	1	<1	1	2	2				
Mn, Manganese	0.102	<0.025	0.055	0.447	<0.025	0.5	25	50	200
Mo, Molybdenum	<0.001	0.003	0.014	<0.001	0.002	0.07	3.5	7	28
Na, Soduim	<1	<1	<1	<1	4				
Ni, Nickel	0.002	<0.001	0.003	0.139	0.002	0.07	3.5	7	28
Pb, Lead	<0.001	<0.001	<0.001	0.003	<0.001	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	1.0	2.3	1.3	1.4	2.4				
Sr, Strontium	0.014	0.012	0.023	0.063	0.027				
U, Uranium	<0.001	<0.001	<0.001	0.002	<0.001				
V, Vanadium	<0.001	0.002	<0.001	<0.001	0.051	0.2	10	20	80
Zn, Zinc	<0.001	<0.001	0.003	0.081	<0.001	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	20	20	30	78	170	1000	12,500	25,000	100,000
Chloride as Cl	<2	<2	<2	<2	6	300	15,000	30,000	120,000
Sulphate as SO4	7	3	13	46	6	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	3.3	11	550	1100	4400
Fluoride as F	<0.2	<0.2	<0.2	<0.2	0.4	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	6.1	6.2	6.0	3.3	5.5				
% Solids	---	---	---	---	---				
Acid Base Accounting	See attached report 80505 ABA								
X-ray Fluorescence [s]	See attached report 80505 XRF								

***Please note:**

1. The samples were used as received.
2. A moisture content were determined for wet or moist samples.
3. In cases where the sample were a slurry, a solid to liquid ratio were done (reported). Moisture content were determined after filtration
4. The results are reported as received. The moisture content were not taken into account.

Analyses	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)				
Sample Number	**53626**	**53627**	**53628**	**53629**	**53630**				
TCLP / Borax / Distilled Water	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	0.175	0.149	0.157	0.224	<0.100				
As, Arsenic	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	0.5	1	4
B, Boron	0.006	0.015	0.041	0.005	0.009	0.5	25	50	200
Ba, Barium	0.094	0.082	0.053	0.048	0.141	0.7	35	70	280
Ca, Calcium	6	1	4	7	24				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	<0.001	<0.001	<0.001	<0.001	0.001	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.001	<0.001	<0.001	<0.001	<0.001	2.0	100	200	800
Fe, Iron	<0.025	0.027	0.025	<0.025	<0.025				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	2.3	1.5	2.9	1.7	1.1				
Mg, Magnesium	2	<1	2	2	3				
Mn, Manganese	<0.025	<0.025	<0.025	<0.025	0.061	0.5	25	50	200
Mo, Molybdenum	0.005	0.003	0.006	0.003	0.006	0.07	3.5	7	28
Na, Soduim	<1	<1	1	<1	1				
Ni, Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	0.07	3.5	7	28
Pb, Lead	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	1.3	2.0	2.0	1.3	0.8				
Sr, Strontium	0.083	0.043	0.098	0.181	0.376				
U, Uranium	<0.001	<0.001	<0.001	<0.001	<0.001				
V, Vanadium	<0.001	<0.001	0.004	<0.001	<0.001	0.2	10	20	80
Zn, Zinc	<0.001	<0.001	<0.001	<0.001	<0.001	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	72	18	24	36	96	1000	12,500	25,000	100,000
Chloride as Cl	<2	<2	<2	<2	4	300	15,000	30,000	120,000
Sulphate as SO4	5	5	8	7	44	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	0.5	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	7.1	6.4	6.6	7.1	7.4				
% Solids	---	---	---	---	---				
Acid Base Accounting	See attached report 80505 ABA								
X-ray Fluorescence [s]	See attached report 80505 XRF								

Analyses	GC03-2 Siltstone/sandstone	GC03-3 Carbonaceous Shale and sandstone mix	GC03-4 Carbonaceous Sandstone	GC03-6 Sandstone & Shale mix	GC03-8 Carbonaceous Shale				
Sample Number	**53631**	**53632**	**53633**	**53634**	**53635**				
TCLP / Borax / Distilled Water	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	0.157	0.427	0.130	0.126	0.574				
As, Arsenic	<0.010	<0.010	<0.010	<0.010	0.016	0.01	0.5	1	4
B, Boron	0.006	0.019	0.007	0.005	0.065	0.5	25	50	200
Ba, Barium	0.086	0.021	0.071	0.135	0.138	0.7	35	70	280
Ca, Calcium	21	1	3	8	2				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	<0.001	<0.001	<0.001	<0.001	0.002	0.5	25	50	200
Cr_{Total}, Chromium Total	<0.001	<0.001	<0.001	<0.001	0.003	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.001	<0.001	<0.001	<0.001	0.003	2.0	100	200	800
Fe, Iron	<0.025	0.031	0.031	<0.025	0.105				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	2.7	1.4	2.5	2.1	2.5				
Mg, Magnesium	4	<1	1	2	<1				
Mn, Manganese	<0.025	<0.025	<0.025	<0.025	<0.025	0.5	25	50	200
Mo, Molybdenum	0.006	0.003	0.012	0.005	0.026	0.07	3.5	7	28
Na, Soduim	<1	1	<1	<1	1				
Ni, Nickel	<0.001	<0.001	<0.001	<0.001	0.004	0.07	3.5	7	28
Pb, Lead	<0.001	<0.001	<0.001	<0.001	0.006	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	1.2	2.5	2.1	1.4	2.5				
Sr, Strontium	0.060	0.012	0.028	0.060	0.049				
U, Uranium	<0.001	<0.001	<0.001	<0.001	<0.001				
V, Vanadium	<0.001	0.005	<0.001	0.001	0.007	0.2	10	20	80
Zn, Zinc	<0.001	<0.001	<0.001	<0.001	0.008	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	88	22	30	32	138	1000	12,500	25,000	100,000
Chloride as Cl	3	<2	<2	<2	5	300	15,000	30,000	120,000
Sulphate as SO4	32	6	8	7	10	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	7.4	6.5	6.7	7.3	6.7				
% Solids	---	---	---	---	---				
Acid Base Accounting	See attached report 80505 ABA								
X-ray Fluorescence [s]	See attached report 80505 XRF								

Analyses	GC03-10 Carbonaceous sand stone and Shale mix	GC04-2 Carbonaceous Shale	GC04-3 Shale and Sandstone mix	GC04-4 Sandstone	GC04-6 Sandstone				
Sample Number	53636	53637	53638	53639	53640				
TCLP / Borax / Distilled Water	Distilled Water	Distilled Water	Distilled Water	Distilled Water	Distilled Water				
Ratio*	1:20	1:20	1:20	1:20	1:20				
Units	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	LCT0 mg/l	LCT1 mg/l	LCT2 mg/l	LCT3 mg/l
Al, Aluminium	0.455	1.96	<0.100	0.241	0.136				
As, Arsenic	0.004	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
B, Boron	0.030	0.014	0.004	0.002	0.008	0.5	25	50	200
Ba, Barium	0.046	0.028	0.182	0.038	0.157	0.7	35	70	280
Ca, Calcium	<1	1	6	2	3				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	<0.001	0.001	<0.001	0.002	0.065	0.5	25	50	200
Cr_{Total}, Chromium Total	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	0.001	<0.001	<0.001	<0.001	<0.001	2.0	100	200	800
Fe, Iron	0.206	2.92	<0.025	0.120	2.62				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	0.6	0.8	1.9	1.3	<0.5				
Mg, Magnesium	<1	<1	2	<1	1				
Mn, Manganese	<0.025	0.072	<0.025	0.126	0.631	0.5	25	50	200
Mo, Molybdenum	0.022	0.010	0.005	0.003	<0.001	0.07	3.5	7	28
Na, Soduim	10	11	<1	<1	<1				
Ni, Nickel	0.002	<0.001	<0.001	0.002	0.122	0.07	3.5	7	28
Pb, Lead	0.003	<0.001	<0.001	<0.001	0.006	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	2.1	3.8	1.4	1.3	0.6				
Sr, Strontium	0.017	0.013	0.051	0.021	0.059				
U, Uranium	<0.001	<0.001	<0.001	<0.001	0.001				
V, Vanadium	0.001	0.001	0.004	<0.001	<0.001	0.2	10	20	80
Zn, Zinc	<0.001	<0.001	<0.001	0.001	0.074	5	250	500	2000
Inorganic Anions	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ				
Total Dissolved Solids*	98	28	32	18	50	1000	12,500	25,000	100,000
Chloride as Cl	2	<2	<2	<2	<2	300	15,000	30,000	120,000
Sulphate as SO4	6	7	6	9	26	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	6.6	6.2	7.1	6.0	3.5				
% Solids	---	---	---	---	---				
Acid Base Accounting	See attached report 80505 ABA								
X-ray Fluorescence [s]	See attached report 80505 XRF								

[s] = Subcontracted

E. Botha

Geochemistry Project Manager

WATERLAB (PTY) LTD

WATERLAB

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

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

CERTIFICATE OF ANALYSES

EXTRACTIONS AS 4439.3

Date received:	**30-01-19**		**Date completed:**	**12-03-19**
Project number:	**1000**	**Report number: 80505**	**Order number:**	**---**

Client name:	**ABS Africa (Pty) Ltd.**	**Contact person:**	**Paul Furniss**
Address:	**PO Box 14003, Vorna Valley, 1686**	**Email:**	**paul@abs-africa.com**
Telephone:	**011 805 0061**	**Contact person:**	**Rob van Hille**
		Email:	**rob@mossgroup.co.za**

Analyses	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)				
Sample Number	**53621**	**53622**	**53623**	**53624**	**53625**				
TCLP / Borax / Distilled Water	**TCLP**	**TCLP**	**TCLP**	**TCLP**	**TCLP**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	0.250	0.148	0.212	0.268	0.114				
As, Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
B, Boron	0.001	0.009	0.001	<0.001	0.011	0.5	25	50	200
Ba, Barium	0.397	0.863	0.553	0.361	1.65	0.7	35	70	280
Ca, Calcium	4	20	11	6	97				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.009	0.018	0.019	0.018	0.001	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	0.007	<0.001	0.003	0.009	<0.001	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.001	0.001	0.007	0.007	<0.001	2.0	100	200	800
Fe, Iron	2.65	0.579	2.81	0.278	<0.025				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	1.2	4.6	2.5	0.5	5.6				
Mg, Magnesium	2	8	5	3	57				
Mn, Manganese	0.756	0.348	0.520	0.559	0.234	0.5	25	50	200
Mo, Molybdenum	<0.001	<0.001	<0.001	<0.001	<0.001	0.07	3.5	7	28
Na, Soduim	35	8	<1	17	<1				
Ni, Nickel	0.007	0.010	0.014	0.046	0.001	0.07	3.5	7	28
Pb, Lead	0.018	0.009	0.034	0.014	<0.001	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	0.8	3.1	1.7	1.1	1.6				
Sr, Strontium	0.039	0.162	0.102	0.086	0.344				
U, Uranium	0.002	0.003	0.002	0.007	<0.001				
V, Vanadium	<0.001	<0.001	<0.001	<0.001	0.003	0.2	10	20	80
Zn, Zinc	0.046	0.022	0.093	0.023	<0.001	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	124	110	162	28	396	1000	12,500	25,000	100,000
Chloride as Cl	<2	<2	<2	<2	2	300	15,000	30,000	120,000
Sulphate as SO4	6	2	14	61	<2	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	4.0	11	550	1100	4400
Fluoride as F	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	4.8	4.8	4.8	4.8	4.8				
% Solids	---	---	---	---	---				

***Please note:**

1. The samples were used as received.
2. A moisture content were determined for wet or moist samples.
3. In cases where the sample were a slurry, a solid to liquid ratio were done (rep
   Moisture content were determined after filtration
4. The results are reported as received. The moisture content were not taken in

Analyses	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)				
Sample Number	**53626**	**53627**	**53628**	**53629**	**53630**				
TCLP / Borax / Distilled Water	**TCLP**	**TCLP**	**TCLP**	**TCLP**	**TCLP**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	0.246	0.277	0.488	0.313	0.242				
As, Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
B, Boron	0.006	0.013	0.034	0.002	<0.001	0.5	25	50	200
Ba, Barium	1.19	1.68	0.803	0.450	0.453	0.7	35	70	280
Ca, Calcium	113	13	22	133	154				
Cd, Cadmium	<0.001	0.001	0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.018	0.008	0.041	0.012	0.035	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	0.005	0.003	0.002	0.006	0.004	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	0.001	0.011	0.005	<0.001	<0.001	2.0	100	200	800
Fe, Iron	23	0.502	0.957	38	0.577				
Hg, Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	2.8	2.3	4.8	2.2	1.0				
Mg, Magnesium	39	7	10	41	6				
Mn, Manganese	1.92	0.345	0.176	2.83	1.54	0.5	25	50	200
Mo, Molybdenum	<0.001	<0.001	<0.001	<0.001	<0.001	0.07	3.5	7	28
Na, Soduim	<1	<1	<1	17	30				
Ni, Nickel	0.010	0.006	0.051	0.008	0.037	0.07	3.5	7	28
Pb, Lead	0.023	0.027	0.030	0.020	0.023	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	2.1	3.4	3.1	1.9	1.1				
Sr, Strontium	0.639	0.483	0.497	0.373	0.624				
U, Uranium	0.004	0.003	0.013	0.002	0.003				
V, Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	0.2	10	20	80
Zn, Zinc	0.038	0.118	0.029	0.037	0.040	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	942	244	296	1080	890	1000	12,500	25,000	100,000
Chloride as Cl	2	<2	<2	2	2	300	15,000	30,000	120,000
Sulphate as SO4	6	4	8	10	55	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	0.5	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	4.9	4.8	4.8	5.0	4.9				
% Solids	---	---	---	---	---				

Analyses	GC03-2 Siltstone/sandstone	GC03-3 Carbonaceous Shale and sandstone mix	GC03-4 Carbonaceous Sandstone	GC03-6 Sandstone & Shale mix	GC03-8 Carbonaceous Shale				
Sample Number	**53631**	**53632**	**53633**	**53634**	**53635**				
TCLP / Borax / Distilled Water	**TCLP**	**TCLP**	**TCLP**	**TCLP**	**TCLP**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	0.835	0.118	0.405	0.206	0.138				
As, Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
B, Boron	0.012	0.003	<0.001	<0.001	0.044	0.5	25	50	200
Ba, Barium	0.942	0.714	1.02	1.10	1.96	0.7	35	70	280
Ca, Calcium	3249	21	18	130	36				
Cd, Cadmium	<0.001	0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.028	0.008	0.021	0.014	0.011	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	0.001	0.001	0.002	0.003	<0.001	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.001	0.009	0.005	0.001	0.015	2.0	100	200	800
Fe, Iron	23	0.105	1.96	12	0.621				
Hg, Mercury	<0.001	0.002	<0.001	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	9.0	2.7	4.1	3.0	9.5				
Mg, Magnesium	98	7	8	34	15				
Mn, Manganese	4.60	0.279	0.570	2.12	0.374	0.5	25	50	200
Mo, Molybdenum	<0.001	<0.001	<0.001	<0.001	<0.001	0.07	3.5	7	28
Na, Soduim	3	<1	<1	<1	<1				
Ni, Nickel	0.044	0.012	0.011	0.009	0.008	0.07	3.5	7	28
Pb, Lead	0.001	0.005	0.013	0.019	0.069	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	4.0	3.2	3.2	2.3	3.9				
Sr, Strontium	0.174	0.172	0.148	0.228	1.76				
U, Uranium	0.005	0.005	0.007	0.004	0.009				
V, Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	0.2	10	20	80
Zn, Zinc	<0.001	0.034	0.043	0.034	0.014	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	7328	314	202	752	192	1000	12,500	25,000	100,000
Chloride as Cl	<2	<2	<2	<2	<2	300	15,000	30,000	120,000
Sulphate as SO4	<2	4	6	7	<2	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	11	550	1100	4400
Fluoride as F	0.3	<0.2	<0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	5.4	4.8	4.8	5.0	4.8				
% Solids	---	---	---	---	---				

Analyses	GC03-10 Carbonaceous sand stone and Shale mix	GC04-2 Carbonaceous Shale	GC04-3 Shale and Sandstone mix	GC04-4 Sandstone	GC04-6 Sandstone				
Sample Number	**53636**	**53637**	**53638**	**53639**	**53640**				
TCLP / Borax / Distilled Water	**TCLP**	**TCLP**	**TCLP**	**TCLP**	**TCLP**				
Ratio*	**1:20**	**1:20**	**1:20**	**1:20**	**1:20**				
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**LCT0 mg/l**	**LCT1 mg/l**	**LCT2 mg/l**	**LCT3 mg/l**
Al, Aluminium	<0.100	0.484	0.293	0.229	0.491				
As, Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
B, Boron	<0.001	<0.001	<0.001	<0.001	<0.001	0.5	25	50	200
Ba, Barium	1.22	0.850	1.15	0.371	0.213	0.7	35	70	280
Ca, Calcium	18	19	48	6	10				
Cd, Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	0.007	0.048	0.011	0.007	0.015	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	0.002	0.001	0.003	0.008	0.005	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	<0.010	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	0.010	0.014	0.006	0.001	<0.001	2.0	100	200	800
Fe, Iron	0.973	2.70	3.06	2.53	0.575				
Hg, Mercury	<0.001	<0.001	0.002	<0.001	<0.001	0.006	0.3	0.6	2.4
K, Potassium	5.2	4.6	2.6	0.7	<0.5				
Mg, Magnesium	7	9	12	3	<1				
Mn, Manganese	0.520	0.710	0.771	0.759	0.656	0.5	25	50	200
Mo, Molybdenum	<0.001	<0.001	<0.001	<0.001	<0.001	0.07	3.5	7	28
Na, Soduim	<1	<1	9	<1	15				
Ni, Nickel	0.018	0.045	0.013	0.007	0.031	0.07	3.5	7	28
Pb, Lead	0.035	0.020	0.038	0.020	0.027	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	0.001	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.5	1	4
Si, Silicon	1.9	3.4	2.2	1.2	0.5				
Sr, Strontium	1.04	0.135	0.201	0.071	0.053				
U, Uranium	0.003	0.013	0.005	0.004	0.002				
V, Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	0.2	10	20	80
Zn, Zinc	0.017	0.032	0.058	0.062	0.016	5	250	500	2000
Inorganic Anions	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**				
Total Dissolved Solids*	187	180	490	192	84	1000	12,500	25,000	100,000
Chloride as Cl	<2	<2	<2	<2	<2	300	15,000	30,000	120,000
Sulphate as SO4	2	7	6	10	34	250	12,500	25,000	100,000
Nitrate as N	<0.1	<0.1	<0.1	<0.1	<0.1	11	550	1100	4400
Fluoride as F	<0.2	<0.2	<0.2	<0.2	<0.2	1.5	75	150	600
Ortho-Phosphate as P	<0.1	<0.1	<0.1	<0.1	<0.1				
Total Cyanide as CN [s]	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	3.5	7	28
pH	4.8	4.8	4.8	4.8	4.8				
% Solids	---	---	---	---	---				

[s] = Subcontracted

E. Botha

Geochemistry Project Manager

porte d).

nto account.

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NAG EXTRACTION

Date received: 30-01-19
Project number: 1000
Report number: 80505
Date completed: 13-03-19
Order number: ---

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061
Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Analyses	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)	
Sample Number	53621		53622		53623		53624		53625	
TCLP / Acid Rain / Distilled Water / H_2O_2	NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)	
Dry Mass Used (g)	5		5		5		5		5	
Volume Used (mℓ)	500		500		500		500		500	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Chloride as Cl	4	400	3	300	2	200	<2	<200	2	200
Sulphate as SO4	28	2800	49	4900	198	19800	542	54200	27	2700
Nitrate as N	0.1	10	0.4	40	0.2	20	<0.1	<10	2.3	230
Fluoride as F	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20
Ortho-Phosphate as P	<0.1	<10	0.1	10	<0.1	<10	<0.1	<10	<0.1	<10
ICP-OES Quant	See ICP - NAG tab									
ICP-MS Quant										

Analyses	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)	
Sample Number	53626		53627		53628		53629		53630	
TCLP / Acid Rain / Distilled Water / H_2O_2	NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)		NAG Leachate (Peroxide)	
Dry Mass Used (g)	5		5		5		5		5	
Volume Used (mℓ)	500		500		500		500		500	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Chloride as Cl	<2	<200	<2	<200	2	200	4	400	2	200
Sulphate as SO4	54	5400	52	5200	36	3600	39	3900	358	35800
Nitrate as N	<0.1	<10	0.3	30	0.7	70	0.3	30	0.1	10
Fluoride as F	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20
Ortho-Phosphate as P	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10
ICP-OES Quant	See ICP - NAG tab									
ICP-MS Quant										

Analyses	GC03-2 Siltstone/sandstone		GC03-3 Carbonaceous Shale and sandstone mix		GC03-4 Carbonaceous Sandstone		GC03-6 Sandstone & Shale mix		GC03-8 Carbonaceous Shale	
Sample Number	**53631**		**53632**		**53633**		**53634**		**53635**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**	
Dry Mass Used (g)	**5**		**5**		**5**		**5**		**5**	
Volume Used (mℓ)	**500**		**500**		**500**		**500**		**500**	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Chloride as Cl	2	200	<2	<200	<2	<200	<2	<200	2	200
Sulphate as SO4	180	18000	77	7700	146	14600	99	9900	18	1800
Nitrate as N	0.1	10	1.6	160	0.2	20	0.2	20	0.2	20
Fluoride as F	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20
Ortho-Phosphate as P	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10
ICP-OES Quant	See ICP - NAG tab									
ICP-MS Quant										

Analyses	GC03-10 Carbonaceous sand stone and Shale mix		GC04-2 Carbonaceous Shale		GC04-3 Shale and Sandstone mix		GC04-4 Sandstone		GC04-6 Sandstone	
Sample Number	**53636**		**53637**		**53638**		**53639**		**53640**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**		**NAG Leachate (Peroxide)**	
Dry Mass Used (g)	**5**		**5**		**5**		**5**		**5**	
Volume Used (mℓ)	**500**		**500**		**500**		**500**		**500**	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Chloride as Cl	<2	<200	3	300	<2	<200	<2	<200	<2	<200
Sulphate as SO4	90	9000	30	3000	145	14500	80	8000	175	17500
Nitrate as N	0.2	20	0.6	60	0.3	30	<0.1	<10	0.2	20
Fluoride as F	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20	<0.2	<20
Ortho-Phosphate as P	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10	<0.1	<10
ICP-OES Quant	See ICP - NAG tab									
ICP-MS Quant										

E. Botha ____________________

Geochemistry Project Manager

CERTIFICATE OF ANALYSES
ICP-MS QUANTITATIVE ANALYSIS

Date received: 30-01-19
Project number: 1000
Date completed: 13-03-19
Report number: 80505

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061
Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
NAG Leachate (Peroxide)	5	500	100

Sample Id	Sample Number	Al*	Al*	As	As	B	B
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.100	<10	<0.001	<0.100	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.100	<10	<0.001	<0.100	<0.001	<0.100
GC01-4 Carbonaceous Shale & Sandstone	53622	10	1000	<0.001	<0.100	<0.001	<0.100
GC01-5 Sandstone (roof of coal seam)	53623	5.83	583	<0.001	<0.100	<0.001	<0.100
GC01-6 Carbonaceous Sandstone	53624	7.77	777	<0.001	<0.100	<0.001	<0.100
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.100	<10	<0.001	<0.100	<0.001	<0.100
GC02-3 Sandstone (floor of B-lower)	53626	<0.100	<10	<0.001	<0.100	0.043	4.32
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	1.46	146	<0.001	<0.100	<0.001	<0.100
GC02-6 Carbonaceous Shale	53628	0.128	13	<0.001	<0.100	<0.001	<0.100
GC02-7 Sandstone	53629	<0.100	<10	<0.001	<0.100	0.189	19
GC02-9 Sandstone (roof and floor of E seam)	53630	9.55	955	<0.001	<0.100	0.021	2.12
GC03-2 Siltstone/sandstone	53631	1.65	165	<0.001	<0.100	0.205	20
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.230	23	<0.001	<0.100	0.025	2.51
GC03-4 Carbonaceous Sandstone	53633	11	1100	<0.001	<0.100	0.067	6.72
GC03-6 Sandstone & Shale mix	53634	<0.100	<10	<0.001	<0.100	0.006	0.606
GC03-8 Carbonaceous Shale	53635	0.564	56	<0.001	<0.100	0.034	3.43
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.598	60	<0.001	<0.100	0.025	2.50
GC04-2 Carbonaceous Shale	53637	9.24	924	<0.001	<0.100	0.019	1.86
GC04-3 Shale and Sandstone mix	53638	10	1000	<0.001	<0.100	0.013	1.29
GC04-4 Sandstone	53639	1.71	171	<0.001	<0.100	0.075	7.53
GC04-6 Sandstone	53640	6.54	654	<0.001	<0.100	0.009	0.913

Sample Id	Sample Number	Ba	Ba	Ca*	Ca*	Cd	Cd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.100	<1	<100	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.013	1.30	2	200	<0.001	<0.100
GC01-4 Carbonaceous Shale & Sandstone	53622	0.166	17	6	600	0.002	0.202
GC01-5 Sandstone (roof of coal seam)	53623	0.076	7.56	14	1400	<0.001	<0.100
GC01-6 Carbonaceous Sandstone	53624	0.042	4.23	3	300	<0.001	<0.100
GC02-2 Carbonaceous Clay (roof of B seam)	53625	1.95	195	35	3500	<0.001	<0.100
GC02-3 Sandstone (floor of B-lower)	53626	0.054	5.43	27	2700	<0.001	<0.100
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.045	4.45	2	200	<0.001	<0.100
GC02-6 Carbonaceous Shale	53628	0.109	11	5	500	<0.001	<0.100
GC02-7 Sandstone	53629	0.012	1.20	18	1800	<0.001	<0.100
GC02-9 Sandstone (roof and floor of E seam)	53630	0.079	7.94	35	3500	<0.001	<0.100
GC03-2 Siltstone/sandstone	53631	0.071	7.09	81	8100	<0.001	<0.100
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.108	11	4	400	<0.001	<0.100
GC03-4 Carbonaceous Sandstone	53633	0.037	3.73	9	900	0.001	0.137
GC03-6 Sandstone & Shale mix	53634	0.056	5.57	26	2600	<0.001	<0.100
GC03-8 Carbonaceous Shale	53635	0.073	7.33	2	200	<0.001	<0.100
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.112	11	6	600	<0.001	<0.100
GC04-2 Carbonaceous Shale	53637	0.172	17	5	500	0.002	0.194
GC04-3 Shale and Sandstone mix	53638	0.037	3.71	15	1500	0.002	0.188
GC04-4 Sandstone	53639	0.058	5.78	4	400	<0.001	<0.100
GC04-6 Sandstone	53640	0.091	9.15	3	300	<0.001	<0.100

Sample Id	Sample Number	Co	Co	Cr	Cr	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.100	<0.001	<0.100	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.100	0.042	4.20	<0.001	<0.100
GC01-4 Carbonaceous Shale & Sandstone	53622	0.060	5.99	0.180	18	0.225	22
GC01-5 Sandstone (roof of coal seam)	53623	0.068	6.78	0.143	14	0.022	2.15
GC01-6 Carbonaceous Sandstone	53624	0.036	3.57	0.717	72	0.076	7.60
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.100	0.444	44	<0.001	<0.100
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.100	0.034	3.42	<0.001	<0.100
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.013	1.34	0.090	9.04	0.079	7.94
GC02-6 Carbonaceous Shale	53628	0.004	0.439	0.154	15	0.008	0.778
GC02-7 Sandstone	53629	<0.001	<0.100	0.051	5.07	<0.001	<0.100
GC02-9 Sandstone (roof and floor of E seam)	53630	0.120	12	0.555	56	0.025	2.53
GC03-2 Siltstone/sandstone	53631	<0.001	<0.100	<0.001	<0.100	<0.001	<0.100
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.001	0.131	0.294	29	0.015	1.46
GC03-4 Carbonaceous Sandstone	53633	0.076	7.58	0.259	26	0.179	18
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.100	<0.001	<0.100	<0.001	<0.100
GC03-8 Carbonaceous Shale	53635	0.005	0.495	0.003	0.345	0.016	1.58
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.013	1.30	0.049	4.88	0.036	3.65
GC04-2 Carbonaceous Shale	53637	0.127	13	0.106	11	0.265	26
GC04-3 Shale and Sandstone mix	53638	0.080	7.98	0.099	9.88	0.160	16
GC04-4 Sandstone	53639	0.042	4.24	0.165	16	0.001	0.134
GC04-6 Sandstone	53640	0.036	3.64	0.438	44	0.019	1.85

Sample Id	Sample Number	Fe*	Fe*	Hg	Hg	K*	K*
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<2.50	<0.001	<0.100	<0.5	<50
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.025	<2.50	<0.001	<0.100	2.6	264
GC01-4 Carbonaceous Shale & Sandstone	53622	17	1700	<0.001	<0.100	3.9	389
GC01-5 Sandstone (roof of coal seam)	53623	16	1600	<0.001	<0.100	4.5	454
GC01-6 Carbonaceous Sandstone	53624	45	4500	<0.001	<0.100	1.5	146
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.062	6.20	<0.001	<0.100	3.4	342
GC02-3 Sandstone (floor of B-lower)	53626	<0.025	<2.50	0.003	0.252	3.1	305
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.047	4.70	<0.001	<0.100	2.0	196
GC02-6 Carbonaceous Shale	53628	<0.025	<2.50	<0.001	<0.100	4.2	421
GC02-7 Sandstone	53629	<0.025	<2.50	<0.001	<0.100	3.4	342
GC02-9 Sandstone (roof and floor of E seam)	53630	21	2100	0.002	0.231	4.2	419
GC03-2 Siltstone/sandstone	53631	<0.025	<2.50	<0.001	<0.100	3.3	328
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.036	3.60	<0.001	<0.100	3.0	303
GC03-4 Carbonaceous Sandstone	53633	39	3900	<0.001	<0.100	4.5	445
GC03-6 Sandstone & Shale mix	53634	0.046	4.60	<0.001	<0.100	2.6	264
GC03-8 Carbonaceous Shale	53635	0.232	23	<0.001	<0.100	5.7	569
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.091	9.10	<0.001	<0.100	6.6	657
GC04-2 Carbonaceous Shale	53637	12	1200	<0.001	<0.100	3.9	385
GC04-3 Shale and Sandstone mix	53638	29	2900	<0.001	<0.100	3.3	335
GC04-4 Sandstone	53639	0.154	15	<0.001	<0.100	3.1	314
GC04-6 Sandstone	53640	11	1100	<0.001	<0.100	1.3	132

Sample Id	Sample Number	Mg*	Mg*	Mn*	Mn*	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<1	<100	<0.025	<2.50	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	3	300	<0.025	<2.50	0.005	0.517
GC01-4 Carbonaceous Shale & Sandstone	53622	3	300	0.993	99	<0.001	<0.100
GC01-5 Sandstone (roof of coal seam)	53623	5	500	3.72	372	<0.001	<0.100
GC01-6 Carbonaceous Sandstone	53624	<1	<100	0.198	20	<0.001	<0.100
GC02-2 Carbonaceous Clay (roof of B seam)	53625	19	1900	<0.025	<2.50	0.003	0.335
GC02-3 Sandstone (floor of B-lower)	53626	<1	<100	<0.025	<2.50	0.004	0.396
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	2	200	0.196	20	0.004	0.379
GC02-6 Carbonaceous Shale	53628	3	300	0.036	3.60	0.006	0.636
GC02-7 Sandstone	53629	<1	<100	<0.025	<2.50	0.003	0.309
GC02-9 Sandstone (roof and floor of E seam)	53630	6	600	1.64	164	<0.001	<0.100
GC03-2 Siltstone/sandstone	53631	<1	<100	<0.025	<2.50	0.002	0.250
GC03-3 Carbonaceous Shale and sandstone mix	53632	2	200	0.034	3.40	0.013	1.33
GC03-4 Carbonaceous Sandstone	53633	6	600	2.75	275	<0.001	<0.100
GC03-6 Sandstone & Shale mix	53634	11	1100	0.031	3.10	0.004	0.361
GC03-8 Carbonaceous Shale	53635	2	200	0.340	34	0.007	0.700
GC03-10 Carbonaceous sand stone and Shale mix	53636	3	300	0.474	47	0.010	1.02
GC04-2 Carbonaceous Shale	53637	4	400	4.23	423	<0.001	<0.100
GC04-3 Shale and Sandstone mix	53638	6	600	0.568	57	<0.001	<0.100
GC04-4 Sandstone	53639	3	300	1.68	168	0.018	1.85
GC04-6 Sandstone	53640	<1	<100	0.241	24	<0.001	<0.100

Sample Id	Sample Number	Na*	Na*	Ni	Ni	Pb	Pb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<1	<100	<0.001	<0.100	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<1	<100	<0.001	<0.100	<0.001	<0.100
GC01-4 Carbonaceous Shale & Sandstone	53622	<1	<100	0.084	8.41	0.003	0.291
GC01-5 Sandstone (roof of coal seam)	53623	<1	<100	0.138	14	0.013	1.34
GC01-6 Carbonaceous Sandstone	53624	<1	<100	0.254	25	0.085	8.55
GC02-2 Carbonaceous Clay (roof of B seam)	53625	1	100	<0.001	<0.100	<0.001	<0.100
GC02-3 Sandstone (floor of B-lower)	53626	<1	<100	<0.001	<0.100	0.001	0.115
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<1	<100	0.014	1.37	0.001	0.139
GC02-6 Carbonaceous Shale	53628	<1	<100	0.004	0.387	<0.001	<0.100
GC02-7 Sandstone	53629	1	100	<0.001	<0.100	<0.001	<0.100
GC02-9 Sandstone (roof and floor of E seam)	53630	1	100	0.182	18	0.070	6.97
GC03-2 Siltstone/sandstone	53631	<1	<100	<0.001	<0.100	<0.001	<0.100
GC03-3 Carbonaceous Shale and sandstone mix	53632	<1	<100	0.002	0.241	<0.001	<0.100
GC03-4 Carbonaceous Sandstone	53633	<1	<100	0.099	9.92	0.001	0.111
GC03-6 Sandstone & Shale mix	53634	<1	<100	<0.001	<0.100	<0.001	<0.100
GC03-8 Carbonaceous Shale	53635	10	1000	0.005	0.470	<0.001	<0.100
GC03-10 Carbonaceous sand stone and Shale mix	53636	6	600	0.044	4.38	<0.001	<0.100
GC04-2 Carbonaceous Shale	53637	<1	<100	0.181	18	0.001	0.100
GC04-3 Shale and Sandstone mix	53638	<1	<100	0.366	37	0.010	1.00
GC04-4 Sandstone	53639	<1	<100	0.058	5.84	0.003	0.303
GC04-6 Sandstone	53640	<1	<100	0.139	14	0.085	8.50

Sample Id	Sample Number	Sb	Sb	Se	Se	Si*	Si*
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.100	<0.001	<0.100	<0.2	<20
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.100	<0.001	<0.100	5.1	509
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.100	0.007	0.746	11.5	1154
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.100	0.001	0.127	12.9	1290
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.100	<0.001	<0.100	9.3	934
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.100	0.014	1.43	1.7	167
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.100	0.001	0.101	3.3	327
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.100	0.001	0.114	8.1	812
GC02-6 Carbonaceous Shale	53628	<0.001	<0.100	0.007	0.724	6.2	617
GC02-7 Sandstone	53629	<0.001	<0.100	<0.001	<0.100	6.7	666
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.100	<0.001	<0.100	15.7	1571
GC03-2 Siltstone/sandstone	53631	<0.001	<0.100	0.003	0.256	0.8	78
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.100	0.006	0.639	9.2	923
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.100	0.002	0.202	13.0	1303
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.100	0.001	0.109	3.1	308
GC03-8 Carbonaceous Shale	53635	<0.001	<0.100	0.004	0.407	5.9	594
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.100	0.003	0.262	7.0	705
GC04-2 Carbonaceous Shale	53637	0.002	0.215	<0.001	<0.100	10.7	1068
GC04-3 Shale and Sandstone mix	53638	0.001	0.133	<0.001	<0.100	11.7	1170
GC04-4 Sandstone	53639	<0.001	<0.100	<0.001	<0.100	8.0	800
GC04-6 Sandstone	53640	<0.001	<0.100	<0.001	<0.100	8.0	800

Sample Id	Sample Number	Sr	Sr	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.100	<0.001	<0.100	<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.018	1.80	<0.001	<0.100	0.002	0.187
GC01-4 Carbonaceous Shale & Sandstone	53622	0.060	5.96	0.016	1.60	0.036	3.61
GC01-5 Sandstone (roof of coal seam)	53623	0.055	5.52	0.005	0.457	0.002	0.206
GC01-6 Carbonaceous Sandstone	53624	0.028	2.82	0.007	0.676	0.018	1.77
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.558	56	<0.001	<0.100	0.217	22
GC02-3 Sandstone (floor of B-lower)	53626	0.310	31	<0.001	<0.100	0.005	0.486
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.088	8.79	<0.001	<0.100	0.088	8.80
GC02-6 Carbonaceous Shale	53628	0.128	13	<0.001	<0.100	0.183	18
GC02-7 Sandstone	53629	0.146	15	<0.001	<0.100	0.015	1.54
GC02-9 Sandstone (roof and floor of E seam)	53630	0.315	32	0.006	0.587	0.005	0.507
GC03-2 Siltstone/sandstone	53631	0.117	12	<0.001	<0.100	0.001	0.133
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.069	6.87	<0.001	<0.100	0.440	44
GC03-4 Carbonaceous Sandstone	53633	0.085	8.48	0.013	1.33	0.014	1.37
GC03-6 Sandstone & Shale mix	53634	0.134	13	<0.001	<0.100	<0.001	<0.100
GC03-8 Carbonaceous Shale	53635	0.143	14	0.001	0.144	0.001	0.124
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.264	26	<0.001	<0.100	0.020	2.00
GC04-2 Carbonaceous Shale	53637	0.059	5.91	0.020	2.01	0.005	0.464
GC04-3 Shale and Sandstone mix	53638	0.141	14	0.007	0.705	0.031	3.10
GC04-4 Sandstone	53639	0.041	4.10	<0.001	<0.100	0.049	4.91
GC04-6 Sandstone	53640	0.028	2.82	0.003	0.264	0.005	0.485

Sample Id	Sample Number	Zn	Zn
		mg/l	mg/kg
Det Limit		<0.001	<0.100
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.010	0.952
GC01-4 Carbonaceous Shale & Sandstone	53622	0.585	58
GC01-5 Sandstone (roof of coal seam)	53623	0.410	41
GC01-6 Carbonaceous Sandstone	53624	0.108	11
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.100
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.100
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.283	28
GC02-6 Carbonaceous Shale	53628	0.010	1.04
GC02-7 Sandstone	53629	<0.001	<0.100
GC02-9 Sandstone (roof and floor of E seam)	53630	0.216	22
GC03-2 Siltstone/sandstone	53631	<0.001	<0.100
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.012	1.17
GC03-4 Carbonaceous Sandstone	53633	0.640	64
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.100
GC03-8 Carbonaceous Shale	53635	0.009	0.911
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.032	3.24
GC04-2 Carbonaceous Shale	53637	0.517	52
GC04-3 Shale and Sandstone mix	53638	1.07	107
GC04-4 Sandstone	53639	0.207	21
GC04-6 Sandstone	53640	0.067	6.69

[*] = Samples analysed on ICP-OES Instrument

WATERLAB

Date received: 30-01-19

Project number: 1000

Client name: ABS Africa (Pty) Ltd.

Address: PO Box 14003, Vorna Valley, 1686

Telephone: 011 805 0061

Analyses	GC01-2 Unweathered Sandstone (fair amount of silica)		GC01-4 Carbon Sand
Sample Number	53621		536
Digestion	HNO3 : HF		HNO3
Dry Mass Used (g)	0.25		0.2
Volume Used (mℓ)	100		10
Units	mg/ℓ	mg/kg	mg/ℓ
ICP-MS Quant			

Analyses	GC02-3 Sandstone (floor of B-lower)		GC02-5 Mix of sand clay (floor
Sample Number	53626		536
Digestion	HNO3 : HF		HNO3
Dry Mass Used (g)	0.25		0.2
Volume Used (mℓ)	100		10
Units	mg/ℓ	mg/kg	mg/ℓ
ICP-MS Quant			

Analyses	GC03-2 Siltstone/sandstone		GC03-3 Carbona sandsto
Sample Number	53631		536
Digestion	HNO3 : HF		HNO3
Dry Mass Used (g)	0.25		0.2
Volume Used (mℓ)	100		10
Units	mg/ℓ	mg/kg	mg/ℓ
ICP-MS Quant			

	GC03-10 Carbonaceous sand stone and	

Analyses	GC03-10 Carbonaceous sand stone and Shale mix		GC04-2 Carbon
Sample Number	53636		536
Digestion	HNO3 : HF		HNO3
Dry Mass Used (g)	0.25		0.2
Volume Used (mℓ)	100		10
Units	mg/ℓ	mg/kg	mg/ℓ
ICP-MS Quant			

E. Botha____________________

Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES

TOTALS

Date completed:

Report number: 80505

Order number:

Contact person:

Email:

Contact person:

Email:

aceous Shale & stone	GC01-5 Sandstone (roof of coal seam)		GC01-6 Carbonaceous Sandstone	
;22	53623		53624	
3 : HF	HNO3 : HF		HNO3 : HF	
25	0.25		0.25	
)0	100		100	
mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
	See ICP Digestion tab			

stone/siltstone and of C seam)	GC02-6 Carbonaceous Shale		GC02-7 Sandstone	
;27	53628		53629	
3 : HF	HNO3 : HF		HNO3 : HF	
25	0.25		0.25	
)0	100		100	
mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
	See ICP Digestion tab			

ceous Shale and)ne mix	GC03-4 Carbonaceous Sandstone		GC03-6 Sandstone & Shale mix	
;32	53633		53634	
3 : HF	HNO3 : HF		HNO3 : HF	
25	0.25		0.25	
)0	100		100	
mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
	See ICP Digestion tab			

ıaceous Shale	GC04-3 Shale and Sandstone mix		GC04-4 Sandstone	
;37	53638		53639	
3 : HF	HNO3 : HF		HNO3 : HF	
25	0.25		0.25	
)0	100		100	
mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
	See ICP Digestion tab			

12-03-19

Paul Furniss
paul@abs-africa.com
Rob van Hille
rob@mossgroup.co.za

GC02-2 Carbonaceous Clay (roof of B seam)	
53625	
HNO3 : HF	
0.25	
100	
mg/ℓ	mg/kg

GC02-9 Sandstone (roof and floor of E seam)	
53630	
HNO3 : HF	
0.25	
100	
mg/ℓ	mg/kg

GC03-8 Carbonaceous Shale	
53635	
HNO3 : HF	
0.25	
100	
mg/ℓ	mg/kg

GC04-6 Sandstone	
53640	
HNO3 : HF	
0.25	
100	
mg/ℓ	mg/kg

CERTIFICATE OF ANALYSES

ICP-MS QUANTITATIVE ANALYSIS

Date received:	30-01-19	Date completed:	12-03-19
Project number:	1000	Report number:	80505

Client name:	ABS Africa (Pty) Ltd.	Contact person:	Paul Furniss
Address:	PO Box 14003, Vorna Valley, 1686	Email:	paul@abs-africa.com
Telephone:	011 805 0061	Contact person:	Rob van Hille
		Email:	rob@mossgroup.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
HNO3 : HF	0.25	100	400

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.100	<40	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	117	46800	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	234	93600	0.001	0.400
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	147	58800	0.001	0.400
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	115	46000	0.002	0.800
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	149	59600	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	187	74800	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	262	104800	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	207	82800	0.001	0.400
GC02-7 Sandstone	53629	<0.001	<0.400	160	64000	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	88	35200	0.002	0.800
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	142	56800	0.005	2.00
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	92	36800	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	199	79600	0.001	0.400
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	209	83600	0.001	0.400
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	141	56400	0.001	0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	110	44000	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	194	77600	0.001	0.400
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	191	76400	0.001	0.400
GC04-4 Sandstone	53639	<0.001	<0.400	87	34800	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	48	19200	<0.001	<0.400

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	0.188	75	0.846	338
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	0.344	138	0.303	121
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	0.485	194	0.531	212
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	0.395	158	0.131	52
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	0.663	265	1.65	658
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	0.586	234	1.14	456
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	0.477	191	0.893	357
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	0.291	116	0.085	34
GC02-7 Sandstone	53629	<0.001	<0.400	0.183	73	1.22	488
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	0.303	121	0.501	200
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	0.645	258	0.470	188
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	0.107	43	0.009	3.60
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	0.403	161	0.286	114
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	<0.001	<0.400	0.975	390
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	<0.001	<0.400	0.487	195
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	<0.001	<0.400	0.064	26
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	<0.001	<0.400	0.096	38
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	<0.001	<0.400	0.120	48
GC04-4 Sandstone	53639	<0.001	<0.400	0.097	39	0.637	255
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	0.006	2.40

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<1	<400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.004	1.60	<0.001	<0.400	2	800
GC01-4 Carbonaceous Shale & Sandstone	53622	0.014	5.60	0.001	0.400	3	1200
GC01-5 Sandstone (roof of coal seam)	53623	0.007	2.80	<0.001	<0.400	3	1200
GC01-6 Carbonaceous Sandstone	53624	0.004	1.60	<0.001	<0.400	<1	<400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.012	4.80	0.001	0.400	30	12000
GC02-3 Sandstone (floor of B-lower)	53626	0.005	2.00	<0.001	<0.400	13	5200
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.010	4.00	<0.001	<0.400	<1	<400
GC02-6 Carbonaceous Shale	53628	0.017	6.80	<0.001	<0.400	3	1200
GC02-7 Sandstone	53629	0.005	2.00	<0.001	<0.400	16	6400
GC02-9 Sandstone (roof and floor of E seam)	53630	0.003	1.20	<0.001	<0.400	9	3600
GC03-2 Siltstone/sandstone	53631	0.007	2.80	<0.001	<0.400	201	80400
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.014	5.60	<0.001	<0.400	<1	<400
GC03-4 Carbonaceous Sandstone	53633	0.014	5.60	<0.001	<0.400	3	1200
GC03-6 Sandstone & Shale mix	53634	0.005	2.00	<0.001	<0.400	13	5200
GC03-8 Carbonaceous Shale	53635	0.015	6.00	0.002	0.800	6	2400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.004	1.60	<0.001	<0.400	3	1200
GC04-2 Carbonaceous Shale	53637	0.014	5.60	0.002	0.800	3	1200
GC04-3 Shale and Sandstone mix	53638	0.010	4.00	<0.001	<0.400	4	1600
GC04-4 Sandstone	53639	0.002	0.800	<0.001	<0.400	1	400
GC04-6 Sandstone	53640	0.002	0.800	<0.001	<0.400	<1	<400

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	0.014	5.60	0.003	1.20
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	0.032	13	0.009	3.60
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	0.017	6.80	0.008	3.20
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	0.015	6.00	0.003	1.20
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	0.007	2.80	0.004	1.60
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	0.009	3.60	0.005	2.00
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	0.036	14	0.002	0.800
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	0.009	3.60	0.010	4.00
GC02-7 Sandstone	53629	<0.001	<0.400	0.009	3.60	0.003	1.20
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	0.009	3.60	0.011	4.40
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	0.027	11	0.008	3.20
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	0.001	0.400	0.003	1.20
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	0.016	6.40	0.010	4.00
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	0.005	2.00	0.005	2.00
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	0.003	1.20	0.020	8.00
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	0.003	1.20	0.002	0.800
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	0.013	5.20	0.017	6.80
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	0.008	3.20	0.008	3.20
GC04-4 Sandstone	53639	<0.001	<0.400	0.014	5.60	0.004	1.60
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	0.002	0.800

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.332	133	0.001	0.400	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.344	138	0.003	1.20	0.017	6.80
GC01-5 Sandstone (roof of coal seam)	53623	0.385	154	0.002	0.800	0.005	2.00
GC01-6 Carbonaceous Sandstone	53624	0.469	188	0.001	0.400	0.004	1.60
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.207	83	0.001	0.400	0.012	4.80
GC02-3 Sandstone (floor of B-lower)	53626	0.270	108	0.003	1.20	0.003	1.20
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.232	93	0.002	0.800	0.006	2.40
GC02-6 Carbonaceous Shale	53628	0.206	82	<0.001	<0.400	0.017	6.80
GC02-7 Sandstone	53629	0.303	121	<0.001	<0.400	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	0.435	174	<0.001	<0.400	0.001	0.400
GC03-2 Siltstone/sandstone	53631	0.340	136	<0.001	<0.400	0.002	0.800
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.183	73	<0.001	<0.400	0.018	7.20
GC03-4 Carbonaceous Sandstone	53633	0.336	134	<0.001	<0.400	0.017	6.80
GC03-6 Sandstone & Shale mix	53634	0.258	103	<0.001	<0.400	0.006	2.40
GC03-8 Carbonaceous Shale	53635	0.232	93	0.001	0.400	0.029	12
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.450	180	<0.001	<0.400	0.007	2.80
GC04-2 Carbonaceous Shale	53637	0.234	94	<0.001	<0.400	0.027	11
GC04-3 Shale and Sandstone mix	53638	0.308	123	<0.001	<0.400	0.011	4.40
GC04-4 Sandstone	53639	0.450	180	<0.001	<0.400	0.001	0.400
GC04-6 Sandstone	53640	0.387	155	<0.001	<0.400	0.001	0.400

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.003	1.20	0.002	0.800	0.001	0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.005	2.00	0.003	1.20	0.001	0.400
GC01-5 Sandstone (roof of coal seam)	53623	0.003	1.20	0.001	0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	0.004	1.60	0.003	1.20	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.003	1.20	0.002	0.800	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	0.002	0.800	0.001	0.400	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.004	1.60	0.002	0.800	0.001	0.400
GC02-6 Carbonaceous Shale	53628	0.001	0.400	0.001	0.400	<0.001	<0.400
GC02-7 Sandstone	53629	0.002	0.800	0.001	0.400	0.001	0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	0.002	0.800	0.001	0.400	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	0.012	4.80	0.007	2.80	0.001	0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	<0.001	<0.400	<0.010	<4.00
GC03-4 Carbonaceous Sandstone	53633	0.002	0.800	0.001	0.400	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	0.001	0.400	0.001	0.400	0.001	0.400
GC03-8 Carbonaceous Shale	53635	0.001	0.400	0.001	0.400	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	0.002	0.800	0.001	0.400	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	0.001	0.400	0.001	0.400	<0.001	<0.400
GC04-4 Sandstone	53639	0.001	0.400	0.001	0.400	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<10	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	22	8800	0.015	6.00	0.002	0.800
GC01-4 Carbonaceous Shale & Sandstone	53622	49	19600	0.015	6.00	0.005	2.00
GC01-5 Sandstone (roof of coal seam)	53623	81	32400	0.020	8.00	0.002	0.800
GC01-6 Carbonaceous Sandstone	53624	55	22000	0.008	3.20	0.003	1.20
GC02-2 Carbonaceous Clay (roof of B seam)	53625	17	6800	0.041	16	0.002	0.800
GC02-3 Sandstone (floor of B-lower)	53626	40	16000	0.025	10	0.001	0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	16	6400	0.019	7.60	0.004	1.60
GC02-6 Carbonaceous Shale	53628	40	16000	0.010	4.00	0.001	0.400
GC02-7 Sandstone	53629	36	14400	0.025	10	0.002	0.800
GC02-9 Sandstone (roof and floor of E seam)	53630	50	20000	0.013	5.20	0.002	0.800
GC03-2 Siltstone/sandstone	53631	121	48400	0.024	9.60	0.007	2.80
GC03-3 Carbonaceous Shale and sandstone mix	53632	9	3600	0.006	2.40	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	70	28000	0.016	6.40	0.002	0.800
GC03-6 Sandstone & Shale mix	53634	40	16000	0.028	11	0.001	0.400
GC03-8 Carbonaceous Shale	53635	78	31200	0.030	12	0.001	0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	26	10400	0.005	2.00	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	72	28800	0.014	5.60	0.002	0.800
GC04-3 Shale and Sandstone mix	53638	35	14000	0.011	4.40	0.001	0.400
GC04-4 Sandstone	53639	42	16800	0.014	5.60	0.001	0.400
GC04-6 Sandstone	53640	19	7600	0.003	1.20	<0.001	<0.400

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.001	0.400	0.001	0.400	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	0.001	0.400	0.003	1.20	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.002	0.800	0.010	4.00	0.001	0.400
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.001	0.400	0.006	2.40	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	0.001	0.400	0.006	2.40	<0.001	<0.400
GC02-7 Sandstone	53629	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	0.006	2.40	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	0.008	3.20	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.001	0.400	0.008	3.20	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	0.001	0.400	0.024	9.60	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	0.001	0.400	0.015	6.00	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.001	0.400	0.017	6.80	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	0.001	0.400	0.014	5.60	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	0.022	8.80	<0.001	<0.400
GC04-4 Sandstone	53639	<0.001	<0.400	0.005	2.00	<0.001	<0.400
GC04-6 Sandstone	53640	0.001	0.400	0.007	2.80	<0.001	<0.400

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-7 Sandstone	53629	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	0.003	1.20	<0.001	<0.400	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-4 Sandstone	53639	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<200	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	75	30000	0.007	2.80	0.026	10
GC01-4 Carbonaceous Shale & Sandstone	53622	44	17600	0.012	4.80	0.300	120
GC01-5 Sandstone (roof of coal seam)	53623	53	21200	0.005	2.00	0.220	88
GC01-6 Carbonaceous Sandstone	53624	4.3	1714	0.006	2.40	0.132	53
GC02-2 Carbonaceous Clay (roof of B seam)	53625	10.3	4113	0.003	1.20	0.253	101
GC02-3 Sandstone (floor of B-lower)	53626	73	29200	0.003	1.20	0.096	38
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	52	20800	0.017	6.80	0.200	80
GC02-6 Carbonaceous Shale	53628	49	19600	0.004	1.60	0.170	68
GC02-7 Sandstone	53629	78	31200	0.004	1.60	0.059	24
GC02-9 Sandstone (roof and floor of E seam)	53630	32	12800	0.003	1.20	0.103	41
GC03-2 Siltstone/sandstone	53631	43	17200	0.013	5.20	0.120	48
GC03-3 Carbonaceous Shale and sandstone mix	53632	30	12000	0.001	0.400	0.222	89
GC03-4 Carbonaceous Sandstone	53633	46	18400	0.007	2.80	0.273	109
GC03-6 Sandstone & Shale mix	53634	66	26400	0.002	0.800	0.111	44
GC03-8 Carbonaceous Shale	53635	35	14000	0.002	0.800	0.138	55
GC03-10 Carbonaceous sand stone and Shale mix	53636	20	8000	0.001	0.400	0.018	7
GC04-2 Carbonaceous Shale	53637	38	15200	0.006	2.40	0.241	96
GC04-3 Shale and Sandstone mix	53638	51	20400	0.004	1.60	0.192	77
GC04-4 Sandstone	53639	50	20000	0.005	2.00	0.078	31
GC04-6 Sandstone	53640	12	4800	<0.001	<0.400	0.066	26

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400	<0.025	<10
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	3	1200	0.523	209
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	10	4000	0.633	253
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	6	2400	1.13	454
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	2	800	0.212	85
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	7	2800	0.184	74
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	10	4000	0.641	256
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	3	1200	0.226	90
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	9	3600	0.363	145
GC02-7 Sandstone	53629	<0.001	<0.400	9	3600	0.673	269
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	4	1600	0.499	200
GC03-2 Siltstone/sandstone	53631	0.001	0.400	19	7600	1.45	581
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	1	400	0.080	32
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	9	3600	1.11	442
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	10	4000	0.565	226
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	7	2800	1.86	745
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	3	1200	0.338	135
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	8	3200	1.81	722
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	6	2400	0.357	143
GC04-4 Sandstone	53639	<0.001	<0.400	2	800	0.520	208
GC04-6 Sandstone	53640	<0.001	<0.400	<1	<400	0.113	45

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.005	2.00	8	3200	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.002	0.800	1	400	0.004	1.60
GC01-5 Sandstone (roof of coal seam)	53623	0.004	1.60	2	800	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	0.009	3.60	<1	<400	0.004	1.60
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.001	0.400	<1	<400	0.007	2.80
GC02-3 Sandstone (floor of B-lower)	53626	0.003	1.20	2	800	0.001	0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.002	0.800	2	800	0.006	2.40
GC02-6 Carbonaceous Shale	53628	0.001	0.400	2	800	0.009	3.60
GC02-7 Sandstone	53629	0.004	1.60	12	4800	0.003	1.20
GC02-9 Sandstone (roof and floor of E seam)	53630	0.009	3.60	1	400	0.002	0.800
GC03-2 Siltstone/sandstone	53631	0.001	0.400	3	1200	0.001	0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.002	0.800	1	400	0.013	5.20
GC03-4 Carbonaceous Sandstone	53633	0.003	1.20	2	800	0.007	2.80
GC03-6 Sandstone & Shale mix	53634	0.004	1.60	2	800	0.009	3.60
GC03-8 Carbonaceous Shale	53635	0.001	0.400	5	2000	0.011	4.40
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.014	5.60	2	800	0.010	4.00
GC04-2 Carbonaceous Shale	53637	0.001	0.400	2	800	0.011	4.40
GC04-3 Shale and Sandstone mix	53638	0.003	1.20	2	800	0.010	4.00
GC04-4 Sandstone	53639	0.008	3.20	2	800	0.002	0.800
GC04-6 Sandstone	53640	0.015	6.00	<1	<400	0.004	1.60

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.008	3.20	0.004	1.60	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	0.015	6.00	0.018	7.20	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	0.006	2.40	0.017	6.80	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	0.005	2.00	0.019	7.60	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.004	1.60	0.022	8.80	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	0.005	2.00	0.008	3.20	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.021	8.40	0.007	2.80	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	0.004	1.60	0.024	9.60	<0.001	<0.400
GC02-7 Sandstone	53629	0.006	2.40	0.007	2.80	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	0.004	1.60	0.016	6.40	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	0.014	5.60	0.014	5.60	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.001	0.400	0.014	5.60	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.007	2.80	0.020	8.00	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	0.003	1.20	0.009	3.60	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	0.002	0.800	0.033	13	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.001	0.400	0.008	3.20	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	0.006	2.40	0.028	11	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	0.003	1.20	0.035	14	<0.001	<0.400
GC04-4 Sandstone	53639	0.005	2.00	0.007	2.80	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	0.008	3.20	<0.001	<0.400

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	2.23	892	0.071	28	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	2.19	877	0.016	6.40	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	2.44	978	<0.001	<0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	2.01	802	<0.001	<0.400	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	1.50	600	<0.001	<0.400	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	2.33	934	0.041	16	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	1.72	688	<0.001	<0.400	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	2.67	1068	0.068	27	<0.001	<0.400
GC02-7 Sandstone	53629	2.17	866	0.075	30	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	2.59	1036	0.067	27	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	5.85	2339	0.054	22	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	1.57	630	0.019	7.60	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	3.33	1332	0.077	31	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	2.22	886	0.076	30	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	2.36	942	0.100	40	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	1.90	759	0.028	11	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	2.14	855	0.071	28	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	2.22	887	0.069	28	<0.001	<0.400
GC04-4 Sandstone	53639	2.61	1042	0.060	24	<0.001	<0.400
GC04-6 Sandstone	53640	2.43	972	0.031	12	<0.001	<0.400

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.002	0.800	<0.001	<0.400	0.047	19
GC01-4 Carbonaceous Shale & Sandstone	53622	0.004	1.60	<0.001	<0.400	0.027	11
GC01-5 Sandstone (roof of coal seam)	53623	0.002	0.800	<0.001	<0.400	0.045	18
GC01-6 Carbonaceous Sandstone	53624	0.001	0.400	<0.001	<0.400	0.010	4.00
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.001	0.400	<0.001	<0.400	0.002	0.800
GC02-3 Sandstone (floor of B-lower)	53626	0.001	0.400	<0.001	<0.400	0.036	14
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.005	2.00	<0.001	<0.400	0.035	14
GC02-6 Carbonaceous Shale	53628	0.001	0.400	<0.001	<0.400	0.002	0.800
GC02-7 Sandstone	53629	0.002	0.800	<0.001	<0.400	0.039	16
GC02-9 Sandstone (roof and floor of E seam)	53630	0.001	0.400	<0.001	<0.400	0.015	6.00
GC03-2 Siltstone/sandstone	53631	0.003	1.20	<0.001	<0.400	0.020	8.00
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.002	0.800	<0.001	<0.400	0.006	2.40
GC03-6 Sandstone & Shale mix	53634	0.001	0.400	<0.001	<0.400	0.027	11
GC03-8 Carbonaceous Shale	53635	0.001	0.400	<0.001	<0.400	0.004	1.60
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	<0.001	<0.400	0.009	3.60
GC04-2 Carbonaceous Shale	53637	0.002	0.800	<0.001	<0.400	0.012	4.80
GC04-3 Shale and Sandstone mix	53638	0.001	0.400	<0.001	<0.400	0.015	6.00
GC04-4 Sandstone	53639	0.001	0.400	<0.001	<0.400	0.044	18
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	0.005	2.00

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-7 Sandstone	53629	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-4 Sandstone	53639	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.2	<80
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.017	6.80	<0.001	<0.400	918	367200
GC01-4 Carbonaceous Shale & Sandstone	53622	0.033	13	<0.001	<0.400	586	234400
GC01-5 Sandstone (roof of coal seam)	53623	0.017	6.80	<0.001	<0.400	834	333600
GC01-6 Carbonaceous Sandstone	53624	0.018	7.20	<0.001	<0.400	880	352000
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.026	10	<0.001	<0.400	382	152800
GC02-3 Sandstone (floor of B-lower)	53626	0.019	7.60	<0.001	<0.400	794	317600
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.030	12	<0.001	<0.400	704	281600
GC02-6 Carbonaceous Shale	53628	0.022	8.80	<0.001	<0.400	587	234800
GC02-7 Sandstone	53629	0.022	8.80	<0.001	<0.400	838	335200
GC02-9 Sandstone (roof and floor of E seam)	53630	0.014	5.60	<0.001	<0.400	945	378000
GC03-2 Siltstone/sandstone	53631	0.032	13	<0.001	<0.400	544	217600
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.009	3.60	<0.001	<0.400	568	227200
GC03-4 Carbonaceous Sandstone	53633	0.025	10	<0.001	<0.400	612	244800
GC03-6 Sandstone & Shale mix	53634	0.024	9.60	<0.001	<0.400	747	298800
GC03-8 Carbonaceous Shale	53635	0.019	7.60	<0.001	<0.400	527	210800
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.009	3.60	<0.001	<0.400	929	371600
GC04-2 Carbonaceous Shale	53637	0.029	12	<0.001	<0.400	503	201200
GC04-3 Shale and Sandstone mix	53638	0.024	9.60	<0.001	<0.400	637	254800
GC04-4 Sandstone	53639	0.011	4.40	<0.001	<0.400	963	385200
GC04-6 Sandstone	53640	0.006	2.40	<0.001	<0.400	974	389600

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.002	0.800	0.001	0.400	0.036	14
GC01-4 Carbonaceous Shale & Sandstone	53622	0.004	1.60	0.003	1.20	0.030	12
GC01-5 Sandstone (roof of coal seam)	53623	0.002	0.800	0.001	0.400	0.058	23
GC01-6 Carbonaceous Sandstone	53624	0.001	0.400	0.001	0.400	0.012	4.80
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.001	0.400	0.005	2.00	0.180	72
GC02-3 Sandstone (floor of B-lower)	53626	0.001	0.400	0.002	0.800	0.096	38
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.005	2.00	0.005	2.00	0.031	12
GC02-6 Carbonaceous Shale	53628	0.001	0.400	0.004	1.60	0.009	3.60
GC02-7 Sandstone	53629	0.002	0.800	0.002	0.800	0.074	30
GC02-9 Sandstone (roof and floor of E seam)	53630	0.001	0.400	0.001	0.400	0.057	23
GC03-2 Siltstone/sandstone	53631	0.004	1.60	<0.001	<0.400	0.101	40
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	0.006	2.40	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.002	0.800	0.003	1.20	0.079	32
GC03-6 Sandstone & Shale mix	53634	0.001	0.400	0.004	1.60	0.046	18
GC03-8 Carbonaceous Shale	53635	0.001	0.400	0.004	1.60	0.094	38
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	0.003	1.20	0.011	4.40
GC04-2 Carbonaceous Shale	53637	0.001	0.400	0.004	1.60	0.013	5.20
GC04-3 Shale and Sandstone mix	53638	0.001	0.400	0.008	3.20	0.005	2.00
GC04-4 Sandstone	53639	0.001	0.400	0.001	0.400	0.034	14
GC04-6 Sandstone	53640	<0.001	<0.400	0.001	0.400	<0.001	<0.400

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	0.001	0.400	<0.001	<0.400
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	0.001	0.400	<0.001	<0.400
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC02-7 Sandstone	53629	<0.001	<0.400	0.001	0.400	<0.001	<0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-2 Siltstone/sandstone	53631	<0.001	<0.400	0.001	0.400	<0.001	<0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC03-6 Sandstone & Shale mix	53634	0.003	1.20	0.001	0.400	<0.001	<0.400
GC03-8 Carbonaceous Shale	53635	0.003	1.20	<0.001	<0.400	<0.001	<0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.001	0.400	<0.001	<0.400	<0.001	<0.400
GC04-2 Carbonaceous Shale	53637	0.003	1.20	<0.001	<0.400	<0.001	<0.400
GC04-3 Shale and Sandstone mix	53638	0.003	1.20	<0.001	<0.400	<0.001	<0.400
GC04-4 Sandstone	53639	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC04-6 Sandstone	53640	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.006	2.40	6.30	2520	0.002	0.800
GC01-4 Carbonaceous Shale & Sandstone	53622	0.048	19	12	4800	0.002	0.800
GC01-5 Sandstone (roof of coal seam)	53623	0.018	7.20	7.66	3066	0.003	1.20
GC01-6 Carbonaceous Sandstone	53624	0.018	7.20	11	4400	0.003	1.20
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.017	6.80	10	4000	0.001	0.400
GC02-3 Sandstone (floor of B-lower)	53626	0.010	4.00	9.74	3896	0.002	0.800
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.024	9.60	14	5612	0.001	0.400
GC02-6 Carbonaceous Shale	53628	0.008	3.20	13	5002	0.001	0.400
GC02-7 Sandstone	53629	<0.001	<0.400	7.23	2892	0.001	0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	5.88	2351	0.002	0.800
GC03-2 Siltstone/sandstone	53631	0.004	1.60	8.41	3364	0.001	0.400
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	13	5200	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.020	8.00	13	5200	0.001	0.400
GC03-6 Sandstone & Shale mix	53634	0.011	4.40	11	4400	0.001	0.400
GC03-8 Carbonaceous Shale	53635	0.020	8.00	14	5600	0.002	0.800
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.007	2.80	9.71	3884	0.001	0.400
GC04-2 Carbonaceous Shale	53637	0.034	14	13	5200	0.002	0.800
GC04-3 Shale and Sandstone mix	53638	0.019	7.60	14	5600	0.003	1.20
GC04-4 Sandstone	53639	0.007	2.80	3.73	1492	0.002	0.800
GC04-6 Sandstone	53640	0.002	0.800	3.54	1414	0.001	0.400

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	<0.001	<0.400	0.004	1.60	0.072	29
GC01-4 Carbonaceous Shale & Sandstone	53622	<0.001	<0.400	0.024	9.60	0.283	113
GC01-5 Sandstone (roof of coal seam)	53623	<0.001	<0.400	0.009	3.60	0.137	55
GC01-6 Carbonaceous Sandstone	53624	<0.001	<0.400	0.009	3.60	0.103	41
GC02-2 Carbonaceous Clay (roof of B seam)	53625	<0.001	<0.400	0.025	10	0.131	52
GC02-3 Sandstone (floor of B-lower)	53626	<0.001	<0.400	0.007	2.80	0.098	39
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	<0.001	<0.400	0.013	5.20	0.156	62
GC02-6 Carbonaceous Shale	53628	<0.001	<0.400	0.015	6.00	0.253	101
GC02-7 Sandstone	53629	<0.001	<0.400	0.004	1.60	0.114	46
GC02-9 Sandstone (roof and floor of E seam)	53630	<0.001	<0.400	0.005	2.00	0.090	36
GC03-2 Siltstone/sandstone	53631	0.001	0.400	0.008	3.20	0.128	51
GC03-3 Carbonaceous Shale and sandstone mix	53632	<0.001	<0.400	0.014	5.60	0.280	112
GC03-4 Carbonaceous Sandstone	53633	<0.001	<0.400	0.015	6.00	0.262	105
GC03-6 Sandstone & Shale mix	53634	<0.001	<0.400	0.008	3.20	0.126	50
GC03-8 Carbonaceous Shale	53635	<0.001	<0.400	0.017	6.80	0.318	127
GC03-10 Carbonaceous sand stone and Shale mix	53636	<0.001	<0.400	0.007	2.80	0.119	48
GC04-2 Carbonaceous Shale	53637	<0.001	<0.400	0.022	8.80	0.289	116
GC04-3 Shale and Sandstone mix	53638	<0.001	<0.400	0.012	4.80	0.273	109
GC04-4 Sandstone	53639	<0.001	<0.400	0.005	2.00	0.078	31
GC04-6 Sandstone	53640	<0.001	<0.400	0.003	1.20	0.045	18

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.002	0.800	0.002	0.800	0.002	0.800
GC01-4 Carbonaceous Shale & Sandstone	53622	0.004	1.60	0.004	1.60	0.002	0.800
GC01-5 Sandstone (roof of coal seam)	53623	0.001	0.400	0.002	0.800	0.002	0.800
GC01-6 Carbonaceous Sandstone	53624	0.003	1.20	0.006	2.40	0.003	1.20
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.002	0.800	0.005	2.00	0.003	1.20
GC02-3 Sandstone (floor of B-lower)	53626	0.001	0.400	0.001	0.400	0.001	0.400
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.002	0.800	0.004	1.60	0.002	0.800
GC02-6 Carbonaceous Shale	53628	0.005	2.00	0.001	0.400	0.001	0.400
GC02-7 Sandstone	53629	0.003	1.20	0.001	0.400	0.001	0.400
GC02-9 Sandstone (roof and floor of E seam)	53630	0.003	1.20	0.002	0.800	0.001	0.400
GC03-2 Siltstone/sandstone	53631	0.003	1.20	0.007	2.80	0.007	2.80
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.005	2.00	<0.001	<0.400	<0.001	<0.400
GC03-4 Carbonaceous Sandstone	53633	0.005	2.00	0.002	0.800	0.001	0.400
GC03-6 Sandstone & Shale mix	53634	0.005	2.00	0.001	0.400	0.001	0.400
GC03-8 Carbonaceous Shale	53635	0.006	2.40	0.001	0.400	0.001	0.400
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.005	2.00	0.001	0.400	0.000	0.000
GC04-2 Carbonaceous Shale	53637	0.006	2.40	0.002	0.800	0.001	0.400
GC04-3 Shale and Sandstone mix	53638	0.005	2.00	0.001	0.400	0.001	0.400
GC04-4 Sandstone	53639	0.003	1.20	0.002	0.800	0.001	0.400
GC04-6 Sandstone	53640	0.003	1.20	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
GC01-2 Unweathered Sandstone (fair amount of silica)	53621	0.003	1.20	0.034	14
GC01-4 Carbonaceous Shale & Sandstone	53622	0.049	20	0.094	38
GC01-5 Sandstone (roof of coal seam)	53623	0.029	12	0.041	16
GC01-6 Carbonaceous Sandstone	53624	0.003	1.20	0.116	46
GC02-2 Carbonaceous Clay (roof of B seam)	53625	0.015	6.00	0.230	92
GC02-3 Sandstone (floor of B-lower)	53626	0.027	11	0.049	20
GC02-5 Mix of sandstone/siltstone and clay (floor of C seam)	53627	0.034	14	0.114	46
GC02-6 Carbonaceous Shale	53628	0.050	20	0.103	41
GC02-7 Sandstone	53629	0.012	4.80	0.033	13
GC02-9 Sandstone (roof and floor of E seam)	53630	0.013	5.20	0.031	12
GC03-2 Siltstone/sandstone	53631	0.017	6.80	0.036	14
GC03-3 Carbonaceous Shale and sandstone mix	53632	0.039	16	0.153	61
GC03-4 Carbonaceous Sandstone	53633	0.054	22	0.093	37
GC03-6 Sandstone & Shale mix	53634	0.034	14	0.101	40
GC03-8 Carbonaceous Shale	53635	0.066	26	0.100	40
GC03-10 Carbonaceous sand stone and Shale mix	53636	0.006	2.40	0.153	61
GC04-2 Carbonaceous Shale	53637	0.059	24	0.094	38
GC04-3 Shale and Sandstone mix	53638	0.059	24	0.124	50
GC04-4 Sandstone	53639	0.010	4.00	0.023	9.20
GC04-6 Sandstone	53640	<0.001	<0.400	0.072	29

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-16
Project number: 1000
Report number: 80069
Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061

Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5				
	Ant 3 (2) 51.74 18/12/18 (0,306)	Ant 110 (1) ESEAM 51.57 18/12/18 (0,582)	Ant 100 (4) ESEAM 51.57 18/12/18 (0,876)	Ant 105 (1) BSEAM 51.72 18/12/18 (1,012)	Ant 185 (1) ESEAM 51,56 18/12/18 (0,832)
Sample Number	**52256**	**52257**	**52258**	**52259**	**52260**
NAG pH: (H_2O_2)	2.7	2.7	2.8	2.6	5.5
NAG (kg H_2SO_4 / t)	81	79	81	70	<0.01

Net Acid Generation	Sample Identification: pH 7				
	Ant 3 (2) 51.74 18/12/18 (0,306)	Ant 110 (1) ESEAM 51.57 18/12/18 (0,582)	Ant 100 (4) ESEAM 51.57 18/12/18 (0,876)	Ant 105 (1) BSEAM 51.72 18/12/18 (1,012)	Ant 185 (1) ESEAM 51,56 18/12/18 (0,832)
Sample Number	**52256**	**52257**	**52258**	**52259**	**52260**
NAG pH: (H_2O_2)	4.5	4.5	4.5	4.5	5.5
NAG (kg H_2SO_4 / t)	54	59	57	49	1.37

Notes:

- Samples analysed with Single Addition NAG test as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1.
- Please let me know if results do not correspond to other data.

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-16
Project number: 1000

Report number: 80069

Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061

Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5	
	Ant 105 (3) CU 51,47 18/12/18 (0,856)	Ant 105 (3) CU 51,47 18/12/18 (0,856)
Sample Number	**52261**	**52261 D**
NAG pH: (H_2O_2)	2.6	2.6
NAG (kg H_2SO_4 / t)	53	54

Net Acid Generation	Sample Identification: pH 7	
	Ant 105 (3) CU 51,47 18/12/18 (0,856)	Ant 105 (3) CU 51,47 18/12/18 (0,856)
Sample Number	**52261**	**52261 D**
NAG pH: (H_2O_2)	4.5	4.5
NAG (kg H_2SO_4 / t)	40	39

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-30
Project number: 1000

Report number: 80505

Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061

Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5				
	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)
Sample Number	**53621**	**53622**	**53623**	**53624**	**53625**
NAG pH: (H_2O_2)	6.1	4.3	2.7	2.2	7.6
NAG (kg H_2SO_4 / t)	<0.01	0.196	8.23	43	<0.01

Net Acid Generation	Sample Identification: pH 7				
	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)
Sample Number	**53621**	**53622**	**53623**	**53624**	**53625**
NAG pH: (H_2O_2)	6.1	4.5	4.5	4.5	7.6
NAG (kg H_2SO_4 / t)	<0.01	10	5.49	6.86	<0.01

Notes:
- Samples analysed with Single Addition NAG test as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1.
- Please let me know if results do not correspond to other data.

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-30
Project number: 1000
Report number: 80505
Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061
Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5				
	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	GC02-7 Sandstone
Sample Number	**53626**	**53627**	**53628**	**53629**	**53629 D**
NAG pH: (H_2O_2)	8.0	4.9	5.9	8.3	8.1
NAG (kg H_2SO_4 / t)	<0.01	<0.01	<0.01	<0.01	<0.01

Net Acid Generation	Sample Identification: pH 7				
	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	GC02-7 Sandstone
Sample Number	**53626**	**53627**	**53628**	**53629**	**53629 D**
NAG pH: (H_2O_2)	8.0	4.9	5.9	8.3	8.1
NAG (kg H_2SO_4 / t)	<0.01	1.96	0.392	<0.01	<0.01

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-30
Project number: 1000

Report number: 80505

Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061

Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5				
	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
Sample Number	**53630**	**53631**	**53632**	**53633**	**53634**
NAG pH: (H_2O_2)	2.5	9.7	6.1	3.6	6.9
NAG (kg H_2SO_4 / t)	18	<0.01	<0.01	1.96	<0.01

Net Acid Generation	Sample Identification: pH 7				
	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
Sample Number	**53630**	**53631**	**53632**	**53633**	**53634**
NAG pH: (H_2O_2)	4.5	9.7	6.1	4.5	6.9
NAG (kg H_2SO_4 / t)	7.25	<0.01	0.392	13.92	<0.01

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-30
Project number: 1000
Report number: 80505
Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061

Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5				
	GC03-8 Carbonaceous Shale	**GC03-10 Carbonaceous sand stone and Shale mix**	**GC04-2 Carbonaceous Shale**	**GC04-3 Shale and Sandstone mix**	**GC04-3 Shale and Sandstone mix**
Sample Number	**53635**	**53636**	**53637**	**53638**	**53638 D**
NAG pH: (H_2O_2)	6.2	4.5	4.6	3.0	3.0
NAG (kg H_2SO_4 / t)	<0.01	<0.01	<0.01	3.92	4.12

Net Acid Generation	Sample Identification: pH 7				
	GC03-8 Carbonaceous Shale	**GC03-10 Carbonaceous sand stone and Shale mix**	**GC04-2 Carbonaceous Shale**	**GC04-3 Shale and Sandstone mix**	**GC04-3 Shale and Sandstone mix**
Sample Number	**53635**	**53636**	**53637**	**53638**	**53638 D**
NAG pH: (H_2O_2)	6.2	4.5	4.6	4.5	4.5
NAG (kg H_2SO_4 / t)	0.392	1.76	8.43	11	11

S. Laubscher
Assistant Geochemistry Project Manager

WATERLAB (PTY) LTD

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

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

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-01-30
Project number: 1000 **Report number: 80505**
Date completed: 2019-03-18
Order number:

Client name: ABS Africa (Pty) Ltd.
Address: PO Box 14003, Vorna Valley, 1686
Telephone: 011 805 0061
Contact person: Paul Furniss
Email: paul@abs-africa.com
Contact person: Rob van Hille
Email: rob@mossgroup.co.za

Net Acid Generation	Sample Identification: pH 4.5	
	GC04-4 Sandstone	GC04-6 Sandstone
Sample Number	**53639**	**53640**
NAG pH: (H_2O_2)	3.0	2.5
NAG (kg H_2SO_4 / t)	3.14	14

Net Acid Generation	Sample Identification: pH 7	
	GC04-4 Sandstone	GC04-6 Sandstone
Sample Number	**53639**	**53640**
NAG pH: (H_2O_2)	4.5	4.5
NAG (kg H_2SO_4 / t)	1.76	4.51

S. Laubscher
Assistant Geochemistry Project Manager

GEOHYDROLOGICAL IMPACT PREDICTION REPORT FOR THE PROPOSED KRANSPAN COLLIERY

FINAL REPORT

iLEH
3 Herbert Baker St
Sharon Park
1496

PO Box 343
Dunnottar
1590

e: irene@ileh.co.za
c: 083 447 8377
t: 011 363 2926
f: 086 672 9900

Report No iLEH-ABS ILI 10-18

MAY 2019

PROJECT DETAILS

PROJECT:	**GEOHYDROLOGICAL IMPACT PREDICTION REPORT FOR THE PROPOSED KRANSPAN COLLIERY**
Report Title:	Geohydrological Impact Prediction Report for the proposed Kranspan Colliery
Client:	ABS Africa
Client Contact	Paul Furniss
Project Number	ILEH-ABS ILI 10-18
Date Submitted	9 May 2019
Author	Irene Lea (M. Sc. *Pri. Sci. Nat*)

INDEMNITY AND CONDITIONS RELATING TO THIS REPORT

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on assessment techniques, which are limited by information available, time and budgetary constraints relevant to the type and level of investigation undertaken, and Irene Lea Environmental and Hydrogeology cc reserve the right to modify aspects of the report including the recommendations if and when new information may become available from on-going research, monitoring and further work in this field pertaining to the investigation.

Although Irene Lea Environmental and Hydrogeology cc exercises due care and diligence in rendering services and preparing documents, Irene Lea Environmental and Hydrogeology cc accepts no liability, and the client, by receiving this document, indemnified Irene Lea Environmental and Hydrogeology cc against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with the services rendered, directly or indirectly by Irene Lea Environmental and Hydrogeology cc and by the use of the information contained in this document.

This report must not be altered or added to without the prior written consent of the author.

Irene Lea M.Sc. Pr. Sci. Nat

9 May 2019

EXECUTIVE SUMMARY

A geohydrological specialist study was completed for the proposed Ilima Kranspan project with the objective of evaluating the risks to groundwater availability and quality associated with the proposed mining activities. The project will entail opencast and underground coal mining of the E Seam in the Ermelo Coal Field. The coal will be washed and processed on site. Discard generated at the plant may either be backfilled to mined-out opencast pits or be placed on surface on a discard stockpile. The impact of both of these discard management measures was assessed as part of the specialist study, the details of which are discussed below.

In order to complete the geohydrological specialist study, eight pairs of shallow and deep monitoring boreholes were drilled and tested to obtain information to characterise the aquifer present. The borehole locations were determined with the aid of surface geophysical methods. Two northeast-southwest striking lineaments transect the proposed mining area. One of these lineaments is located underneath the largest pan present on site. The geophysical surface was used to pinpoint the locations of these and monitoring boreholes were used to characterise aquifer conditions associated with the lineaments. The results indicate that the lineaments have enhanced aquifer characteristics and will act as preferential flow paths to groundwater. Groundwater samples were taken from the monitoring boreholes for chemical analysis to establish ambient groundwater quality conditions.

The information obtained from the monitoring boreholes indicates that there are two aquifers present, namely a shallow weathered aquifer that extends to a depth of 10m and a deeper fractured rock aquifer.

The average depth to groundwater in the weathered aquifer is 4m. In low-lying areas, the groundwater table is however shallower and springs occur in the area. The aquifer is not considered significant in terms of water supply due to its limited thickness. It does however play an important role in terms of the recharge of rainwater and baseflow to streams and pans, especially during the dry season.

The weathered aquifer is underlain by a deeper fractured rock aquifer. The fractured rock aquifer is most prominent along the two lineaments identified, which have higher permeabilities compared to the unfractured rocks. The average depth to groundwater in the fractured rock aquifer is 9,7m.

A hydrocensus of private groundwater use was also completed as part of the study. A total of 26 private boreholes and springs were identified during the hydrocensus. Groundwater level measurements could be taken in 7 of these boreholes. Seven groundwater samples were furthermore taken from selected hydrocensus boreholes for chemical analysis and to establish baseline conditions. The weathered aquifer is not isolated from the fractured rock aquifer and aquifer tests confirmed that there is interaction between the two aquifers.

Groundwater flow patterns that were established from the data obtained from the monitoring and hydrocensus boreholes indicate that groundwater flow is mainly towards the largest of the pans present on site. Local variations in groundwater flow occur and groundwater also flows towards the smaller pans.

The results of the chemical analysis of groundwater samples taken from the monitoring and private boreholes indicate that groundwater quality is generally good and complies with South African drinking water standards. The dominant cations are sodium and potassium and the dominant anions are bicarbonate and to a lesser extent chloride. The groundwater is however naturally hard, which can result in scaling and has a so-called “soap destroying” nature. Elevated concentrations of iron and aluminium and to a lesser extent of fluoride were also recorded. At the concentrations recorded, staining in plumbing may be expected. Groundwater with elevated iron concentrations may also result in adverse health effects in young children and sensitive individuals and may promote the proliferation of iron-oxidizing bacteria, which may manifest as slimy coatings in plumbing.

The geohydrological impact assessment was completed with the aid of a numerical groundwater flow and contaminant transport model, which was calibrated with data obtained from the monitoring and private boreholes. In order to ensure that boundary conditions do not affect the outcome of the assessment, a modelled area was created that is much larger than the project site, covering an area of 270 km^2. The results of model calibration indicate that the calibration criteria set for the project were met. The model is therefore considered suitable to complete the impact assessment with the available dataset. The outcome of the assessment indicates that the model is sensitive to large fluctuations in the rate of recharge to the aquifers as well as to the storage coefficient and specific yield of the aquifers. Model calibration and confidence levels can be improved once additional monitoring information becomes available from the site. Model verification should therefore be undertaken once mining starts and the groundwater monitoring programme results are available.

The calibrated model was used to complete the impact assessment for the project. During simulations, the opencast and underground mine plans made available by Ilima was incorporated into the model. Opencast mining will be completed over a period of 14 years and underground mining over 12 years. The impact of mining on wetlands was a specific focus during the assessment. The extent of the wetlands and associated buffer zones as identified as part of the Scoping Phase of this project were used during the assessment.

Based on the outcome of provisional geochemical tests completed on waste rock and discard material sourced from the project site, the main source of contamination associated with the site is leachate from the discard. The study indicates that the waste rock samples poses a low environmental risk with only one out of twenty samples pointing to acidification of water in the long-term. The discard material on the other hand has a high probability of becoming acid generating if stored in a surface discard dump for a significant amount of time. There is however a level of uncertainty regarding the magnitude of the acid generating potential from the provisional geochemical tests. Greater clarity is expected once more sophisticated kinetic tests are completed. These are currently underway. The geochemical study confirms that sulphate is an indicator element associated with the project. Increased sulphate concentrations result from the oxidation of pyrite and other sulphide minerals in the coal, overburden and discard material. In the absence of the results of the kinetic tests, medium and long-term sulphate concentrations were inferred from literature-based values during the assessment.

The impact assessments associated with discard management included three alternative disposal options. The first and preferred option is the placement of discard into mined-out pits. The second was placing the discard on surface on an unlined stockpile. The third option evaluated was to assess the impact of lining the discard stockpile with a Class C liner. It is noted that the final liner design will be determined by the professional engineer who will design the facility. During simulations, the rate of recharge to un-rehabilitated and rehabilitated mining areas was varied, according to rates described in literature.

The results of the impact assessment are summarised as follows:

- **Impact on groundwater availability during the construction and operational phases of mining:**
    - The rate of groundwater seepage during the construction and operational phases of mining was calculated. Due to the anticipated heterogeneous nature of the fractured rock aquifer, a range of seepage rates is provided. Under average conditions, the total volume of groundwater seepage to the box cut and adit may be around 125m^3/d during the construction phase. It is further recommended that provision is made for 18 000 m^3 of groundwater per year in the pollution control dam that will be constructed during this phase of mining. During the operational phase of mining,

groundwater seepage rates may vary according to many factors that influence the seepage rate. On average, the total volume of groundwater seepage may vary between 100 and 340 m^3/d. Maximum flow rates are expected during Year 10 due to the depth and extent of mining at this stage. It is further recommended that provision is made for a total of 50 400 m^3/a of groundwater in all the pollution control dams. This is equivalent to 8 400 m^3/a for each of the six planned dams.

- It is anticipated that mining activities will have a negative impact on groundwater availability in private boreholes and springs. The following boreholes and springs, only one of which is currently in use (KR_Spring5), will in all likelihood be destroyed during mining:

BH ID	Owner	Current use
KR5	Jaco Papenfus	Open hole not in use
KR6	Jaco Papenfus	Open hole not in use
KR7	Jaco Papenfus	Submersible pump (not operational): supply to house and animals
KR8	Jaco Papenfus	Windpump not in use
KR_Spring5	Koos Jordaan	Fenced in: supply to animals

- In addition to the boreholes that may be destroyed, groundwater levels may also be lowered in private boreholes as a result of mine dewatering. Even though the boreholes and spring listed above will be destroyed, they are included in the assessment presented below for comparison. The impact of mine dewatering on private boreholes is listed below. It is noted that groundwater is one of the only water resources available to farmers in the area. Whether or not the estimated lowering in groundwater levels will have a negative impact on current groundwater use will depend on the depth and construction of the boreholes. This information is not available for the private boreholes. It is however likely that boreholes in which groundwater levels are lowered by more than 10m will be lost Two boreholes (KR7 and KR8) could be lost in this regard. Neither of these were recorded to be in use during the hydrocensus:

Affected BH	Owner Current Use	Current abstraction volume (l/hr)	Anticipated lowering in groundwater level (m)	Timing of impact (year of mining)
KR3	Rudi Prinsloo Windpump: supply to animals	Not available	<2	Year 3 – 5
KR4	Rudi Prinsloo Open borehole: not in use	Not available	<2	Year 3 – 5
KR5	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 – 11
KR6	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 - 11
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	Not available	<25	Year 1 - 14
KR8	Jaco Papenfus Windpump: not in use	Not available	<25	Year 1 - 14
KR10	Gysbert Klein Windpump: supply to animals	Not available	<5	Year 10 - 14
KR11	Rudi Prinsloo Windpump: supply to house and animals	Not available	<5	Year 1 – 5
KR12	Koos Jordaan Submersible pump: supply to house and animals	Not available	<2	Year 14

- **Impact on groundwater quality during the construction and operational phases of mining:**
  - Under average conditions and based on the results of preliminary geochemical analyses, modelling suggests that sulphate concentrations may increase to above 150 mg/l within the mining area during the operational phase. This assessment excludes the placing of discard in pits or on surface. The contamination is not expected to move significant distances from the mining areas due to the impact of mine dewatering and the reversal of groundwater flow towards the mining areas during the operational phase.
  - The most significant impact on private boreholes is expected to occur in the vicinity of KR7 and KR8, which are situated near the proposed plant. The increase in sulphate concentrations is however not expected to pose a health or aesthetic risk.
- **Long-term impacts on groundwater - rate of groundwater level recovery:**
  - Regional groundwater levels are expected to take 30 – 50 years to recover around the mining areas after mining and mine dewatering ceases.
- **Long-term impacts on groundwater - risk of decant:**
  - The risk of decant depends on several factors, which are discussed in more detail in this report. The main factor that controls the risk of decant is the rate of recharge of rainwater to the disturbed areas. It is unlikely that the opencast mining areas could be rehabilitated to natural recharge conditions and for this reason, decant is likely from all the pits. The most likely decant point at each pit is associated with the lowest topographical elevation and a total of 20 possible decant locations are listed below for the thirteen planned pits. The locations of the decant points are indicated on a map presented in this report. 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 suitable for discharge to the environment. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

Decant No	Pit	Decant elevation (mamsl)	Time to possible decant (yrs)	Possible decant volume (m^3/a)
1	Pit 1	1659	26	21873
2		1672		
3		1656		
4	Pit 2	1665	16	7849
5		1665		
6	Pit 3	1666	14	2848
7	Pit 4	1671	17	2257
8	Pit 5	1661	19	23431
9		1664		
10		1667		
11	Pit 6	1666	19	11732
12		1668		
13	Pit 7	1653	32	5118
14	Pit 8	1652	39	15014
15	Pit 9	1654	13	11908
16		1653		
17	Pit 10	1656	10	8078
18	Pit 11	1655	6	1724
19	Pit 12	1671	32	1635
20	Pit 13	1663	13	1159

  - The most significant impact of decant will be on wetland functioning. As the decant points are all associated with low-lying areas, they are typically associated with wetlands. If the decant is not contained, the acidic pH conditions and high salt and trace metal concentrations are expected to kill the wetland fauna and flora. These impacts would most probably be irreversible in the long-term.
  - In addition to impacting negatively on wetlands, the unmanaged decant will also flow across land to the pans and non-perennial streams that drain the project area. As

with the wetlands, the decant will negatively affect water quality in these surface water bodies and will most probably result in irreversible acidification and unacceptable salt loads.

- If no subsidence takes place over the underground mining areas, it is unlikely that the underground workings would decant in the long-term.

- **Long-term impacts on groundwater quality:**
  - As mentioned previously, various scenarios were tested to determine the long-term impact of mining on groundwater quality. These are:
    - Scenario 1: the long-term impact if all rehabilitation measures are implemented and deterioration in groundwater quality does not take place during the operational phase of mining. This option does not take the impact of discard disposal on site into consideration.
    - Scenario 2: tests the impact of placing discard material into the mined-out pits. Although it is acknowledged that this will not take place in all of the pits as the volume of discard generated will be less than the void space available in all the pits, the model was used to see the impact of backfilling all the pits with discard. This will allow identification of pits that may be more suitable for backfill with discard. In order to complete this scenario, it was assumed that the discard material will acidify during the operational phase as well as post-closure resulting in an increase in sulphate concentrations.
    - Scenario 3: evaluates the impact of placing discard in a stockpile on surface within the plant area. The scenario assumes that the discard stockpile will not be lined and the rate of seepage would be governed by the permeability of the weathered aquifer.
    - Scenario 4: test the effect of lining the discard stockpile with a Class C liner. As noted previously the final liner design will be determined by the professional engineer appointed to design the facility. In order to complete this simulation, literature-based liner leakage volumes were applied.
  - The outcome of each scenario is discussed in detail in the report. A summary of the simulations is presented below in terms of the estimated salt loads resulting from each scenario on receptors identified. It is shown that backfilling the pits with discard will result in the most significant impact. It is however noted that the information presented is an over-estimation, as not all pits would be backfilled with discard. The calculations further indicate that a Class C liner (or a liner described in the design of the facility by a professional engineer) installed at a surface discard stockpile would result in a 9% decrease in salt load.

Description	Average SO_4 (mg/l)				Estimated volume (m^3/a)	Salt load (t/a)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Pans and streams									
Largest pan	275	450	325	275	41245	11,3	18,6	13,4	11,3
Smallest pan	200	350	200	200	657	0,1	0,2	0,1	0,1
Smallest NE pan	100	300	100	100	3778	0,4	1,1	0,4	0,4
Largest NE pan	225	300	225	225	3869	0,9	1,2	0,9	0,9
Non-perrenial stream Pit 10	50	70	50	50	5400	0,3	0,4	0,3	0,3
Non-perrenial stream Pit 7 & 8	300	450	300	300	4500	1,4	2,0	1,4	1,4
Non-perennial stream Largest Pan	50	70	50	50	900	0,05	0,06	0,05	0,05
Wetlands									
Largest pan	650	800	750	650	9736	6,3	7,8	7,3	6,3
Pits 7 & 8	400	675	400	400	6912	2,8	4,7	2,8	2,8
Pit 5	650	800	650	650	4702	3,1	3,8	3,1	3,1
Pit 11	600	600	600	600	2822	1,7	1,7	1,7	1,7
Pit 10	550	625	550	550	4748	2,6	3,0	2,6	2,6
Pit 9	650	725	650	650	2030	1,3	1,5	1,3	1,3

- The result of the simulations indicates that not all of the pits are suitable for backfilling with discard. It is noted that this option would result in a negative impact on decant quality in the long-term and that sulphate concentrations may increase by up to 30% inside the pits. As the discard is expected to acidify in the long-term, the impact on groundwater quality, wetlands and private boreholes may therefore be more significant.
- Due to the increased risk of decant and deterioration in groundwater quality, pits around the largest of the pans should not be backfilled with discard. Pits that are located along the two lineaments should also not be backfilled with discard, as these would preferentially transmit contaminated water. Pits that are situated immediately adjacent to streams should also not be backfilled with discard due to the increased negative risks associated with decant and the groundwater component of baseflow to the streams. Based on the criteria used during the evaluation, it is concluded that only one pit is suitable for discard disposal, as detailed in the report. Mining from this pit is scheduled from Year 6.
- Two scenarios were evaluated for the placement of discard on a surface stockpile, namely an unlined and a lined facility. As expected, an unlined facility will result in a significant increase in sulphate concentrations in the immediate vicinity of the discard stockpile in the long-term. Sulphate concentrations may increase to above 2500 mg/l in the weathered aquifer in the immediate vicinity of the discard facility in this case. It is further possible that the plume may reach the lineament to the west of the discard stockpile and that contamination from the discard stockpile may flow preferentially along the fault towards the largest pan in the southwest. It is expected that leachate from the unlined discard stockpile will be captured in the backfilled pit situated down gradient of it and will to a certain extent be contained in the pit until such time that it is flooded. This is however expected to have a negative impact on decant quality in the long-term. Due to the proximity to the largest pan and the wetlands associated with it, this is expected to result in significant negative impacts in the long-term.
- If the discard dump is lined with a Class C liner the most significant positive impact on sulphate concentrations is expected in the immediate vicinity of the site. For this scenario, sulphate concentrations are expected to remain below 900 mg/l at the stockpile. Groundwater quality will however still be affected by the mining activities in this area and lining of the facility will not mitigate the regional impact of mining on groundwater quality. For this scenario, the discard facility is not expected to have a noticeable impact on pitwater and decant quality.

A groundwater management plan was developed, based on the outcome of the impact assessment presented. The management plan is based on objectives and targets set for the project. Over-arching groundwater management measures are provided, which are aimed at planning for groundwater management from the start of the project and installing good house-keeping measures. All dirty water must be contained in suitably sized and designed facilities and clean water must be diverted around the mining area back into the catchment. Mine design must consider the results of this study, specifically relating to underground mine stability (to prevent subsidence) and the concurrent backfilling and rehabilitation of opencast pits.

Geochemical static leach tests on Kranspan discard samples indicate low concentrations of sulphate in leachate from the discard under the conditions of the test. Kinetic leach tests and geochemical modelling are currently underway, which will improve the understanding of long-term leachate quality. Available information however suggests that the discard material is likely to acidify with time, which will result in a deterioration in leachate quality. For this reason, the groundwater impact assessment is based on a worse case scenario (oxidation of the discard material), in line with the precautionary principle. Ilima is committed to implementing measures to reduce the risk of groundwater contamination associated with the handling of the discard material. For example, for the preferred option of in-pit discard disposal, restrictions are placed on the pit location and depth to which the discard can be backfilled. With these management measures, the rate and extent to which the discard could oxidise will be reduced. The resultant discard leachate could therefore be of better quality than what was used in this report, resulting in a reduced impact on groundwater quality. For this reason, it is recommended that the groundwater quality impact assessment is revised once the results of the kinetic tests and geochemical modelling are available.

Specific groundwater management measures are proposed for each of the impacts identified. These include measures to minimise the impact of mine dewatering as well as of the long-term impact of decant and deteriorating groundwater qualities. It is important that additional information is obtained to characterise borehole depth, construction and yield of private boreholes that fall inside the delineated zones of impact prior to the commencement of mining. This information must be used as a basis for discussions and negotiations with private borehole owners that may be negatively impacted during mining. It is important that the mine provides feedback to private borehole owners on a regular basis regarding mining, rehabilitation and monitoring activities.

The impact on groundwater and decant quality can be minimised by positioning surface infrastructure off the two lineaments, which are preferential flow paths to groundwater. Strict measures must be implemented if discard is backfilled into the pit identified as most suitable. This includes requirements regarding the placement of discard, the extent of mining and monitoring requirements. If discard is to be placed on a surface stockpile, it is recommended that at least a compacted clay liner is considered. This facility must be designed according to legal requirements.

A dedicated groundwater monitoring programme must be implemented during the construction phase of mining and maintained throughout the life of mine. Additional monitoring boreholes that may be required are discussed and specified in the report. The monitoring information must be used to measure the short and long-term impact of mining on groundwater levels and quality. Should adverse impacts be identified, the monitoring programme must trigger the necessary response and implementation of additional management measures, as required. This information must further be used to update, verify and re-calibrate the numerical groundwater flow and contaminant transport model prepared as part of the assessment. This will increase the level of confidence in the impact prediction results.

The assessment presented in this report must be updated once the results of the kinetic geochemistry results are available to ensure that all simulations are based on the best possible dataset. The model should also be updated on a regular basis, once the monitoring programme results become available.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS USED

BH	Borehole
BPG	Best Practice Guideline
CDT	Constant Discharge Test
DTM	Digital Terrain Model
DWS	Department of Water and Sanitation
DWAF	Former Department of Water Affairs and Forestry
iLEH	Irene Lea Environmental and Hydrogeology cc
HDPE	High Density Polyethylene
K	Hydraulic conductivity or permeability (unit: m/d)
L/h	Litre per hour
LOM	Life of Mine
LOW	Limit of weathering
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	Metres below ground level
Ml/d	Megalitres per day
MRP	Metals Recovery Plant
NA	Not applicable
NS	Not specified
PCD	Pollution Control Dam
RMSE	Root mean square error
S	Storage coefficient (-)
S_y	Specific yield (-)
S&EIR	Social and Environmental Impact Assessment Report
SANAS	South African National Accreditation System
SANS	South African National Standards
SDT	Step Drawdown Test
SWL	Static Water Level
T	Transmissivity (unit: m^2/d)
WL	Water level
WMA	Water Management Area
WML	Waste Management License

1 PROJECT BACKGROUND

1.1 Project Description

The study area is approximately 15 kilometres south of Carolina, Mpumalanga situated along the R36 road between Carolina and Breyten town, on the Mpumalanga Highveld. It is the intention of Ilima to mine the E Coal Seam that forms part of the Ermelo Coalfield. Both surface and underground mining is planned at the proposed colliery. Surface mining is planned for Portion RE, 2, 3, 5 and 7 of the farm Kranspan. Underground mining is planned for Portion 4, the northern section of Portion 2, the northwestern section of Portion 3 and the southern section of Portion 7 of the farm Kranspan.

The existing land uses include cultivated fields, farm roads, private groundwater abstraction, cattle farming and farm steads (ABS Africa, 2018). Two coalmines are located on land surrounding the Kranspan project area, namely Msobo and Northern Coal Mine.

According to the Scoping Report (ABS Africa, 2018), the project will include the following activities that are relevant to the groundwater specialist study presented in this report. It is noted that the broad placement of mining and surface infrastructure was informed by an environmental sensitivity plan, which considered the location of all known sensitive physical, social and environmental features within the application area. In addition, a consultation process is underway following the completion of the scoping phase of the project. Input from the public and authorities will be taken into consideration during final site selection for the project. The locations of the areas listed are indicated on Figure 1.

- Opencast mining over an area of 1 054ha, focussing on the E Seam. The roll over mining method (strip mining) will be implemented to ensure that mined-out areas are concurrently rehabilitated as mining progresses. Overburden and topsoil will be placed back into mined-out voids in the former stratigraphic sequence. The final re-instated surface is anticipated to be approximately 0,52m above the original surface level to ensure a free-draining surface. Upon completion of pit backfilling, each strip will be re-vegetated with suitable pasture grass species.
- Mine production will ramp up over a period of 11 months, with full production planned to commence in Year 2 of mining (Ilima, 2018). The estimated life of mine (LOM) is 12 years, producing 2,256 million tonnes per annum.
- Underground mining over an area of 392ha, using the conventional board and pillar method. The underground mine will be designed for the maximum extraction, but no pillar extraction will take place. In order to gain access to the underground workings, a mine access shaft and a ventilation shaft will be constructed.
- Dry crushing and screening of the coal prior to putting the coal through a wash plant (coal processing plant). The plant will cover an area of 1,7ha. The planned raw coal feed to the plant is 4,24 Mt/a, with an efficiency of 87,6% and a plant yield of 70,8%. Coal will be processed at a rate of 670 t/hr.
- Plant waste material will be disposed of into mined-out opencast pits. Alternatively, the construction of an engineered surface discard dump, covering an area of 26,94ha, may be considered. The selection of the preferred option for discard disposal will be informed by the findings of the geohydrological modelling presented in this report. The results of the geochemistry specialist study will be used to complete this assessment.
- Washed coal will be placed on a coal product stockpile with an anticipated area of 5,3ha in the loading area from where it will be transported off site for sale.
- The placement of overburden and topsoil stockpiles. These will be temporary stockpiles, as opencast mining areas will be concurrently rehabilitated during the operational phase of

mining. Topsoil and soft overburden will be removed in two strips in advance of the working strip and will either be stockpiled or placed directly on rehabilitated areas behind the advancing strip. Hard overburden will be blasted and dozed or hauled to the spoil strip side of the current strip from where it can be backfilled into mined-out areas.

- All dirty runoff will be separated form clean water with the use of cut-off drains. Polluted runoff will be contained in high-density polyethylene (HDPE) lined pollution control dams (PCD). These will be situated adjacent to the processing plant and in the proximity of the opencast pits. This water will be used for dust suppression and in the processing plant.
- For both mining methods, mine dewatering is anticipated over the life of mine (LOM). Water removed from the pits will be stored in the PCDs.
- Ancillary services and activities, like the construction of haul and internal roads; construction of overland conveyors in the pit loading area; construction of a mine contractors camp and a mine support and administration block; the creation of a fuel storage area with a back-up power generator and the construction of an explosives storage area.
- It is anticipated that boreholes will be established to supply potable water to mine staff. It is estimated that approximately 40 m^3/d of water will be required per day to meet the demand at the mine. A small water treatment plant will be constructed at the mine to produce potable water from the boreholes.
- Process water will be used at the processing plant, for dust suppression and for underground cooling. It is anticipated that the processing plant will require around 986m^3/d. Process water may be sourced from ground- or surface water resources available to the mine, or from the dirty water containment facilities.
- Sewage handling and management is not expected to impact on groundwater, as modular sewage package plants and chemical toilets will be used.
- No solid waste disposal facility will be constructed at the mine. Waste will be segregated into general and hazardous waste and will be removed off site by contractors. An oil recycling company will also be appointed to remove waste oil off site. The on-site waste storage area will be located at the processing plant. Medical waste will also be removed by a contractor. Based on the available information, it is not anticipated that solid waste disposal will impact on groundwater at the operations.

1.2 Details of the Specialists

The project was managed by Irene Lea. She has 27 years experience in the field of geohydrology. She has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist (400278/06). Her focus includes numerical groundwater flow and contaminant transport modelling, water treatment, integrated water and waste management strategies, rehabilitation and closure projects, environmental management systems and risk assessments.

The fieldwork programme was managed and undertaken by Lucas Smith of Groundwater Abstract. Lucas has 26 years experience in the field of geohydrology. He also has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist.

Both consultants that completed the project have no direct or indirect beneficial interest or contingent in the Ilima Kranspan Project at present or in the past. They will be paid a fee by ABS Africa, the environmental consultants appointed to the project for coordinating the groundwater specialist study, numerical groundwater flow and contaminant transport modelling within normal professional consulting practice. Payment of these fees is in no way contingent upon the conclusions or opinions expressed in this report.

1.3 Compliance Framework

This study is submitted as part of the requirements for the application for a mining right, waste management license and a water use license, currently undertaken by ABS Africa. The listed activities that will be included and assessed as part of the groundwater specialist study are listed in Table 1. These are based on information presented in the project Scoping Report (ABS Africa, 2018).

The application is made for a duration of 30 years.

Table 1 Activities applicable to the geohydrological specialist study

Regulation	Description
Mineral and Petroleum Resources Development Act , 2002 (Act No 28 of 2002) (MPRDA)	Ilima is applying for a mining right in terms of section 22 of the MRPDA.
National Environmental Management: Waste Act, 2008 (Act No 59 of 2008) (NEM:WA)	The project will require a waste management license (WML) for the planned PCDs, mineral stockpiles and mine residue stockpiles, in addition to non-mineral waste (the latter is not expected to impact on groundwater).
National Environmental Management Act, 1998 (Act No 107 of 1998) (NEMA)	The proposed mining activities fall within the ambit of various listed activities in Listing Notice 1, 2 and 3, as detailed below. A Social and Environmental Impact Assessment Report (S&EIR) will therefore be compiled and submitted as part of the application.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 1	The placement of PCDs and material stockpiles within a watercourse, or if no development setback exists, within 32m of a watercourse. It is noted that avoidance of such areas is prioritised as part of the environmental sensitivity planning for the project.
	The planned PDCs may exceed a combined capacity of 50 000 m^3.
	The establishment of borrow pits and other small-scale mining of minerals within the project area.
	The operation of facilities to treat effluent, wastewater or sewage with a daily throughput capacity of between 2000 and 15000m^3. Although the sewage treatment facility will be self-contained, the installation of a treatment facility for contaminated water may be necessary.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 2	The development and submission of a water use license application in terms of the requirements of the NWA.
	The project will require a mining right according to the requirements of the MPRDA.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 3	The placement of PCDs and material stockpiles within a watercourse, or if no development setback exists, within 32m of a watercourse. It is noted that avoidance of such areas is prioritised as part of the environmental sensitivity planning for the project.
GN R921, 29 November 2013 Categories A and B	The need and construction of the PCDs, which are categorised as the storage of general waste in lagoons.
	The construction of the mine residue stockpiles.
	The reclamation of residue stockpiles or deposits as part of mining activities, specifically the process of backfilling and rehabilitating the opencast mining voids with topsoil and overburden stockpiles as well as the possible in-pit disposal of discard.
The National Water Act, 1998 (Act No 36 of 1998) (NWA)	The proposed mining activities will require a water use licence for the activities detailed below. An integrated water use license application will be submitted in this regard.
Water Uses in terms of Section 21 of the NWA	Section 21 (a): taking water from a resource Section 21 (b): storing of water Section 21 (c): Impeding or diverting the flow of water in a water course Section 21 (i): Altering the beds, banks, course or characteristics of a water course Section 21 (g): Disposing of waste in a manner which may impact on a water resource Section 21 (j): Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of any activity, or for the safety of people

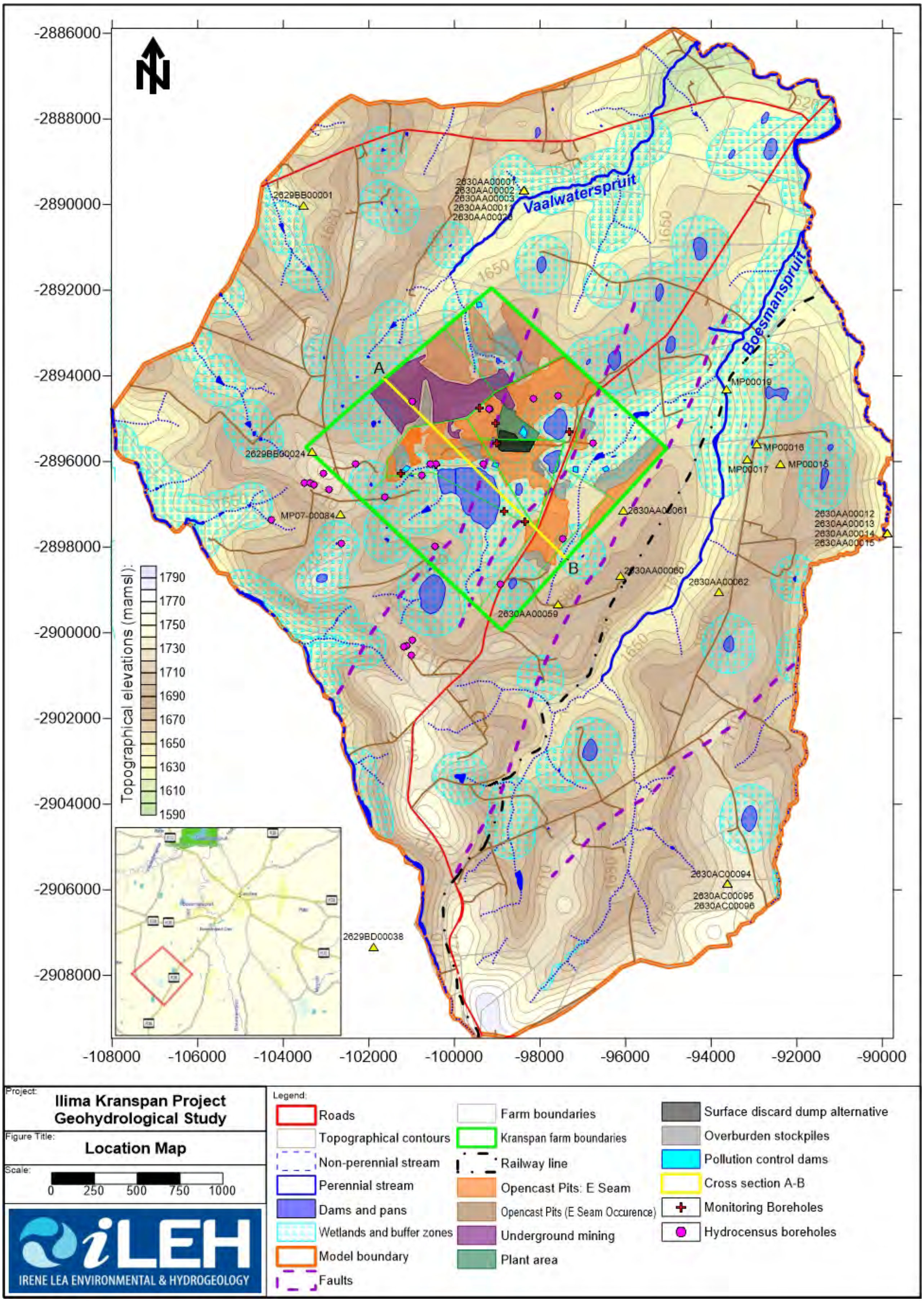


Figure 1 Location map

1.4 Date and season of investigation

The fieldwork component of the project was undertaken between December 2018 and February 2019. The information presented therefore represents groundwater conditions during the wet season.

1.5 Project methodology

The geohydrological impact assessment was completed with information obtained from ABS Africa, Ilima as well as from a dedicated fieldwork programme.

Information made available by ABS Africa and included in this assessment includes:

- A copy of the Scoping Report submitted as part of the mining right application (ABS Africa, 2018).
- Certificates of analyses on various rock samples completed as part of the geochemistry specialist study for the project.
- A copy of the surface water study completed by Peens & Associates (2019).
- Various maps indicating the surface and mining layouts applicable to the project.

Ilima made the results of their exploration programme available in order to conceptualise the coal seam roof and floor elevations in the geohydrological modelling context.

The fieldwork programme was completed by Groundwater Abstract in consultation with iLEH. The fieldwork included a hydrocensus to identify private groundwater use in the region. Ground geophysics were used to site eight dedicated groundwater monitoring boreholes. These boreholes were drilled using percussion methods and aquifer tests were completed to calculate aquifer parameters. Both shallow and deep boreholes were drilled to obtain information on the two main aquifers that are expected on site. Groundwater samples were taken from some of the hydrocensus and all of the monitoring boreholes for chemical analysis in order to characterise ambient groundwater quality conditions.

The geohydrological impact assessment was completed based on the outcome of simulations with a numerical groundwater flow and contaminant transport model. The model was calibrated with the available groundwater monitoring dataset. Details regarding model construction and calibration are discussed later in this report.

The numerical model was used to complete the geohydrological impact assessment presented in this report.

1.6 Geohydrological Study Objectives

The groundwater impact assessment has the following objectives:

- Define the current groundwater use in the project area;
- Define potential receptors in the project area, for example wetlands and private groundwater use;
- Define the aquifers underlying the project, as well as current groundwater table depth, groundwater quality, and flow characteristics;
- Develop a numerical model to define groundwater related impacts and groundwater inflow into the proposed mining areas;
- Define the radius of influence that will be created by mine dewatering, plus the extent of possible contamination originating from the proposed mining areas and mine infrastructure;
- Assess whether decant will occur during the operational phase or post closure; and
- Recommend a groundwater monitoring network that will initiate monitoring of groundwater quality and level changes; pre-mining and into the operational phases.

1.7 Affected catchments

The Kranspan project area is in the Komati River catchment, in the X11B quaternary catchment, forming part of the Inkomati-Usuthu Water Management Area (WMA:3). The main drainage is the Boesmanspruit and it is located approximately 5 km east of the project area. The Boesmanspruit discharges into the Nooitgedacht Dam approximately 17 km north of the project area.

The far western corner of the farm Kranspan is in the X11A quaternary catchment; drained by the Vaalwaterspruit. The Vaalwaterspruit also discharges into the Nooitgedacht Dam.

1.8 Wetlands

At least three wetland types are represented in the study area, namely Endorheic Pans, Valley-bottom Wetlands and Hillslope Seeps (ABS Africa, 2018). The wetlands cover approximately 330 ha of the project area. The extent of the wetlands is indicated on Figure 2.

Satellite imagery indicates several circular to sub-circular permanent or seasonal pans in the study area, of which Kranspan is the most significant, with a size of approximately 125 ha (see Figure 2). Kranspan and a second pan to the north-east are likely to support significant numbers of congregatory waterbirds at certain times of the year.

While wetlands typically have lower species diversity than adjacent undisturbed grassland, a high proportion of habitat specialist plants are usually present and likelihood of fauna species of conservation concern being present is moderate to high.

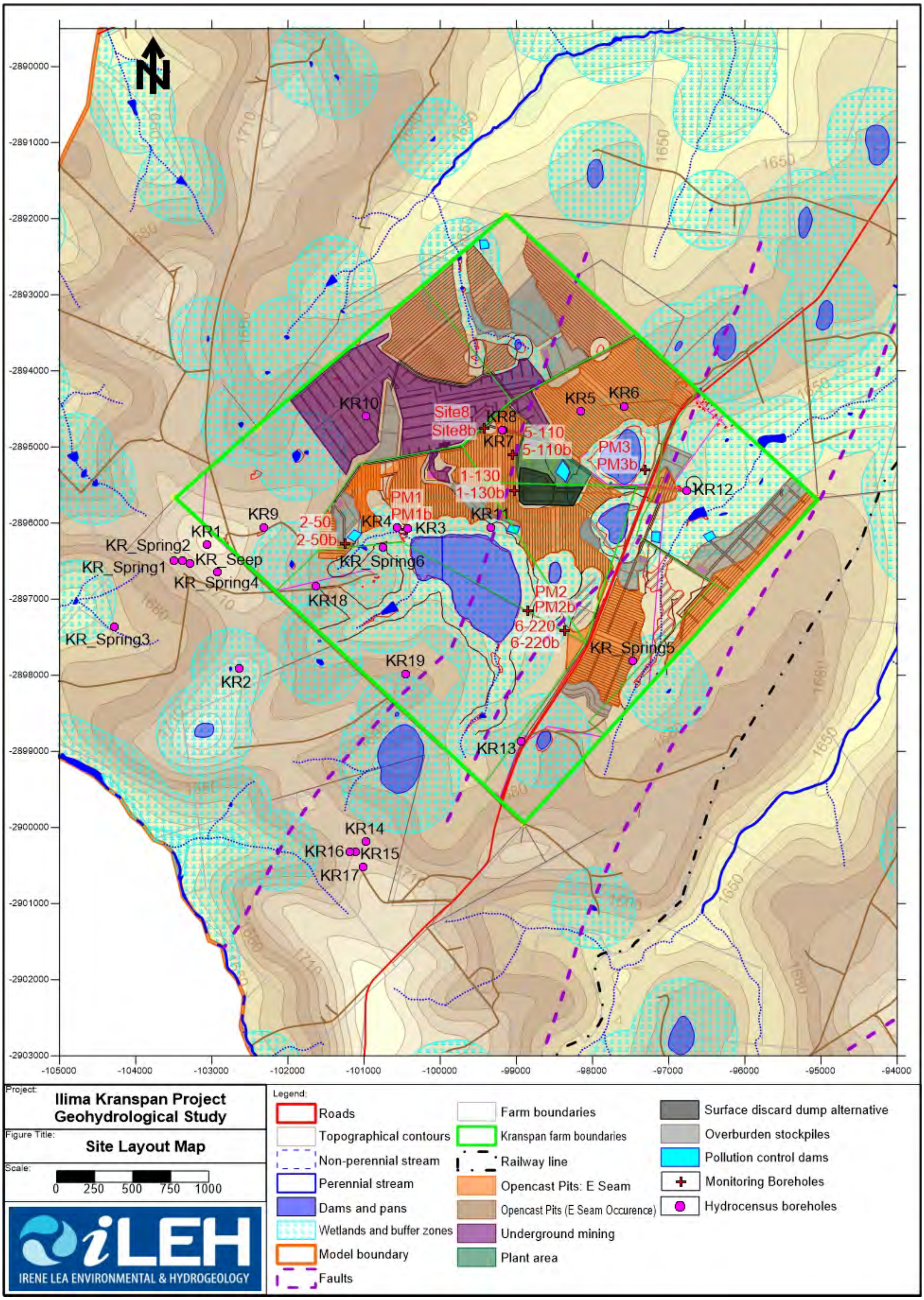


Figure 2 Site layout map

1.9 Climate and rainfall

The climate of the project area is mild to warm during the summer and cool to cold during the winter. During the rainy season it is sub-humid, but during the cold dry season it is mildly sub-arid.

Rain occurs as mild to heavy showers and thunderstorms during the summer months between November and February, with an average of 500 to 750mm per year (ABS Africa, 2018). The winter months are dry. Heavy falls (>100mm) in a single 24-hour period do not occur.

The mean annual precipitation (MAP) for the mining area is 698mm/a (Peens & Associates, 2019). In comparison, the mean annual evaporation (MAE) for the area is 1 450mm/a, which is twice as high as the rainfall.

1.10 Alternatives considered

All project alternatives available to the Kranspan Project were evaluated by ABS Africa as part of the Scoping Phase of the project. The outcome of this assessment was an environmental sensitivity map, which was used to develop optimal surface and mining layouts.

The only project alternative that will be considered as part of this impact assessment is that of discard management. As mentioned previously, two options are under consideration:

- The preferred alternative is to backfill the discard material into mined-out opencast voids. The numerical groundwater model will be used to assess the impact of this option and to identify the most suitable pits for discard backfilling, if any.
- The alternative that will be considered entails an engineered surface discard dump, covering an area of 26,94ha. The location of the discard dump alternative is indicated on Figure 2.

2 GEOHYDROLOGICAL ASSESSMENT

2.1 Geological setting

The Kranspan project is located in the Ermelo Coal Field. Compared to the adjacent Witbank and Highveld Coal Fields, the Ermelo Coal Field hosts thinner seams, is sedimentologically and structurally more complex and is not as well studied or understood (Ilima, 2018). The coalfield is underlain by glacial pre-Karoo rock formations, including the Dwyka tillite. The Karoo Supergroup hosts all the South African coal deposits. The coal in the Carolina area occurs within the Vryheid Formation of the Ecca Group, which forms part of the Karoo Supergroup. Five coal seams are recognised within an 80 – 90m thick sedimentary succession. These are, from the top down, the A to E Seams. The regional geological setting for the project is indicated on Figure 3.

The A Seam, although present in the project area, is too thin to be of economic interest (Ilima, 2018). The B Seam varies from 1 – 2,7m in thickness and splits into two units, referred to as the B Lower and B Upper Seams. It is thought that the quality of the B Seam is often inferior to that of the C Seam, which makes it uneconomical. Normally the C Seam is the main economic coal deposit in the Ermelo Coal Field. Unfortunately it is not economically mineable in the Kranspan area. The D Seam is of good quality, but is generally too thin (0,1 – 0,4m) to be of economic importance. The E Seam is the main mining target in the Kranspan project area. The coal is mostly bright and banded and has a competent sandstone roof and floor. It is sometimes split by a thin sandstone or carbonaceous fines parting

The overall coal seam dip is around 1.5° to the southwest, which is consistent with the regional characteristics. The immediate roof is a hard and competent material.

A dolerite sill occurs in the area, usually above the C-seam and has been identified towards the west and north of the big pan, on the farm Kranspan. The intrusion has resulted in the devolatisation of the coal in certain areas in the south of the project area. No significant structural faults have been identified (Ilima, 2018).

There are two (2) major structural geological features which may have an impact on groundwater flow and possibly mining. These possible dyke structures extend from north to south, with the one structure underlying the big pan on the farm Kranspan and the second roughly following the R36 road.

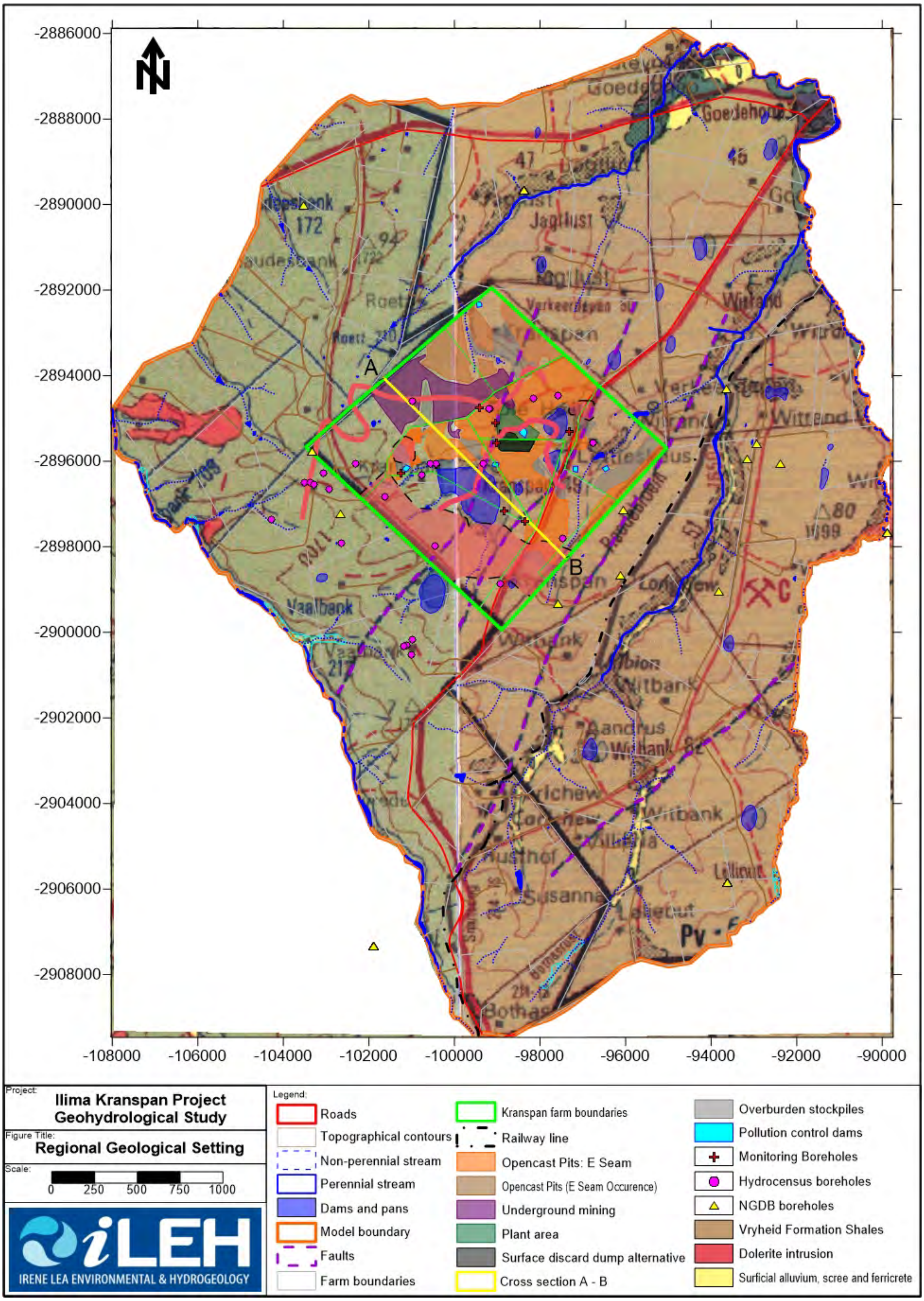


Figure 3 Geological setting

2.2 Geohydrology

2.2.1 Current groundwater use

Groundwater Abstract conducted a hydrocensus across the proposed Kranspan mining area during January 2019. The survey included the proposed mining footprint areas as well as the adjacent properties. The hydrocensus focussed on identifying existing private boreholes and private groundwater use and to enhance the knowledge of the aquifers present.

During the hydrocensus 26 groundwater sites (boreholes and springs) were identified, as detailed in Appendix 1. Farms surveyed included:

- Kranspan 49 IT; and
- Vaalbank 212 IS.

During the hydrocensus the following information was collected for each site:

- Borehole position (X, Y, Z-coordinates);
- Information relating to equipment installed;
- Borehole construction details;
- Borehole yield, if known;
- Groundwater level, if possible; and
- Current use.

The 26 sites included 19 boreholes and 7 springs. In terms of private groundwater use, the following information was obtained:

- 12 boreholes are in use:
    - 3 boreholes fitted with submersible pumps;
    - 8 boreholes fitted with windpumps;
    - 1 borehole fitted with solar submersible pump;
- 2 boreholes are equipped, but not in use (old windpumps); and
- 5 open boreholes are not currently in use.

Groundwater level measurements were possible in 7 hydrocensus boreholes. Pumping equipment blocked the remaining boreholes visited. Seven groundwater samples were collected for water quality analysis during the hydrocensus.

Water levels were measured by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was subtracted from the measured water level to define a water level below surface, the details of which are presented in Appendix A.

The depth to groundwater level varied between a maximum depth of 22.38 m bgl (borehole KR7), and the surface elevation for the springs where the water table daylights. The average depth to groundwater in the hydrocensus boreholes is 14,7m, if the springs and seeps are excluded from the calculation.

Based on communication with the landowners the springs in the area are seasonal, with the exception of KR-Spring3 and KR-Spring5 that flow throughout the year. The springs serve as water supply to livestock and wildlife in the area. KR-Spring3 is the most prominent spring identified during the hydrocensus (based on flow rate). During the hydrocensus the discharge rate was approximately 86m^3/d (3,600 L/h) and the water quality is good.

Detailed information in terms of borehole construction and yields are not available for the identified private boreholes. The information provided by the landowners indicated low borehole yields for most of the Kranspan project area.

2.2.2 Groundwater monitoring boreholes

2.2.2.1 Geophysical Survey

A ground geophysical investigation was conducted to identify linear geological structures, which could act as preferential groundwater flow paths and potentially be high water yielding aquifers. The geophysical survey has been used in conjunction with the available remote sensing images and geological maps. The two linear north-south geological structures were one of the key targets. Others included the dolerite sill and potential deep weathered zones across the study area.

The geophysical investigation was conducted during November 2018. The following techniques were applied:

- EM 34–3 electromagnetic (EM) system, with a coil spacing of 20 m, and a station spacing of 10 m; and
- Magnetic survey.

The survey included 8 survey lines, and line and station coordinates were marked in the field using a Garmin hand-held GPS. The geophysical data is presented in Appendix 2. The geophysical survey was successful in identifying the dolerite sill contact, as well as the north-south lineaments indicated on Figure 3.

2.2.2.2 Drilling Programme

Based on the geophysical survey results and an understanding of the local geology, Groundwater Abstract identified 8 suitable drilling positions for groundwater characterisation purposes. The information pertaining to the drilling programme is presented in Table 2. The drilling sites were chosen from the geophysical surveys undertaken, but where possible, were placed outside the planned mining areas to ensure that they are not destroyed during mining. This was however not possible in all instances.

WJ Water Drilling carried out the percussion drilling programme during December 2018. The Client was responsible for the drilling supervision. A pair of groundwater characterisation and monitoring boreholes was drilled at each of the eight targets in order to target the shallow and deep aquifers through to be present. The first borehole was therefore drilled to a depth of 50 m below surface, with the aim of characterising and monitoring the deeper fractured aquifer. The second borehole was drilled to a depth of 20m, to monitor the shallow weathered aquifer and to establish whether there is a hydraulic connection between the two aquifers. These two aquifers are often separated by a less permeable dolerite sill in the area.

The boreholes were positioned relatively close to the proposed mining areas, as well as to the large natural pans in the area. The boreholes closer to the pans (boreholes PM1, PM2 and PM3) aim to define surface water- groundwater interaction close to the pan structures.

Data collected include the recording of geological formations at 1 metre intervals, water strike depths, the cumulative final blow yield and final rest water level. A summary of the results is presented in Table 2.

The borehole construction details are as follows:

- Deep boreholes (50 m) – the diameter of the casing is 177 mm, which goes down to 24 m below surface. Beyond this depth the diameter of the borehole is 165 mm.
- Shallow boreholes (20 m) – the diameter of the casing is 152 mm and cased across the total depth to the borehole. The bottom 6m of the casing in the shallow boreholes is perforated.

The geological profiles intercepted by the percussion and core drilling programmes are presented in Appendix 3.

The new Kranspan percussion boreholes produced blow yields between zero litres per hour (L/h) (thus dry) and 10,000 L/h, as detailed in Table 2. In general, borehole yields throughout the project area are low, indicating minor aquifer systems.

From the information presented in Table 2 it can be concluded that the majority of the water strikes are associated with the soil and sub-soil horizons and the upper fractured aquifer. The weathered zone, the fractures in the coal seams and the geological contacts yielded low quantities of water (borehole yields of 800 to 1,000 L/h).

The fractured aquifers in the area can be classified as confined aquifers based on an assessment of the rest groundwater level depths versus water strike depths. All rest water levels were at a shallower depth compared to the water strike depths.

The base of the weathered zone yielded some water, but in very low quantities. Most water strikes produced low yields (1,000 to 2,000 L/h). The highest yielding water strike (>10,000 L/h) is associated with one of the north-south lineaments (borehole PM3). The water yielding zones can be classified as follows:

- Weathered sandstone – 1,000 to 2,000 L/h.
- Fractures in sandstone – 2,500 to 10,000 L/h.
- Dolerite top contact – 1,500 L/h.
- Dolerite bottom contact – 1,000 L/h.
- Sandstone shale contact 1,000 L/h.

Based on the percussion drilling results coal was found in borehole 1-130 only.

The depth of weathering varies between 3 and 50 m bgl; mostly around 7 to 9 metres below surface.

Table 2 Drilling summary of new deep monitoring boreholes

		Borehole ID	1-130	2-50	5-110	6-220	Site8	PM1	PM2	PM3
Borehole Location	WGS84	Latitude	26° 9'56.79"S	26°10'18.91"S	26° 9'41.29"S	26°10'56.51"S	26° 9'29.79"S	26°10'12.94"S	26°10'48.15"S	26° 9'48.17"S
		Longitude	30° 0'34.46"E	29°59'14.14"E	30° 0'33.81"E	30° 0'57.79"E	30° 0'20.37"E	29°59'43.45"E	30° 0'40.43"E	30° 1'36.13"E
		Elevation	1688	1680	1692	1669	1713	1666	1664	1664
Borehole Data	Borehole Depth (m)		50	50	50	50	50	50	50	50
	Blow Yield (L/h)		Seepage	1000	10000	2500	1000	2000	Seepage	>10000
	Water Strike depth (m)		None	5m - seep 35m – 1000L	15m – 1500L 35m – 10000L	15m – 1000L 45m – 2500L	35m – 1000L	30m – 2000L	None	---
	Main Strike Geology		---	Sandstone	Dolerite upper contact; Fracture in sandstone	Shale/sandstone contact; Fracture in sandstone	Base dolerite contact / coal contact	Sandstone	---	---
	Borehole Geology		Laterite, sandstone, carbonaceous shale / coal	Laterite, clay, sandstone / shale	Sandstone, shale, dolerite	Sandstone, carbonaceous shale	Sandstone, shale, dolerite, coal	Clay, sandstone, shale, dolerite	Clay, sandstone	Sand, shale, sandstone
	Static Water Level (m bgl)		5.54	4.22	4.99	5.30	9.71	0.90	1.91	4.98
	Depth of Weathering (m)		3	25	7	5	9	47	50	50,

Table 3 Drilling summary of new shallow monitoring boreholes

		Borehole ID	1-130b	2-50b	5-110b	6-220b	Site8b	PM1b	PM2b	PM3b
Borehole Location	**WGS84**	**Latitude**	26° 9'56.79"S	26°10'18.91"S	26° 9'41.29"S	26°10'56.51"S	26° 9'29.79"S	26°10'12.94"S	26°10'48.15"S	26° 9'48.17"S
		Longitude	30° 0'34.46"E	29°59'14.14"E	30° 0'33.81"E	30° 0'57.79"E	30° 0'20.37"E	29°59'43.45"E	30° 0'40.43"E	30° 1'36.13"E
		Elevation	1688	1680	1692	1669	1713	1666	1664	1664
Borehole Data	**Borehole Depth (m)**		20	20	20	20	20	20	20	20
	Blow Yield (L/h)		Dry	Dry	Dry	Dry	5000	Dry	Dry	Dry
	Water Strike depth (m)		None	None	None	None	13	None	None	None
	Static Water Level (m bgl)		---	4.52	6.44	3.13	5.54	1.04	---	5.54

2.2.2.3 Aquifer Testing

Following completion of the drilling programme, an aquifer test programme was initiated to determine the hydrogeological characteristics of the local aquifers. This includes defining:

- Borehole drawdown and recovery characteristics.
- Aquifer hydraulic parameters:
    - Transmissivity (T) defined as the product of the average hydraulic conductivity (K) and the saturated aquifer thickness. It is a measure of the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. The unit of measurement is m^2/day.
- Characterisation of aquifer flow boundaries such as low permeable, no-flow or recharge boundaries. No-flow or low permeable boundaries refer to a lower transmissive structure (e.g. fracture with a lower conductance or low permeable dyke) or aquifer boundary (limit of aquifer – no-flow boundary) that results in an increase in groundwater drawdown during borehole abstraction. Recharge boundaries relate often to leakage from surface water bodies.

In Situ Groundwater Services was subcontracted to carry out the aquifer testing during January 2019. Aquifer testing was undertaken on the following boreholes, as presented in Table 4:

- 12-hour constant drawdown test on 6 new boreholes:
    - 2-50
    - 5-110
    - 6-220
    - Site8
    - PM1
    - PM3
- Slug test on 2 new boreholes:
    - PM2
    - 1-130.

Prior to each aquifer test, static groundwater levels are measured in the pumping and observation boreholes to enable drawdown calculations during test pumping. Pumped water was released via a discharge pipe at least 100 m from the test borehole, to avoid rapid recharge from the discharged water. During the test, the abstraction rate is continuously monitored by means of electronic flow meters and calibrated by manually measuring the time it takes to fill a container of known volume, with a stopwatch and drum.

The pumping test programme included the following different tests:

- Firstly, a step drawdown test (SDT) is performed. During the SDT the borehole is pumped at a constant discharge rate for 60 minutes, where after the step is repeated at a progressively higher discharge rate. During the SDT the drawdown over time is recorded in pumping and observation boreholes. The advantage of this test is that the pumping rate for any specific drawdown can easily be determined from the relationship between laminar and turbulent flow. After the test stopped, residual drawdown is measured until approximately 90% recovery of the water level has been reached. The discharge rate for the constant discharge test (see below) is calculated from the interpretation of the time drawdown data generated during the SDT.

- The constant discharge test (CDT) follows the SDT. During a CDT a borehole is pumped for a predetermined time at a constant rate. During the CDT test the drawdown over time is recorded in the pumping and observation boreholes. Discharge measurements are taken at predetermined time intervals to ensure that the constant discharge rate is maintained throughout the test period. Any changes in discharge rate are recorded. The duration of CDT at Kranspan was 12-hours. During CDT, the aquifer needs to be stressed sufficiently to identify boundary effects that may impact on long-term aquifer utilization. At each CDT on the deep monitoring boreholes, groundwater levels were monitored in the shallow boreholes in order to determine whether there is an interaction between the two aquifers under stressed conditions.
- Eight (8) groundwater samples were collected at the end of each of the CDTs for chemical analysis.
- The recovery test (RT) follows directly after pump shut down, at the end of the SDT and CDT. The residual drawdown over time (water level recovery) is measured in production and observation boreholes until approximately 90% recovery is reached. Aquifer parameters and sustainable borehole yields can be derived from the time drawdown data of the CDT and recovery tests by application of a variety of analytical methods.

The following software was used for test pumping data analysis:

- The Flow Characteristic Method or FC Method. The FC method uses the first and second order derivatives interpreted from time drawdown data (during test pumping), available drawdown, boundary conditions and recharge to derive sustainable borehole yields. The method is suited for characterising fractured rock aquifers.

A summary of the test programme is given in Table 4.

Five of the 8 boreholes tested indicate a slow recovery, this includes low and high yielding boreholes. The recovery of the groundwater table after abstraction normally provides a good indication of the aquifer yield potential. The volume of abstracted water should not exceed the rate of recovery of the system, to ensure that the aquifer is not over-utilised, which might have a negative impact on other groundwater users within the same hydrogeological system.

The recovery test data for the monitoring boreholes indicate that the recovery is slow and that full recovery (100%) is often not achieved within the predetermined testing timeframe, as detailed in Table 4. An obvious link was not identified in the aquifer test and recovery data in terms of specific geology structures such as lineaments.

The low borehole yields, fast water level drawdown and slow recovery observed during the aquifer testing indicate low transmissivity (T) aquifers, with low groundwater flow conditions in the surrounding aquifers. The mean T-value calculated from the test data was 1.7 m^2/d. The highest T-values (18.8 m^2/d to 26.1 m^2/d) were observed at boreholes that intercepted the main north-south linear structures. This suggests that these lineaments act as preferential flow paths to groundwater. The slug tests yielded average hydraulic conductivity values of approximately 0.2 m/d.

The following has been concluded from the aquifer test data:

- Two of the 6 boreholes tested showed a connection between the shallow and the deep borehole during the 12-hour aquifer testing. These are boreholes 6-220 and PM3. Both boreholes are located along the eastern boundary of the study area and on, or close to the north-south lineament. It appears that these north-south lineaments are possibly fault zones, possibly intruded by dolerite and with secondary fracturing, which as mentioned act as preferential flow paths to groundwater in the horizontal and vertical directions.

- The north-south lineaments are preferred groundwater flow paths, with higher T-values compared to the dolerite sills and sandstone or shale.
- The three sets of boreholes drilled close to the large pans indicate slow groundwater level recovery after pumping stopped. The exception is borehole PM1, where the borehole recovered to 100% of the original rest water level within 40 minutes after pump shut-down.
- The dolerite sill yielded water along the top and bottom contact; in the order of 1,000 L/h.
- Clay was only observed in the boreholes close to the largest pan, in boreholes PM1, PM2 and 2-50.
- The two boreholes with the highest blow yield and constant pump rate (5-110 and PM3) indicate very slow water level recovery after pumping. This suggests that the fractures into which these boreholes were drilled carry water, but that once these fractures are dewatered, the rate at which groundwater flows towards the boreholes from the surrounding aquifers is low.
- The shallow monitoring borehole at Site 8b yielded approximately 5,000 L/h (blow yield) and the deeper borehole only 1,000 L/h. During the aquifer test conducted on borehole Site 8 (deeper borehole) there was no response in the shallow, high yielding borehole. This suggests that the stress imposed on the fractured aquifer during the pumping test was not large enough or the aquifer test not long enough to induce vertical flow.

Table 4 Aquifer test programme summary

		Borehole ID	2-50	5-110	6-220	site8	PM1	PM3	PM2	1-130
Location	WGS84	Lat	S 26.171920°	S 26.161470°	S 26.182365°	S 26.158275°	S 26.170262°	S 26.163380°	S 26.180042°	S 26.165775°
		Long	E 29.987260°	E 30.009393°	E 30.016054°	E 30.005659°	E 29.995403°	E 30.026703°	E 30.011232°	E 30.009571°
		Elevation	1679	1692	1669	1713	1666	1664	1664	1688
Aquifer Test Data	Available Drawdown (m)		39,96	39,19	38,88	34,47	26,98	39,2	---	---
	Step 1 (L/s) / Drawdown (m)		0,21 / 9,19	1,04 / 7,57	0,39 / 4,95	0,2 / 10,35	0,28 / 6,99	1,04 / 2,9	---	---
	Step 2 (L/s) / Drawdown (m)		0,41 / 19,41	2,12 / 13,31	0,61 / 14,11	0,4 / 29,23	0,41 / 26,8	2,12 / 4,72	---	---
	Step 3 (L/s) / Drawdown (m)		0,61 / 40,95	3,54 / 18,47	0,91 / 38,4	0,6 / 44,18	---	3,57 / 25,14	---	---
	Step 4 (L/s) / Drawdown (m)		---	5,60 / 22,44	---	---	---	4,6 / 39,04	---	---
	Step Recovery - % (time)		92% (6hrs)	56% (4hrs)	97% (3hrs)	98% (3hrs)	98% (1,5hrs)	100% (40 min)	---	---
	Constant Discharge (L/s)		0,22	5,1	0,53	0,21	0,23	3,2	slug test	slug test
	Duration (min)		720	300	720	720	720	720	---	---
	Available Drawdown (m)		36,55	29,29	37,72	33,87	26,42	39,2	---	---
	Final Drawdown (m)		10,53	29,19	15,77	17,47	9,92	17,5	---	---
	Observation boreholes (20m deep)		Rest water level 4,52m no response during test	Rest water level 6,44m no response during test	Rest water level 3,13m 0,25m drawdown, slow recovery to 0,09m	water level Rest 5,54m no response during test	Rest water level 1,04m no response during test	Rest water level 4,98m 3,29m drawdown, recovery to 0,1m	---	---
	Recovery - % vs time		87% (10hrs)	63% (12hrs)	100% (40 min)	98% (5hrs)	100% (40 min)	39% (12hrs)	---	recovered very little
	FC Method									
	T - m²/day		3,5 to 4,6	26,1 (fracture) 6,95 (formations)	1,3 to 3,1	0,3 to 1,2	2,1 to 3,05	18,8 (fracture) 5,7 (formations)	4	1
	K - m/day		---	---	---	---	---	---	0,3	0,1
	Safe abstraction rate (L/s)		0,2 (8 hrs/day)	1,5 (12 hrs/day)	0,34 (8 hrs/day)	0,06 (6 hrs/day)	0,21 (8 hrs/day)	2,2 (8 hrs/day)	---	---

2.2.3 Aquifers present

Two main aquifers are typically found in the Karoo sediments of the Ermelo Coal Field. These are a shallow weathered aquifer and a deeper fractured rock aquifer. These are discussed in more detail below.

Please note that perched water in the soil horizon does not form part of the geohydrological study. It is noted that this water often contributes to wetland functioning in the region.

2.2.3.1 Weathered aquifer

The shallow weathered aquifer forms within the limit of weathering (LOW). Information on the LOW available from exploration boreholes, National Groundwater Database (NGDB) boreholes and the newly drilled monitoring boreholes is summarised in Table 5.

Table 5 Summary of information on the limit of weathering in the project area

Source	Minimum depth (m)	Maximum depth (m)	Average depth (m)
NGDB boreholes	0,3	15,8	6,4
Exploration boreholes	1,3	14,9	5,7
Monitoring boreholes	3	50	15,5

It is shown that the average depth of the LOW varies between 5,7 and 15,5 from the three available sources. For the purpose of conceptualisation, it will be assumed that the average LOW is down to a depth of 9m. This depth will be used to estimate the extent of the upper weathered aquifer during the geohydrological impact assessment presented in this report.

Clay material was found in boreholes drilled around the larger of the two pans on site. This suggests that the pans are formed on clay lenses that do not facilitate vertical infiltration of surface water. The clay lenses are most probably associated with highly weathered dolerite sills that were identified during the exploration drilling phase of the project.

The permeability of weathered aquifer is variable, but groundwater occurrence is most often associated with the transition between weathered and fresh rock. In this area, the dolerite sill could form a barrier between the upper weathered and deeper fractured rock aquifers. At present, the permeability of the dolerite is not known, but based on experience in similar aquifer conditions, it is thought that the permeability of fresh and unfractured dolerite is low compared to the host rock and that it will therefore act as an aquitard or even an aquiclude, forming a barrier to the vertical flow of groundwater from the weathered to fractured rock aquifers.

In low-lying areas, the groundwater table is shallow. Springs develop in the weathered aquifer where groundwater seeps to surface along areas of lower permeability for example against a dolerite intrusion or a palaeographic high or where the topography cuts into the water table. Six springs were identified during the hydrocensus (see Appendix 1).

The average depth to groundwater in the shallow boreholes drilled during the investigation is 4,37m, varying between 1,04 and 6,4m below surface.

This aquifer is not considered significant in terms of water supply due to its limited thickness. Information obtained from monitoring boreholes suggests that no water strikes occur in this aquifer. The exception is borehole Site8b, which yielded a blow yield of 5000 L/hr. but it does play an important role in terms of recharge to the underlying fractured rock aquifer and to the baseflow of streams and pans, especially in the dry season.

Permeabilities could be calculated from two of the shallow monitoring boreholes drilled. The results indicate that the permeability of the weathered material varies between 0,1 and 0,3m/d.

The rate of recharge to this aquifer is typically assumed to be around 3% of the mean annual precipitation (MAP) (Hodgeson and Kranz, 1998).

2.2.3.2 Fractured rock aquifer

Underneath the shallow weathered aquifer, groundwater is associated with fractures, faults, bedding planes and contact zones with intrusions. The rock matrices are tight and do not transmit significant volumes of groundwater, as indicated from the results of the aquifer tests. Groundwater flow in the fractured rock aquifer therefore takes place along the identified preferential flow paths. These include the two major north NE-SW striking lineaments and the dolerite intrusions.

The two large lineaments delineated on the regional geological map (Figure 3) were identified as aquifers and will therefore preferentially transmit groundwater. Monitoring boreholes 5-110, 6-220 and PM3 target these lineaments. Some of the private boreholes also target these lineaments, including KR11, KR19 and possibly KR7, KR8 and KR12.

The permeability of these aquifers is highly variable as it is dependent on the nature and extent of the secondary features mentioned. Results from the aquifer tests on these boreholes suggest that although the fractures carry groundwater, they are quickly dewatered when pumped due to the fact that inflows from the rock matrix are slow and cannot therefore sustain high volumes of groundwater abstraction. Transmissivities calculated from the aquifer tests for the lineaments vary between 19 and 26 m^2/d. This is higher compared to transmissivities calculated for the unfractured rocks, where transmissivities vary between 0,3 – 7 m^2/d. The wide range in transmissivities calculated from the available data (Table 4) is typical of the heterogeneous nature of fractured rock aquifers.

The aquifer testing data obtained during this study further indicates that vertical groundwater flow between the weathered and fractured rock aquifers are generally low, except along the strike of the NE-SW lineaments. Where present, zones of increased permeability allow groundwater flow through otherwise tight rock matrices . Measurements in borehole pairs that were drilled into the lineaments confirm that groundwater levels in the shallow boreholes react when the deeper boreholes are pumped.

Depth to groundwater in the deeper boreholes varies between 0,9 and 22,38m, based on data from the private and monitoring boreholes. Groundwater levels in the monitoring boreholes vary between 0,9 and 9,7m below surface, which is similar to that measured in the shallow boreholes. How well the seals were installed into the annulus of the deeper boreholes affects groundwater level measurements. For the purpose of this study, it will be assumed that the seals are intact and that groundwater level measurements in the deep monitoring boreholes indicate conditions in the fractured rock aquifer.

Based on the information obtained, the average depth to groundwater in the deeper boreholes based on all the data points is 9,4m, which is just below the average limit of weathering. The average depth to groundwater in the monitoring boreholes is 4,7m, which falls within the limit of weathering. Based on this information, the fractured rock aquifer seems to be confined to semi-confined, as groundwater levels rest above the depth of groundwater strikes in these. The dolerite sill could play a role in creating confined conditions in the fractured rock aquifer, where it is present.

2.2.4 Groundwater flow patterns

Groundwater flow contours were generated with the information obtained from the monitoring boreholes for both the shallow weathered and the deeper fractured rock aquifers in order to establish groundwater flow patterns at the site. The information used to generate the contours is presented in Table 2 and 3 and the flow contours for the two aquifers are shown in Figures 4 and 5. The extent over which the contours are generated depends on the available dataset. More data points are available for the fractured rock aquifer, compared to the weathered aquifer.

The groundwater flow gradient in the shallow weathered aquifer is towards pans. This suggests that groundwater from the shallow weathered aquifer discharges to the pans, especially during the wet season. The springs to the west of the Kranspan farm boundary are higher compared to that of the monitoring boreholes, as shown. The groundwater flow gradient in weathered aquifer is approximately 1:53 (0,019).

Groundwater flow patterns in the fractured rock aquifer are dominated by a depression around private boreholes KR3 and KR4 and monitoring borehole PM1. This is most probably indicative of groundwater flow towards the large pan, as no groundwater abstraction takes place from boreholes KR3 and KR4.

The average groundwater flow gradient in the fractured rock aquifer is 1:83 (0,012), which is flatter compared to the weathered aquifer.

2.2.5 Groundwater quality

Groundwater Abstract collected Seven (7) groundwater samples during the 2019 hydrocensus. The boreholes sampled are indicated in Appendix 1. The water samples were submitted to Waterlab, a South African National Accreditation System (SANAS) accredited laboratory, for analysis. Samples were collected from boreholes across the project area to ensure a good indication of ambient groundwater qualities.

Samples were taken using single valve, decontaminated bailers or from pump discharge lines in the case of boreholes, which were equipped, and in use. Sterilized 1 litre sample bottles were used and filled to the top. Samples were stored in a cooler box during the site surveys.

The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards. It is recommended that all identified boreholes, used for abstraction for domestic and agricultural purposes be sampled again before the construction phase of mining, if the application is successful in order to update the baseline assessment and build a water quality database for the area. The database will help to identify water quality and level trends in the area and will serve as reference to identify and quantify potential impacts on private boreholes.

Groundwater samples were also collected from the 8 monitoring boreholes during the 2019 aquifer testing programme. The results are discussed below.

The results of the analyses are presented in Table 6 and the certificates of analyses in Appendix 5. The information presented in Table 6 contains the main elements present in the water. A full analysis, including trace elements, is presented in Appendix 5. It is noted that the results indicate that the concentrations of most of the trace elements are below laboratory detection limits.

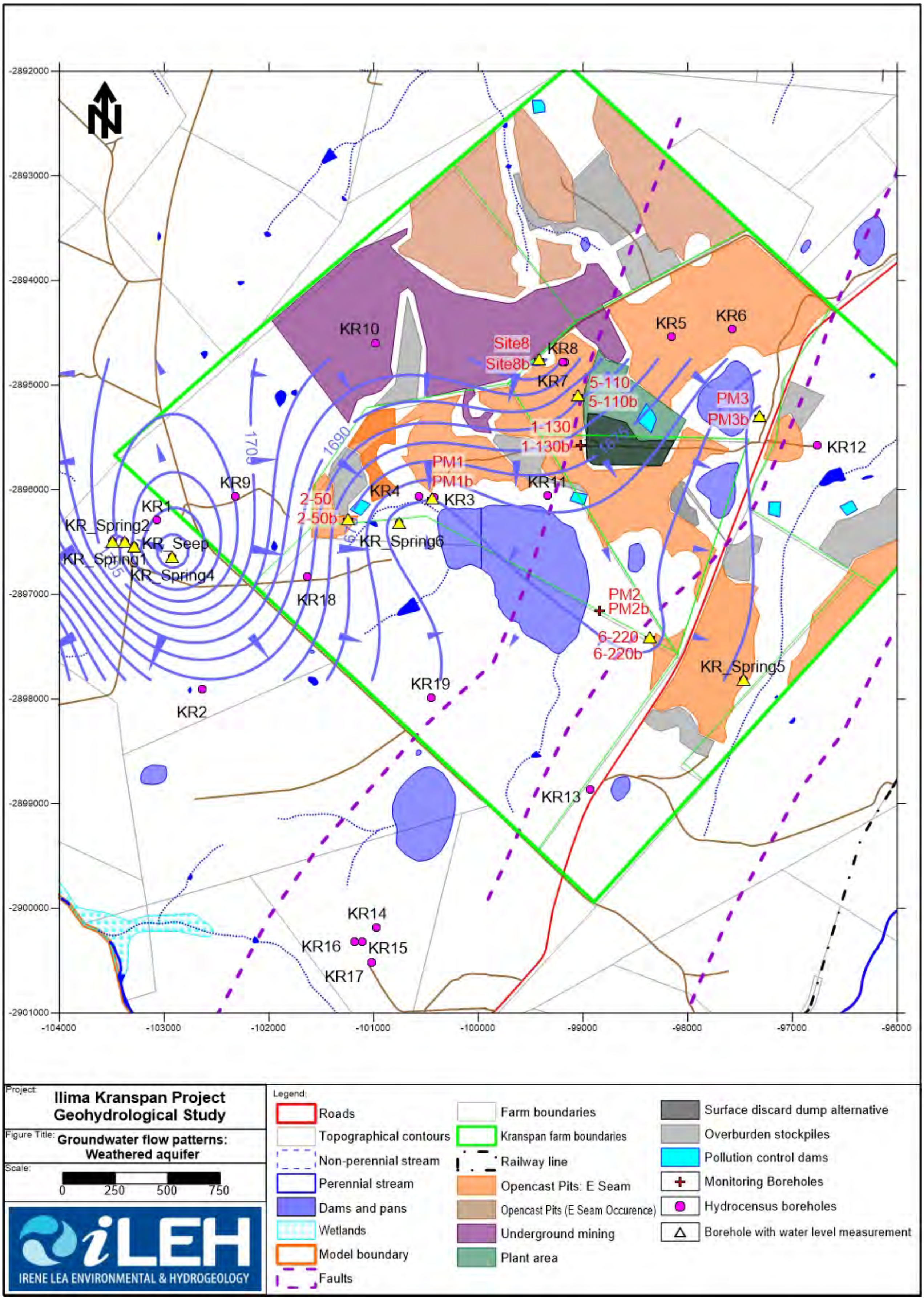


Figure 4 Groundwater level contours in the shallow weathered aquifer

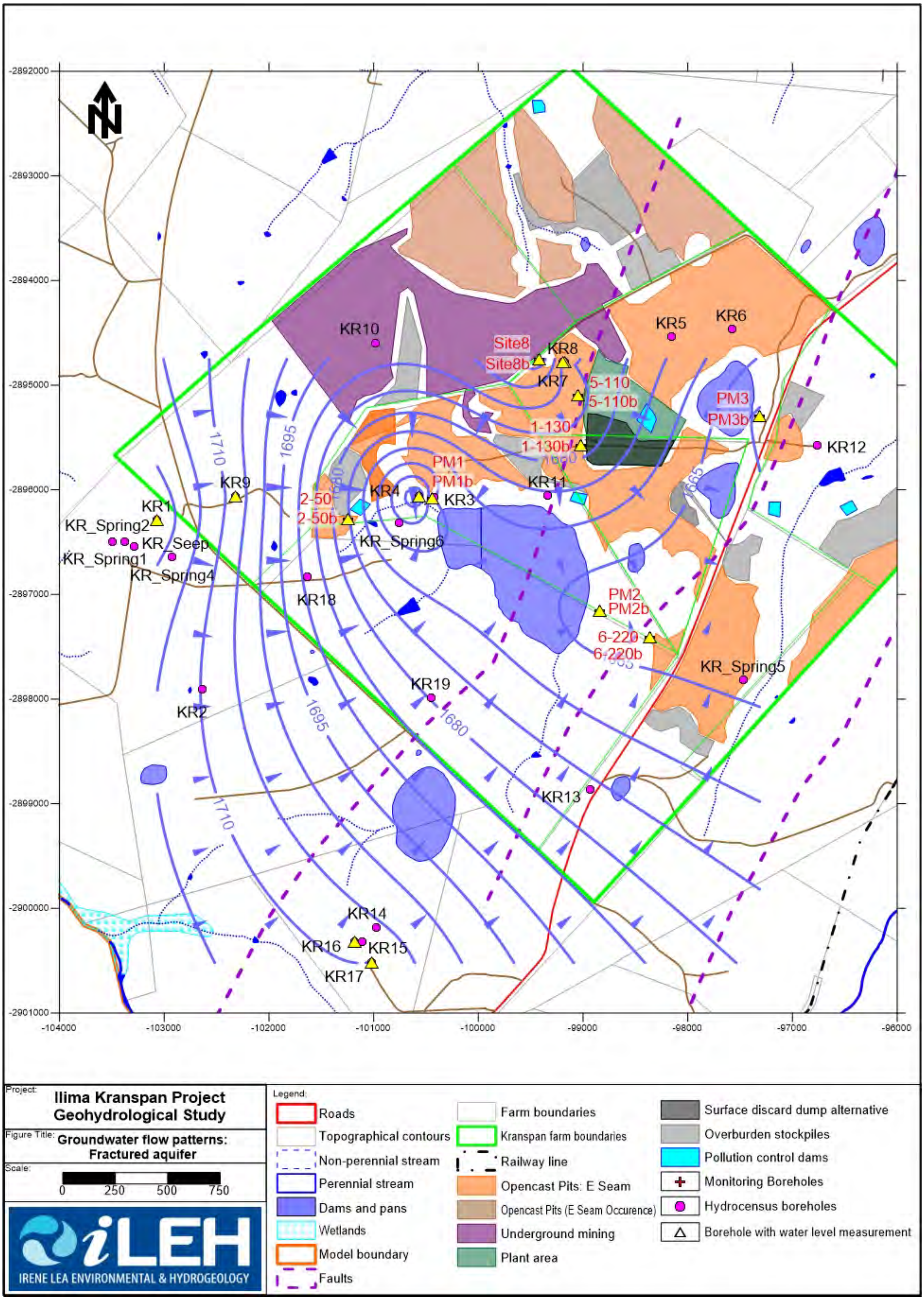


Figure 5 Groundwater level contours in the fractured rock aquifer

Table 6 Groundwater Quality – Hydrocensus January 2019

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers						
Unit: mg/l unless otherwise stated	**Aesthetic Limit**	**Health Limit**		**KR3**	**KR11**	**KR12**	**KR14**	**KR18**	**KR19**	**KR Spring 3**
pH – Value at 25°C	≥5 - ≤9.7			7.9	8.0	7.7	8.8	8.6	7.7	5.7
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			31.0	48.5	41.9	25.2	26.3	31.2	4.8
Total Dissolved Solids at 180°C	Aesthetic ≤1200			216	375	365	255	177	285	21
Total Alkalinity as $CaCO_3$	NS	NS	NS	116	156	128	100	136	80	<5
P-Alkalinity as $CaCO_3$	NS	NS	NS	<5	<5	<5	10	10	<5	<5
Bicarbonate as HCO_3	NS	NS	NS	141	190	156	99	142	98	5
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	47	139	27	42	71	94	7
Chloride as Cl	Aesthetic ≤300			16	58	35	14	3	2	7
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		22	8	20	14	5	69	3
Fluoride as F		Chronic health ≤1.5		0.6	0.2	0.6	0.2	0.2	0.7	<0.2
Nitrate as N		Acute health ≤11		0.5	0.1	2.7	0.3	0.7	0.2	0.2
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	<0.05	0.2	<0.05	<0.05	<0.05
Total Nitrogen as N	NS	NS	NS	0.8	0.9	3.2	1.6	1.4	1.4	0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Kjeldahl Nitrogen	NS	NS	NS	<0.5	0.8	0.6	1.1	0.7	1.1	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.2	0.5	0.6	1.1	0.2	0.2	0.2
Calcium as Ca			No health. Scaling intensifies from 32mg/L	11	29	6	10	18	20	1
Potassium as K			No aesthetic or health effects below 50mg/L	3,1	4,1	5,2	3,2	4,2	7,6	1,9
Magnesium as Mg	Aesthetic ≤0.1	Chronic health ≤0.4		5	18	3	5	8	13	1
Sodium as Na	Aesthetic ≤200			46	38	73	32	27	20	4
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		3,27	0,210	0,033	0,161	0,177	0,350	0,257
Total Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2		<0,025	0,084	<0.025	<0.025	<0.025	0.16	<0.025
Aluminium as Al	≤0.3			0,183	<0.100	<0.100	0,150	<0.100	<0.100	1,44

Table 7 Groundwater Quality – Monitoring Boreholes

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers							
Unit: mg/l unless otherwise stated	**Aesthetic Limit**	**Health Limit**		**2-50**	**1-130**	**Site8**	**5-110**	**6-220**	**PM1**	**PM2**	**PM3**
pH – Value at 25°C	≥5 - ≤9.7			9.2	8.9	7.2	7.6	7.6	5.7	8.8	6.6
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			53.4	25.0	28.4	29.3	26.3	25.0	74.9	32.5
Total Dissolved Solids at 180°C	Aesthetic ≤1200			425	215	200	180	120	113	453	300
Total Alkalinity as $CaCO_3$	NS	NS	NS	284	120	120	160	128	12	304	136
P-Alkalinity as $CaCO_3$	NS	NS	NS	52	15	<5	<5	<5	<5	48	<5
Bicarbonate as HCO_3	NS	NS	NS	219	109	146	195	156	15	253	166
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	<5	75	95	105	20	53	27	55
Chloride as Cl	Aesthetic ≤300			9	5	8	5	12	44	68	22
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		<2	9	19	3	<2	28	6	6
Fluoride as F		Chronic health ≤1.5		0.9	1.0	0.2	0.2	1.0	<0.2	1.7	0.4
Nitrate as N		Acute health ≤11		0.1	0.1	<0.1	<0.1	<0.1	2.5	<0.1	<0.1
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	0.4	<0.05	<0.05	<0.05	0.6	<0.05
Total Nitrogen as N	NS	NS	NS	1.0	0.6	<0.5	<0.5	<0.5	2.5	0.6	<0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Kjeldahl Nitrogen	NS	NS	NS	0.8	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.7	0.6	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
Calcium as Ca			No health. Scaling intensifies from 32mg/L	1	15	22	28	5	9	6	12
Potassium as K			No aesthetic or health effects below 50mg/L	1.2	8.0	6,6	3,3	3,6	3,7	17,7	7,4
Magnesium as Mg			Diarrhoea and scaling issues from 70mg/L	<1	10	13	14	3	9	4	9
Sodium as Na	Aesthetic ≤200			127	17	13	13	45	18	144	40
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		0,058	5,89	7,47	0,077	0,197	2,77	1,34	1,44
Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2	Diarrhoea and scaling issues from 70mg/L	<0,025	0,186	0,096	0,079	0,030	0,067	0,065	0,110
Aluminium as Al	≤0.3			0,115	0,895	0,171	<0.100	<0.100	0,124	0,350	<0.100

2.2.5.1 Interpretation of groundwater quality information

The results of the chemical analyses presented in Tables 6 and 7 show that the groundwater quality in the hydrocensus and monitoring boreholes generally comply with the SANS241:2015 Drinking Water Standards. The exceptions are hardness, iron, aluminium and fluoride. These are discussed in more detail below. Reference is made to DWAF (1996) in the interpretation of the result :

- **Acute Health effects**: Exceedances may pose an intermediate unacceptable health risk.
- **Aesthetic effects**: Exceedances may taint the water with respect to taste, odour or colour, but does not pose an unacceptable health risk.
- **Hardness**: the groundwater is naturally hard. This is caused by high concentrations of calcium and magnesium salts. Temporary hardness is due to the presence of bicarbonates and can be removed by boiling the water. Permanent hardness is attributed to other salts (sulphates and chloride salts), which cannot be removed by boiling. Excessive hardness can result in scaling in plumbing and household heating appliances and pose a nuisance to personal hygiene (the so-called “soap destroying” nature of water).
- **Iron**: elevated iron concentrations were recorded in one private borehole (KR3) and three monitoring boreholes (boreholes 1-130, Site8 and PM1). The elevated iron concentrations are considered natural and is probably associated with the rock formations present. It is unlikely that the surrounding mining activities could impact on groundwater quality at the Kranspan project. At concentrations exceeding 2 mg/l, a pronounced aesthetic effect (taste) and staining in plumbing is expected. Health effects are expected in young children and sensitive individuals. These are associated with hemochromatosis and tissue damage. Elevated iron concentrations in water also promote the proliferation of iron-oxidising bacteria, which manifests as slimy coatings in plumbing.
- **Aluminium**: The main effect of aluminium at the concentrations observed is relating to the discolouration in the presence of manganese. Concentrations below 0,5 mg/l are not expected to result in adverse health effects. Prolonged exposure to concentrations exceeding 0,5 mg/l may result in neurotoxic effects.
- **Fluoride**: One monitoring borehole (PM2) yielded elevated fluoride concentrations. If ingested, it is absorbed and retained in the skeleton and teeth. At the concentration recorded in the borehole, a small risk of dental mottling exists, but no skeletal fluorosis is expected. It is noted that fluorosis is less severe when the water is hard, since the occurrence of calcium limits fluoride toxicity.

The information presented in Tables 6 and 7 will form the groundwater quality baseline for the project. Future monitoring results must be compared to these concentrations to establish the impact of coal mining on groundwater quality.

2.2.5.2 Piper Diagram

A Piper Diagram uses the relationship between selected chemical parameters to classify water samples according to the dominant cation and anions composition, as well as allowing for the grouping of water according to hydrogeological facies. The Piper Diagram uses concentrations calculated in meq/L to represent a percentage of the total cations or anions. The cations and anions of each sample are plotted on the respective triangular plot and the points are then projected onto the central diamond graph. The Piper Diagram prepared with the Kranspan data is presented in Figure 6. Depending on where the sample point falls on the diamond graph, basic assumptions can be attributed to the sample, and for this reason the diagram is divided into quarters. Plotting the results of the chemical analysis on the diagram gives an understanding and comparing the types of groundwater present.

The left quarter in a Piper Diagram represents freshly recharged water, dominated by calcium-magnesium-bicarbonate signature. The right quarter is associated with stagnant or slow-moving groundwater and is dominated by sodium and chloride. The bottom quarter is typical of dynamic groundwater flow and is dominated by sodium and bicarbonates; and the top quarter typically indicates contamination and is dominated by sulphate.

The diagram indicates that groundwater in boreholes KR11, KR14, KR18, KR19, Site8, 5-110, 1-130b and PM3 fall in the freshly recharge groundwater. Groundwater in boreholes KR12, PM2, 6-220 and 2-50 fall in the dynamic category and KR Spring 3 and PM1 contains stagnant groundwater.

2.2.5.3 Stiff Diagrams

Stiff diagrams are graphical presentation of the general chemistry of water. A polygonal shape is created from four parallel horizontal axes extending on either side of a vertical axis. Cations are plotted on the left of the vertical axis and anions are plotted on the right. The diagrams can be relatively distinctive for showing water composition differences or similarities. One feature is the tendency of a pattern to maintain its characteristic shape as the sample becomes diluted. It may be possible to trace the same types of groundwater contamination from a source by studying the patterns.

Stiff diagrams for the water samples analysed are presented in Figure 7.

The results indicate that the dominant anion in all of the samples, except the KR Spring 3 and PM1, is bicarbonate. This also accounts for the hardness in the groundwater. KR Spring 3 and PM1 is chloride dominant, suggesting stagnant flow conditions.

The dominant cations are sodium and potassium, with the exception of boreholes 5-110 and Site8, which are calcium dominant.

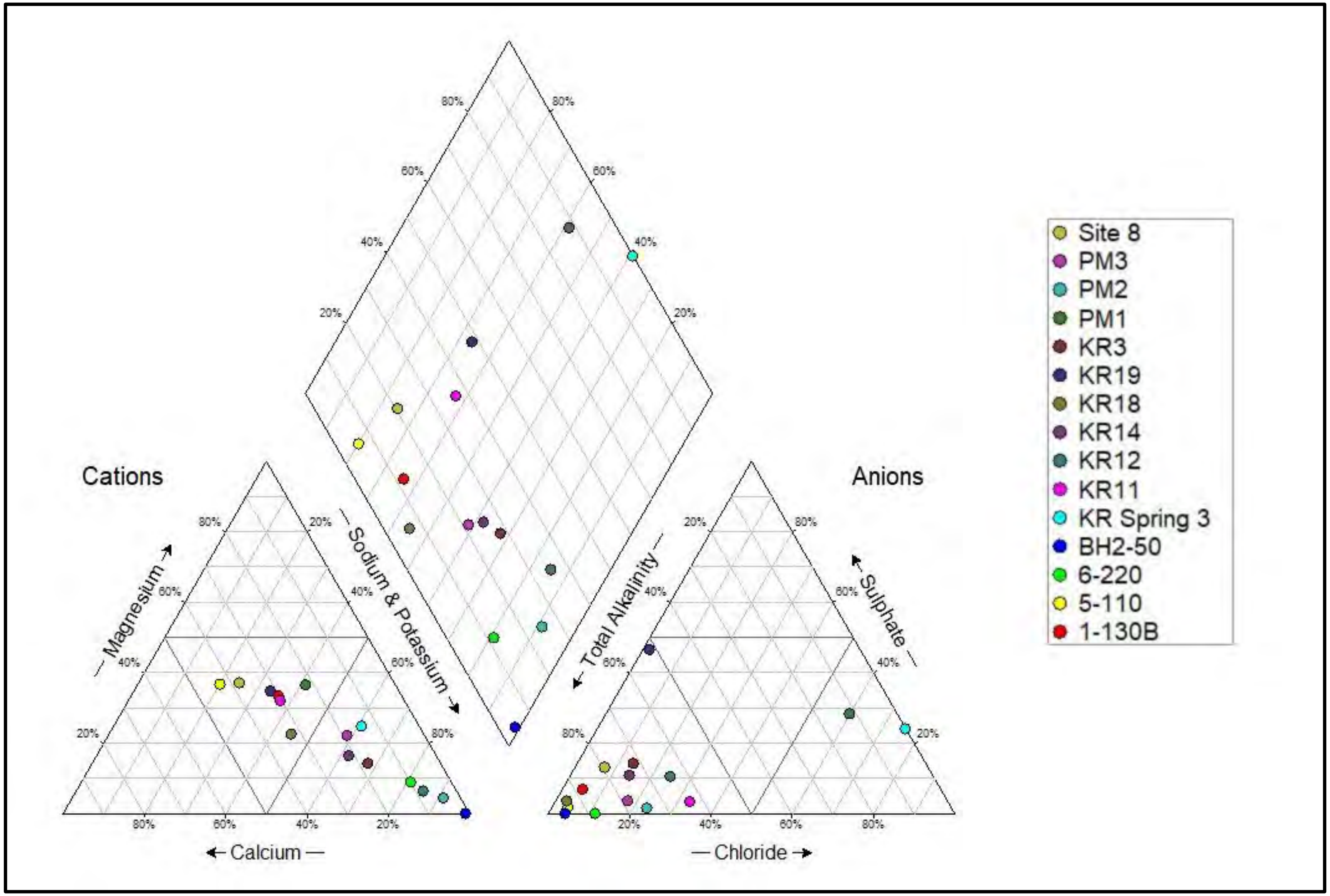


Figure 6 Piper Diagram

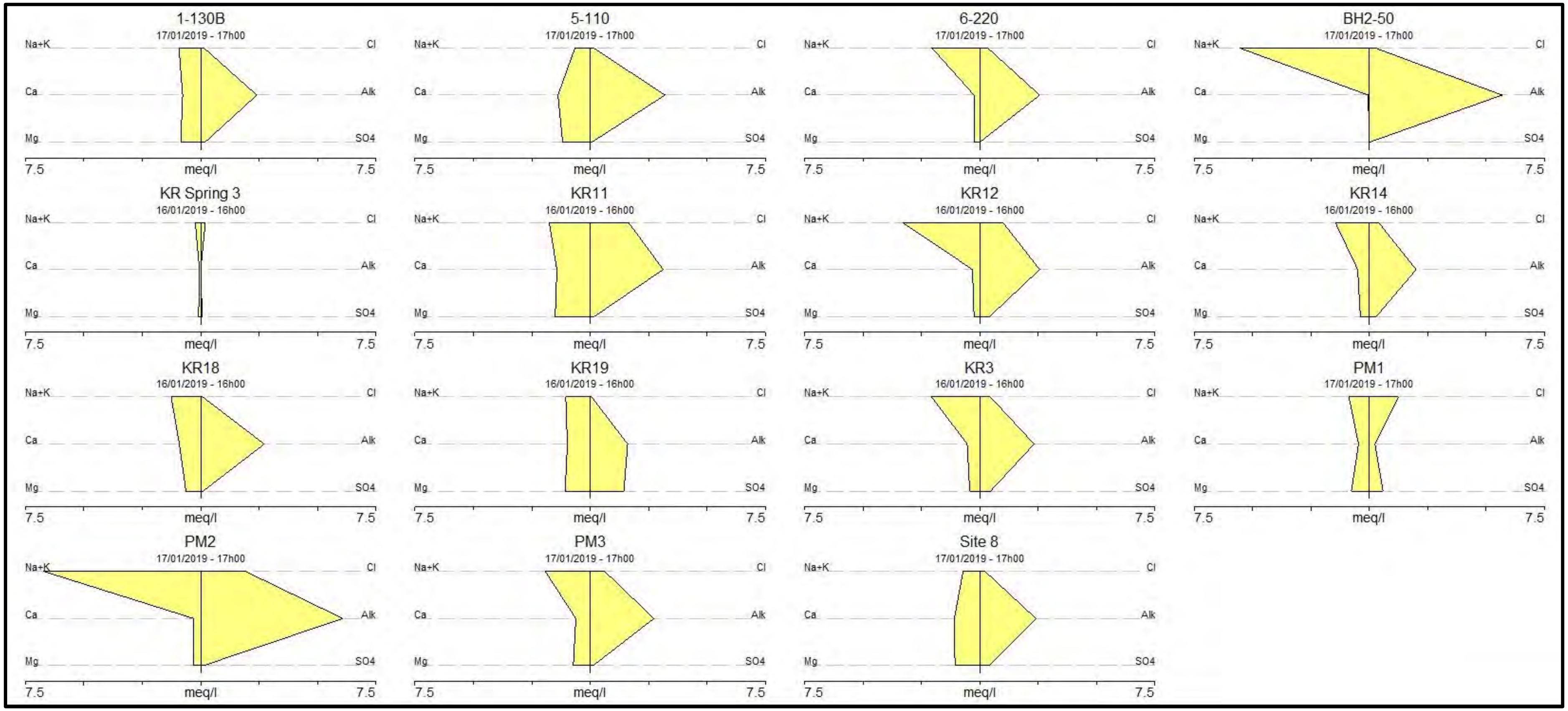


Figure 7 Stiff diagrams

2.3 Summary of conceptual model

The schematic cross section through the project area presented in Figure 8 demonstrates the conceptual model developed from the information discussed above. The location of the cross section is indicated on Figures 1 and 3. The cross section was generated from the exploration borehole data, the digital terrain model (DTM) generated for the area, the geological map presented in Figure 3 and the aquifer information obtained from monitoring and hydrocensus boreholes. This information is summarised in Table 8 as reference.

The cross section indicates the extent of the weathered and fractured rock aquifers as well as the position of the E Seam to be mined using opencast (OC) and underground (UG) mining methods. The NE-SW striking lineaments indicated on the regional geological map is indicated. In the absence of specific information, it is assumed that these structures are vertical and extend to the base of the Ecca Formation. The basement of the geological succession pertinent to the groundwater impact assessment is assumed to be situated beneath the coal seam and comprises Dwyka Tillites.

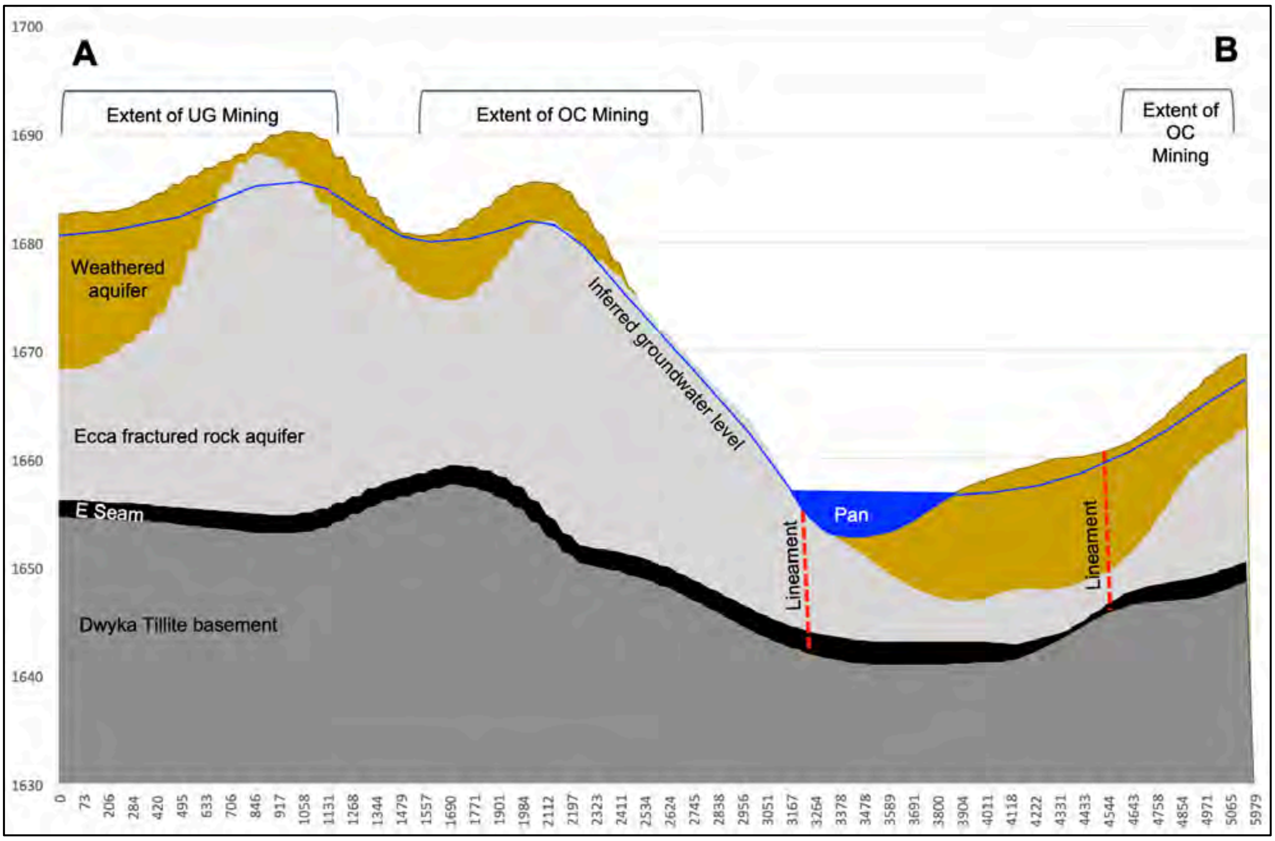


Figure 8 Schematic cross section through the project area

In order to simulate the impact of the proposed mining and auxiliary activities more accurately, especially in terms of the vertical movement of potential contamination from the site, the model was constructed with several layers, as detailed in Table 8.

MODFLOW, the modelling software used during simulations, is based on the assumption that aquifers are continuous porous media. For this reason, average aquifer parameters are assigned during simulations. The heterogeneous nature of a fractured rock aquifer is therefore approximated by a homogenous porous flow field. This is the nature of all groundwater modelling software and not just of MODFLOW. The known lineaments and intrusions are included as discrete zones in the model.

Table 9 Conceptual model configuration

Layer	Description	Thickness (m)	K (m/d): Avg (min; max)	Assumed		
				Sy (-)	S (-)	Porosity (%)
1	Weathered aquifer	9	0,2 (0,1 – 0,3)	0,1		10
2	Fractured aquifer	20	0,08 (0,01 – 0,15)		1,00E-04	1
3		20	0,08 (0,01 – 0,15)		1,00E-04	1
4	E Seam	2	0,08 (0,01 – 0,15)		1,00E-04	1
	Dolerite sill: discrete zone	Varies	0,58 (0,48 – 0,67)		1,00E-03	5
	NE-SW lineaments: discrete zones	Varies	0,58 (0,48 – 0,67)		1,00E-03	5

3 SOURCE TERM

In order to identify and quantify the potential sources to groundwater contamination at the Kranspan project, a desktop study was completed on the available dataset. A geochemistry study will be completed as part of the mining right application. The laboratory results of leach tests completed on various rock samples taken at the operations as part of the geochemistry study was made available for inclusion in the geohydrological impact assessment. A detailed discussion of these results will be provided in the geochemistry report. Evaluation of the geochemical information confirms that sulphate (SO_4) is the indicator element for the project. Elevated sulphate concentrations are characteristic of the impact of coal mining on water quality. Increased sulphate concentrations result from the oxidation of pyrite and other sulphide minerals in the coal, overburden and discard material. This reaction takes place when sulphide-rich rocks are disturbed and exposed to oxygen and water during the mining process.

The information presented in Table 9 reflects sulphate concentrations from static leach tests using three different extraction conditions. It is shown that for all the rock samples taken at the project, sulphate concentrations remain below 250 mg/l. These concentrations are expected to increase with time, especially if acid mine drainage takes in the long-term. The specific concentrations can be determined from kinetic leach tests that are currently underway, as well as from geochemical modelling of the mining environment. The latter falls outside the scope of this investigation. Assumed sulphate concentrations for the operational, medium and long-term that will be used during simulations are presented in Table 10. These are based on the author's experience in similar environments.

Table 9 Results of leach tests completed on rock samples

Sample No	Distilled Water Leachable concentration (mg/l)	Acid Leachable concentration (mg/l)	Peroxide leachable concentration (mg/l)
Ant 3 (2)	249	210	118
Ant 110 (1) E Seam	52	64	210
And 100 (4) E Seam	12	7	146
Ant 105 (1) B Seam	25	30	187
Ant 185 (1) E Seam	39	34	87
Ant 105 (3) CU	21	22	144

Table 10 Assumed source term

Sulphate concentrations	Short-term operational conditions	Medium-term post-closure conditions (<25 years after closure)	Long-term post-closure conditions (25 – 100 years after closure
Opencast mining area	50 - 250	500 – 3000	3000 - 1000
Underground mining: 5 Seam	50 - 250	500 – 3000	3000 - 1000
Discard material	50 - 250	500 – 3000	3000 - 1000

4 POTENTIAL PATHWAYS AND RECEPTORS

Based on the available dataset, the following aquifer pathways are identified for the project:

- Vertical flow through the unsaturated soil horizon from surface source of contamination like the overburden stockpiles, the coal crushing plants, discard dumps and possibly the PCDs to the underlying weathered and fractured rock aquifers. It is noted that the PCDs will be HDPE lined and as such should not impact on groundwater quality unless they overflow or if the liners leak. The rate at which the vertical flow can take place is governed by the permeability of the soils.
- Vertical and horizontal flow through the weathered aquifer from surface sources of contamination as well as mining areas that intersect this aquifer. It is noted that the contact between fresh and weathered rock is considered a preferential flow path to groundwater.
- The dolerite sill that has intruded into the shallow Ecca Formation sediments in the western part of the mining area is expected to act as a barrier to vertical flow over the extent that it has been mapped. The rate at which potential contamination could migrate through the dolerite sill is not clearly understood and assumptions have been made during simulations, which must be tested and updated as necessary.
- Once the possible contamination reaches the fractured rock aquifer, the preferential flow paths include fractures, faults, joints and bedding planes in the rock formations. Groundwater will also flow through the rock matrix, but at much lower rates compared to the preferential pathways (NE-SW trending lineaments).

The following receptors were identified:

- Existing private groundwater users.
- The pans present within the mining area.
- Rivers and streams down gradient of each mining area. Groundwater is expected to contribute to river and stream baseflow, specifically during the wet season when groundwater levels are expected to rise above the base of the streams as a result of the recharge of rainwater.

5 KEY ASSUMPTIONS AND LITERATURE-BASED DATA INPUTS

The numerical modelling is based on the following assumptions:

- Aquifer parameters were inferred from the fieldwork programme completed as part of this study. Aquifer parameters used to construct the numerical model are presented in Table 4, as discussed above. Parameters that were assumed include aquifer storage coefficients, porosities and the rate of recharge. It is further assumed that the vertical permeability is $1/10^{th}$ that of the horizontal permeability.
- The source characterisation used for the project was inferred from the existing dataset. The values that will be assigned during simulations are presented in Table 10.
- Only advective transport of contaminants was simulated. Assumptions made regarding advection, are discussed below. While it is acknowledged that attenuation will take place in the soils, there is currently insufficient information available to quantify the extent to which this takes place. As such, simulations are based on the precautionary principle and take the worst-case scenario into consideration.
- The extent of the numerical model is based on natural groundwater barriers, as discussed below. These include water divides as well as rivers and streams.
- The extent and timing of mining activities were obtained from information made available as part of the study. Details of this are discussed below.

6 NUMERICAL GROUNDWATER MODELLING

6.1 Modelling objectives

The objectives of the numerical modelling undertaken as part of the project are to:

- Define the radius of influence that will be created by mine dewatering and identify which existing private groundwater users would be affected by mine dewatering.
- Estimate the volume of groundwater that would seep into the opencast and underground workings during mining.
- Estimate the impact of mine dewatering on rivers, streams and wetlands.
- Determine the period of time it would take for groundwater levels to recover after mining ceases.
- Assess whether or not decant from the underground workings is likely.
- Define the extent of possible contamination originating from the proposed mining areas and mine infrastructure on the shallow weathered and deeper fractured rock aquifers during and post mining.
- Estimate the impact of groundwater contamination associated with the mining areas on private groundwater users, rivers, streams and wetlands.

6.2 Delineation of the modelling area

The project location within the chosen model boundary is indicated on Figure 1. The following aspects were considered during the delineation of the model boundary:

- The extent and location of quaternary catchment boundaries.
- Natural groundwater flow boundaries, for example streams, rivers, water divides and geological contact zones.
- The extent of the project area.

The model boundary will comprise a no-flow boundary along its northern and southern sections. General head boundaries are used along the eastern and western sections in order to allow for flexibility in groundwater level elevations at model boundaries. Positions where the Vaalwaterspruit and the Boesmanspruit exit the model area are simulated with constant head boundaries.

The model boundary covers an area of 270 km^2. The NE-SW trending lineaments indicated on the 1:250 000 geological map for the project area are included as discrete zones.

Aquifer characteristics compiled from all sources for the monitoring boreholes on site, as discussed above, are included in the model.

6.3 Model construction

The numerical modelling was undertaken according to accepted industry principles and standards, including the South African Department of Water and Sanitation's Best Practice Guideline for Impact Prediction (DWS BPG G4, 2008). The design and construction of the numerical model is based on the conceptual model discussed above.

The numerical model for the project was constructed using MODFLOW and MT3DS. MODFLOW is a modular three-dimensional groundwater flow model and MT3DS a modular three dimensional solute transport models published by the United States Geological Survey. MODFLOW and

MT3DS use 3D finite difference discretization and flow codes to solve the governing equations. MODFLOW and MT3DS are a widely used simulation codes, which is well documented. MODFLOW is used to simulate groundwater flow rate and direction. MT3DS is superimposed on the MODFLOW simulation results and is used to predict the rate and direction of contaminant movement in the aquifers.

The NW-SE trending lineaments indicated on the 1:250 000 geological map for the project area are included as discrete zones in the model domain. The dolerite sill present along the western boundary of the project area was also included as a discrete zone.

The model boundary comprises a no-flow boundary along its northern and eastern sections. The perennial rivers and streams that co-incide with model boundaries were simulated as general head boundaries. Water divides and catchment divides were simulated as no-flow boundaries. The positions where perennial streams exit the model domain were simulated as constant head boundaries. Perennial streams that fall inside the model domain were simulated with the MODFLOW River Package. Non-perennial rivers and streams inside the model boundary were simulated with MODFLOW's Drain Package. The drains will remove groundwater from the model if the groundwater level rises above the specified drain elevation.

The model area was refined into block cells of 25 x 25m around the mining areas (Figure 9). The finer grid allowed more detailed simulations around the areas of interest. Towards the model boundaries and away from the area of interest, the model grid size increases to 200m.

The model grid comprises cubic cells, used to represent the aquifers present. The layer configuration used during simulations is summarised in Table 11.

In the vertical direction, four layers were included in the model. The position and thickness of each layer was inferred from the exploration and monitoring borehole data made available to the study. The upper layer presents the weathered aquifer. The second to fourth layers represent the Ecca aquifer. The dolerite sill is included as a discrete zone in Layer 2 of the model.

The upper layer was simulated as an unconfined aquifer. The remainder of the layers were simulated as varying between confined and unconfined conditions with the transmissivity for each layer calculated from the hydraulic conductivities prescribed and the varying groundwater levels. All units used during simulations were presented in metres (length) and days (time).

6.4 Model input files and integration

6.4.1 Groundwater flow simulations

The conceptual model discussed above was used to construct the numerical model for the project area. The modelling input parameters used are based on the information currently available for the project area, as discussed earlier in this report. The initial parameters were gradually adjusted during calibration to obtain an acceptable fit between simulated and measured heads, as discussed below.

The initial head conditions, used during model calibration, were interpolated from the digital terrain model (DTM) for the model domain. It was assumed that the average depth to groundwater in the upper weathered aquifer is 4,4m, as calculated from the groundwater monitoring dataset. The average depth to groundwater in the underlying fractured rock aquifer is 9,7m.

The DTM was also used to ensure that the elevations of the river and General Head and Constant Head Boundary conditions reflect the ground conditions as closely as possible.

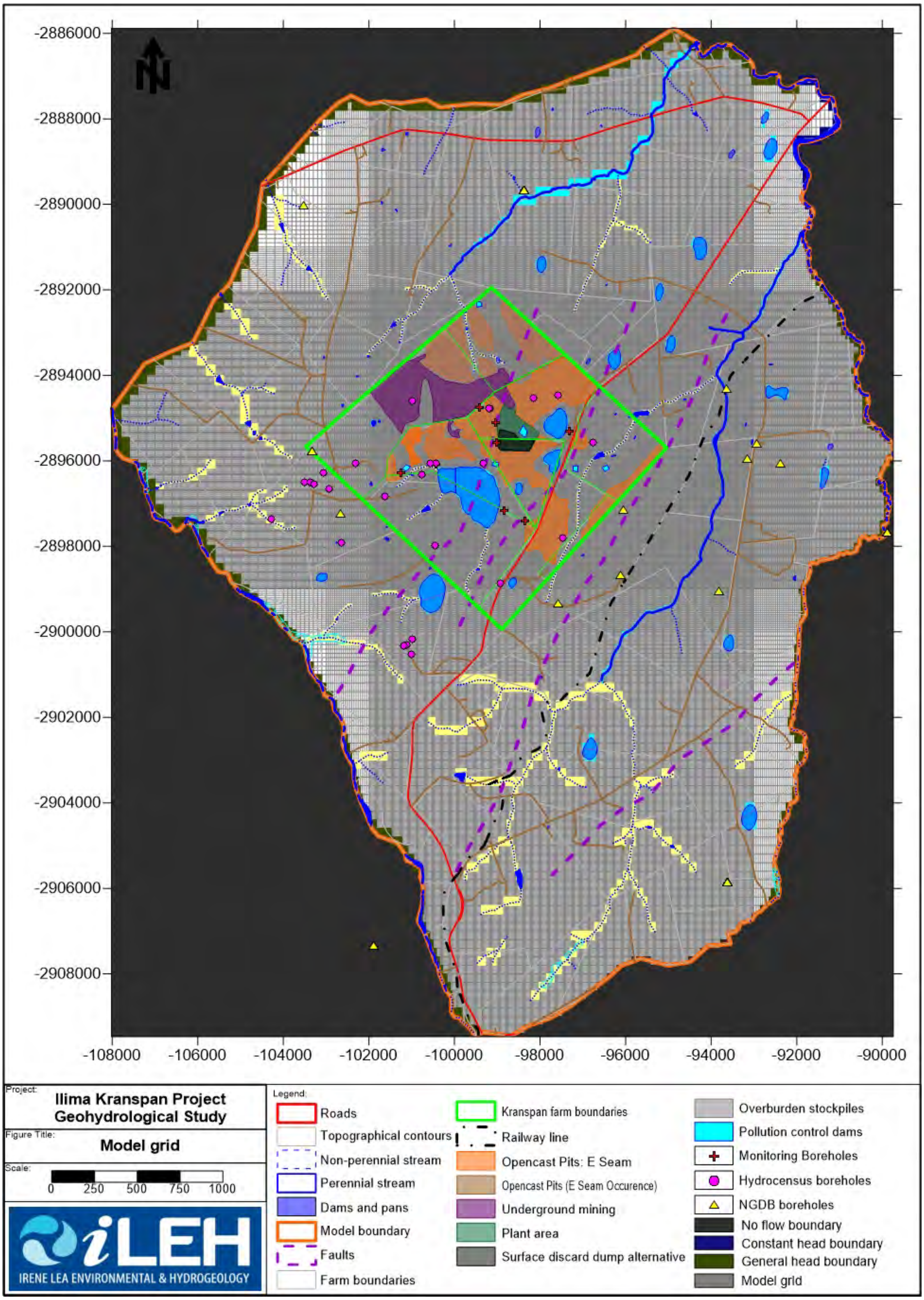


Figure 9 Model grid layout

6.4.2 Contaminant transport simulations

The MT3DS contaminant transport model used for the project is based on the calibrated flow model. During simulations contamination was simulated only under advective and dispersive conditions. Darcy's Law governs advective flow. Under advective flow, the distance that the simulated plumes may move under uniform flow conditions is calculated from the flow velocity and the specified simulation times.

It was assumed that flow would predominantly take place in the horizontal flow direction and that transverse dispersivity is 10 times lower. Molecular diffusion, which is mainly the result of transverse dispersivity, was simulated with a coefficient value of 8,64E-5 m^2/d and that the longitudinal dispersivity is between 50 and 100m.

It is acknowledged that other factors play a role in the movement of contamination in the aquifers, other than advection and dispersion. This may include chemical reaction with or adsorption to clay and soil material, ion exchange or precipitation of salts from solution. These chemical reactions were not included during simulations undertaken for the project. It is acknowledged that these chemical processes would in most instances further retard plumes thus reducing the concentrations of contaminants. There is currently insufficient information available to consider these factors during simulations. As such, advective and dispersive contaminant transport simulations provide a worst-case outcome scenario, as it assumes that the plume will move at the same rate as groundwater flow.

The impact of the proposed Kranspan project on groundwater quality was simulated using SO_4 as indicator element. The conceptual source term used to commence contaminant transport simulations is presented in Table 10.

During simulations, it was assumed that the pollution control dams (PCDs) will be lined with HDPE and are designed to meet the requirements of GN704. As such, these dams are not expected to leak or spill during the operational phase and should therefore not pose a threat to groundwater contamination. If leaks and spills occur, it would be impossible to predict when, where and how these would take place, excluding realistic simulations with the model. Upon closure, the PCDs will be removed and fully rehabilitated, leaving no long-term risk to groundwater contamination.

6.5 Groundwater flow model calibration results

Calibration of a numerical model refers to the demonstration that the model is capable of reproducing field-measured data, which are the calibration values. Calibration is achieved when a set of parameters, boundary conditions, source terms and stresses are found that produce simulated heads and concentrations that match field measured data within the calibration criteria set for the project. This is an important step in the modelling project, which ensures that model results are reliable.

The calibration criteria set for the project are presented in Table 12.

Table 12 Flow model calibration criteria

Requirement	Acceptability criteria	Compliance
Model convergence	Maximum change in head of 0,001m	Complied with (see discussion below)
Water balance	Difference between inflow and outflow <1%	Complied with (see discussion below)
Calibration error	80% of targets with <5m error between simulated and measured head	Complied with (see discussion below)

The model convergence of 0,001m was achieved during calibration. The water balance error obtained at the end of calibration was 0%, as presented in Table 14.

Table 14 Model water balance output

Flow term	Inflow (m^3/d)	Outflow (m^3/d)	Balance (m^3/d)
Storage	1,139E+02	1,373E+04	-1,259E+04
Constrant head	7,152E+00	1,911E+01	-1,196E+01
Drains	0.000E+00	2,526E+02	-2,526E+02
Recharge	1,532E+04	0.000E+00	1,532E+04
River leakance	1,143E+01	6,615E+02	-6,501E+02
General Head Boundaries	1,505E+04	1,686E+04	-1,812E+03
Total flow	3,152E+04	3,152E+04	0,000E-03
Discrepancy (%)	0%		

Model calibration results are discussed below.

It is shown that the calibration residual (the difference between measured and simulated head) is less than 5m for 85% of the steady state calibration data points. The term "head" refers to the groundwater levels. During transient calibration, 81% of the data points complied with the calibration residual criteria.

The root mean square error (RMSE) of the calibration results was calculated in order to determine the goodness of fit of the calibration results. This calculation provides an indication of the standard deviation of the calibration errors. As the calibration error measures how far the simulated values are from the regression line, the root mean square error provides an indication of how spread out the calibration errors are. The RMSE of the steady state calibration results is 3,27m; and 4,57m for the transient calibration set, which are both within the calibration criteria set.

6.5.1 Steady state calibration

The steady state calibration was completed with the available groundwater level monitoring set and the results are presented in Table 13 and in Figure 10.

Table 13 Steady state calibration results

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
KR1	1719,30	1723,56	-4,26
KR4	1653,67	1649,88	3,79
KR7	1688,37	1685,49	2,88
KR8	1688,54	1690,23	-1,69
KR9	1704,43	1707,94	-3,52
KR16	1697,56	1708,04	-10,48
KR17	1705,06	1710,04	-4,98
1-130	1678,92	1682,46	-3,54
2-50	1669,29	1675,78	-6,49
5-110	1684,64	1687,01	-2,37
6-220	1660,79	1663,70	-2,91
PM1	1663,54	1665,10	-1,56
PM2	1661,54	1662,09	-0,55
PM3	1657,14	1659,02	-1,88
KR-SPR1	1706,17	1711,00	-4,83
KR-SPR2	1700,45	1708,00	-7,55
KR-SPR3	1647,78	1648,00	-0,22
KR-SPR4	1729,88	1730,00	-0,12
KR-SPR5	1659,32	1659,00	0,32
KR-SPR6	1663,74	1662,00	1,74
KR-SEEP	1711,48	1718,00	-6,52
2-50B	1671,29	1675,48	-4,19
5-110B	1682,73	1685,56	-2,83

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
6-220B	1661,79	1665,87	-4,08
SITE8B	1702,90	1707,46	-4,57
PM1B	1663,54	1664,96	-1,42
PM3B	1657,14	1658,46	-1,32

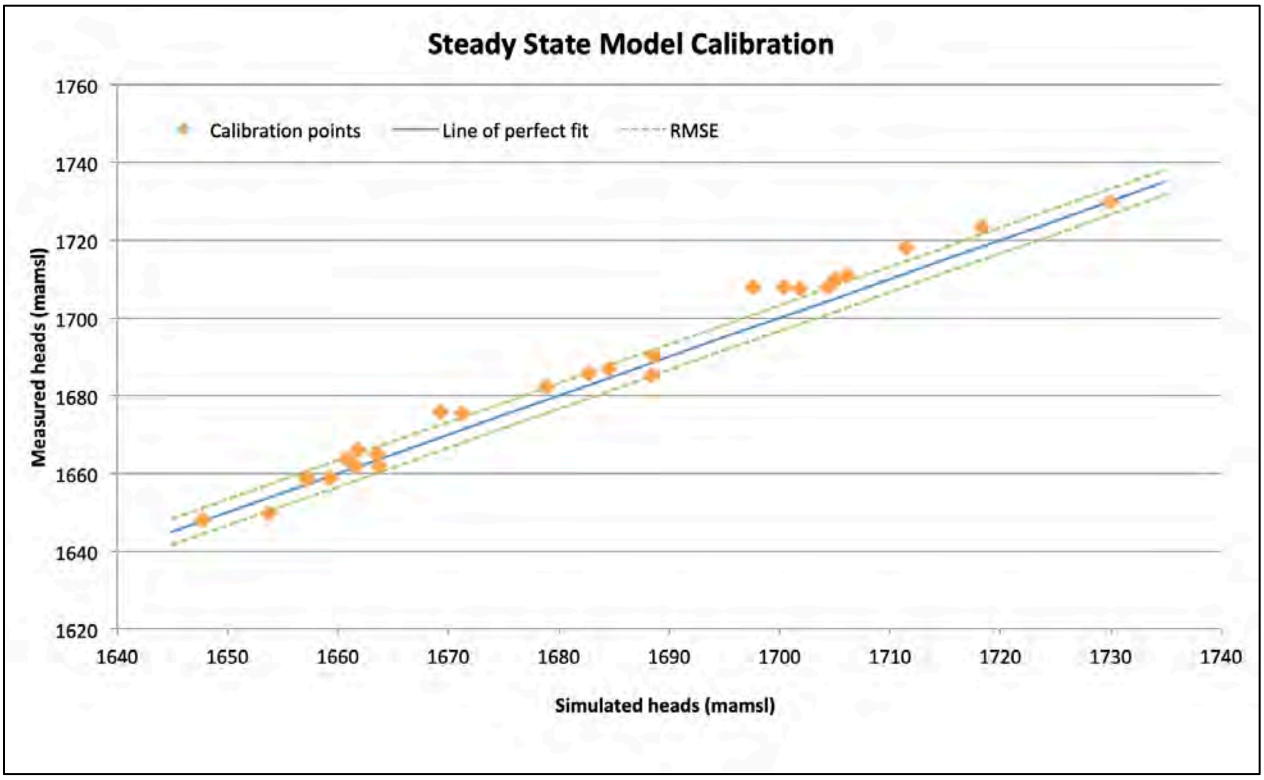


Figure 10 Steady state calibration error distribution

A scatter diagram of the calibration results is presented in Figure 10. A perfect calibration will yield results that fall on a straight line through the origin at zero with a slope of one. The RMSE of the calibration results is also indicated on the graph. It is shown that most of the calibration results (85%) plot close to or within the RMSE bandwidth on the graph.

6.5.2 Transient calibration

Transient calibration was completed with the current monitoring information and the results are presented in Table 14 and Figure 11.

As mentioned above, 81% of the data points were within the 5m calibration residual criteria, as demonstrated on the graph in Figure 14.

The RMSE for the transient calibration process is 4,57m, which is within the calibration criteria set.

Table 14 Transient calibration results

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
KR1	1719,10	1723,56	-4,46
KR4	1658,31	1649,88	8,43
KR7	1689,31	1685,49	3,82
KR8	1689,49	1690,23	-0,74
KR9	1705,15	1707,94	-2,79
KR16	1704,14	1708,04	-3,90
1-130	1679,57	1682,46	-2,89
2-50	1669,49	1675,78	-6,29
5-110	1684,83	1687,01	-2,18
6-220	1665,48	1663,70	1,78
PM1	1665,20	1665,10	0,10
PM2	1666,51	1662,09	4,42
PM3	1660,79	1659,02	1,77
KR-SPR1	1702,88	1711,00	-8,12
KR-SPR2	1707,10	1708,00	-0,90
KR-SPR3	1652,16	1648,00	4,16
KR-SPR4	1725,37	1730,00	-4,63
KR-SPR5	1663,39	1659,00	4,39
KR-SPR6	1666,60	1662,00	4,60
KR-SEEP	1708,12	1718,00	-9,88
2-50B	1673,76	1675,48	-1,72
5-110B	1686,25	1685,56	0,69
6-220B	1665,46	1665,87	-0,41
SITE8B	1698,45	1707,46	-9,01
PM1B	1668,43	1664,96	3,47
PM3B	1662,06	1658,46	3,60
KR17	1711,66	1710,04	1,62

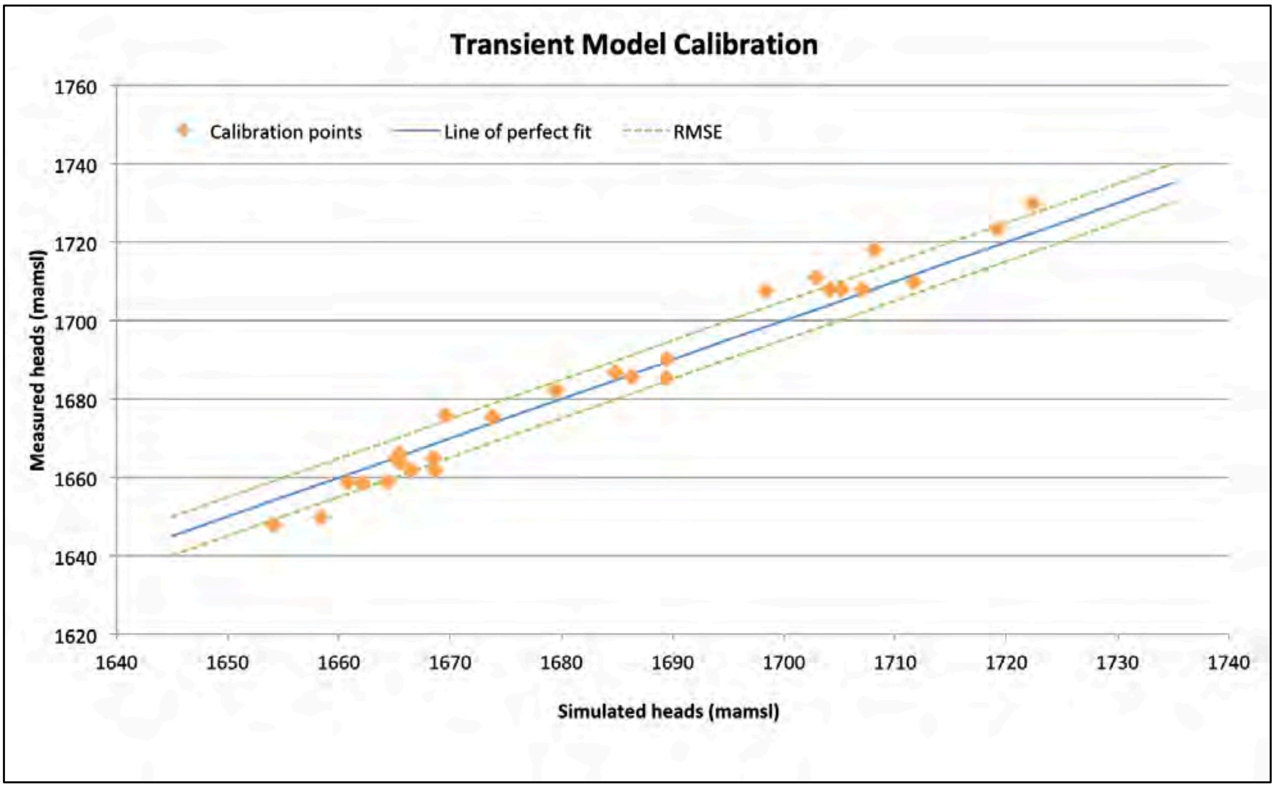


Figure 11 Transient calibration error distribution

6.5.3 Measures to improve calibration results

Factors that influence the calibration process and results include the following:

- Errors in the coordinates and elevations recorded for the hydrocensus boreholes. These boreholes were captured with a hand-held GPS, which is not always accurate.
- Errors in groundwater level measurements.
- The effect of groundwater abstraction by private groundwater users on the measured groundwater level measurements.
- The absence of borehole logs and depths which to characterise the aquifer conditions that groundwater levels in hydrocensus boreholes represent. The purpose of calibration, it was assumed that all hydrocensus and monitoring boreholes target the fractured rock aquifer. The springs recorded were used to calibrate the weathered aquifer.
- The use of average values to approximate heterogeneous aquifer conditions also adds to the calibration error.

6.5.4 Calibrated aquifer parameters

The calibrated aquifer parameters, based on the outcome of model calibration, are presented in Table 15. The calibrated rate of recharge is 3% of MAP.

Table 15 Calibrated aquifer parameters

Layer	Description	Thickness (m)	K (m/d): Avg (min; max)	Specific yield (-)	Specific storage (-)
1	Weathered aquifer	9	2E-3	0,06	
2	Fractured aquifer	20	8E-4		3,2E-6
3		20	8E-4		3,2E-6
4	E Seam	2	8E-4		3,2E-6
	Dolerite sill: discrete zone	Varies	5E-3		6,7E-5
	NE-SW lineaments: discrete zones	Varies	3		2,98E-5

6.6 Model sensitivity

A sensitivity analysis was completed on the model. The purpose of the sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses and boundary conditions. The level of heterogeneity of the aquifer material can never be accurately measured with field data. The uncertainty of the impact of heterogeneity on simulations is therefore assessed as part of the sensitivity analysis. Test simulations were therefore undertaken to determine the sensitivity of the modelling results to variations in key parameter values.

The results of the sensitivity analysis are presented in Figure 12. The larger the head changes during the analysis, the more sensitive the model is to that parameter.

The results indicate that the model is most sensitive to changes in the rate of recharge to the aquifers as well as the specific yield of the upper weathered aquifer. There is currently no site-specific information available to characterise these parameters and the calibration results are based on estimates based on the author's experience. A better understanding of these parameters can be obtained through analysis of hydrographs (groundwater level fluctuations with time) that will be available once a groundwater monitoring programme is in place at the proposed mine.

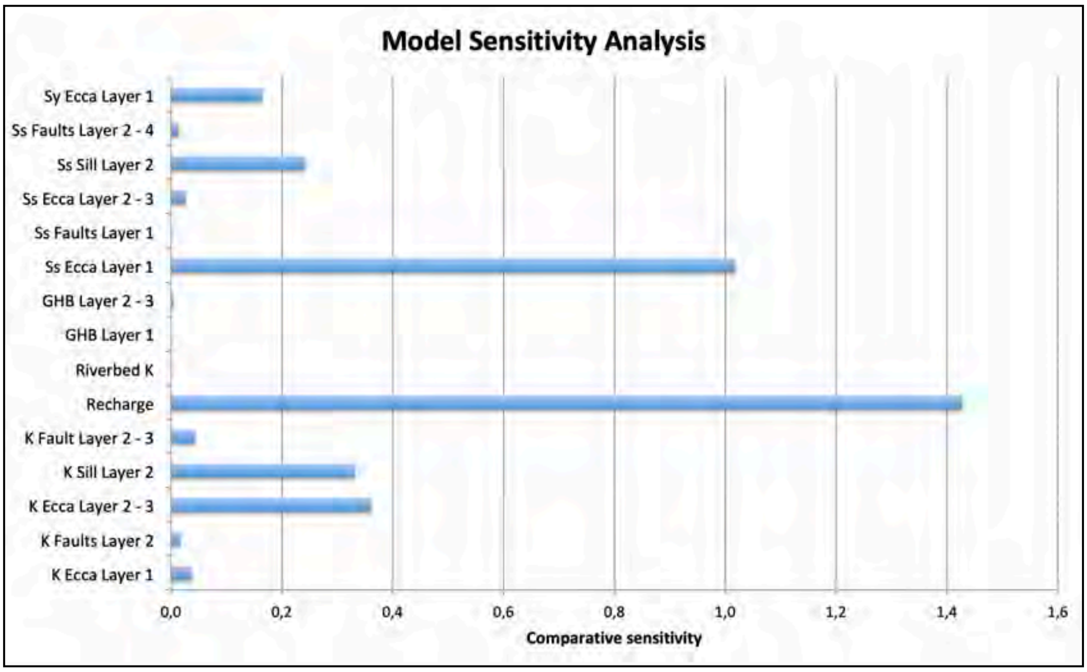


Figure 12 Sensitivity analysis

6.7 Assessment uncertainties

The accuracy of the modelling project depends on the quality of the input data, the available information, time available to complete the calibration process and to test the outcome of scenario modelling. Even with an unchanging environment, impacts are difficult to predict with absolute certainty. Predictions were calculated with the calibrated flow model, which is a simplified version of reality. The model represents a tool that can be used to assess the impact of the proposed mining areas on the aquifers and to identify data gaps. The calibration error is discussed above and is thought to be acceptable. The model should be updated and verified with site-specific monitoring information, when it becomes available. Calibration against hydrographs will be of specific value in improving the current understanding of aquifer parameters. Uncertainties are approached conservatively, based on the precautionary principle, in order to ensure that the predictions and impact assessment in this report addresses the maximum potential impact of the proposed development. The uncertainties in the model include:

- **Uncertainties regarding aquifer conditions within the project area**: This understanding can be improved through the implementation of a groundwater level and quality monitoring programme at the mine.
- **Uncertainties regarding borehole depth, construction and geology intersected**: This information is not available for the hydrocensus boreholes. For this reason, it was assumed that all hydrocensus boreholes target the fractured rock aquifer.
- **Uncertainties regarding the borehole elevations**: The elevations used for the hydrocensus boreholes during simulations were inferred from hand-held GPS measurements and inaccuracies may occur. It is however thought that the error in elevation will not exceed the calibration error of 5m.
- **Mathematical modelling uncertainties**: It is not possible with the available information to quantify the heterogeneity present in the aquifers simulated. For this reason, there are inherent uncertainties in the model. The level of confidence in the model can be improved with the incorporation of additional monitoring data.

The uncertainties listed above can be reduced or eliminated through implementing an on-going groundwater monitoring programme at the mine. This information can be used to improve aquifer parameter estimation and model calibration.

7 GEOHYDROLOGICAL IMPACT ASSESSMENT

7.1 Mine plan used

The mine plan used during the simulations is presented in Figure 13. The figure is based on information made available to the study and indicates the extent and timing of both opencast and underground mining. For the sake of convenience, the pits were numbered in the sequence in which they will be mined. Mining will commence from Pit 1 situated close to the Plant area. Opencast mining will be undertaken over a 14-year period. Mining will be completed at Pits 10 and 11. Underground mining will be completed over a period of 12 years, as indicated in the Mining Work Programme submitted for the project (Ilima, 2018).

The E Seam floor contours are overlain on the figure. It is shown that the depth to coal increases towards the northwest. In this area, underground mining is proposed. The coal seam is shallower in the southern and eastern mining areas. The dip of the coal seam is indicated as vectors on Figure 13. It is shown that the dip of the coal seam is variable over the mining area.

7.1.1 Wetlands

The wetlands are often associated with areas of shallow groundwater table conditions, as well as with the pans and streams present. As such, the impact of mining on the shallow weathered aquifer is of importance to the sustainability of wetlands during and after mining. A lowering in groundwater levels would have a negative impact on wetlands. The impact of mine dewatering is therefore of importance when evaluating the impact on wetlands.

The wetlands were delineated as part of the Scoping Phase of the project. The extent of these, including the mandatory buffer zone around each, is indicated on all figures in this report.

It is thought that any permanent lowering of the groundwater table will reduce the groundwater that feeds many of the wetlands in the area, on which the wetland fauna and flora is dependent for survival. This could result in a loss of riparian vegetation and wildlife habitat. The depth of groundwater fluctuation that would negatively affect wetland sustainability will depend on the root depth of the plants. For the simulations discussed below, it is assumed that wetlands that fall in zones of impact where the groundwater level is lowered by more than 1 m, would be negatively affected during mining. This assumption needs to be confirmed and re-assessed, if necessary. It is however a conservative approach, as a 1 m drawdown in groundwater level would be closely associated with the edge of the zone of influence delineated by the 0 m drawdown contour.

In addition to the impact of fluctuations in groundwater levels, contaminated groundwater that infiltrates from the mining areas will also have adverse impacts on wetland flora and fauna. Any changes in the geochemical character of the soil and/or water are expected to have a negative impact on biological communities in the wetlands. This is especially true if the pH of water drops because of acid mine drainage or if the salt and metal concentrations increase to toxic levels in the groundwater discharging to the wetlands.

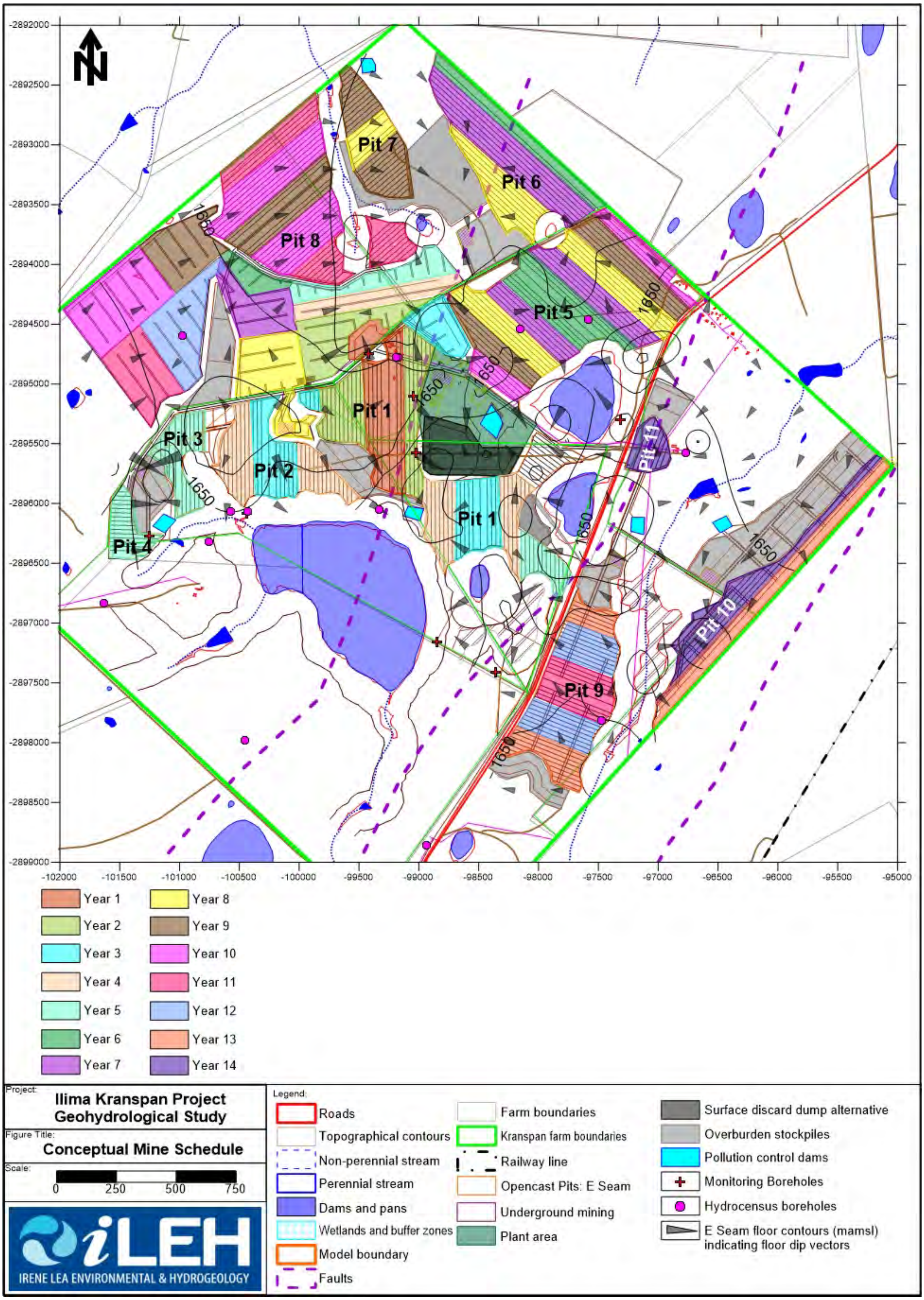


Figure 13 Mining schedule used during the assessment

7.1.2 Risk of acidification of the mine water

A geochemical assessment is currently underway. To date, the results of static tests completed on samples taken from the Kranspan project, are available (Van Hille, 2019). Kinetic testing is still underway and the results of these were not available at the time of compilation of this report.

Two rock sampling sets were analysed as part of the static tests completed. These include discard samples generated during a small-scale washing experiment, using reject coal samples. A number of drill core samples were also taken for analysis. There are representative of waste rock/overburden stockpile material. The results of whole rock analyses on the samples taken indicate that zinc and to a lesser extent manganese are indicator trace elements and are present in significant concentration in six of the samples analysed.

In addition, the tests completed indicate that the samples have relatively low concentrations of calcium and magnesium, suggesting limited acid neutralising capacity. The results of acid base accounting analysis completed by Van Hille (2019) indicate that five of the six coal discard samples must be considered acid generating. It is noted that the remainder of the samples had a low neutralising capacity.

The results of the leach tests indicate that the drill core samples were essentially inert under deionised water leach conditions. Under acid leach conditions, elevated barium, manganese and lead were recorded. Net Acid Generation leach tests yielded elevated concentrations of chromium, manganese, lead and nickel, but not exceeding the LCT1 threshold values.

The study concludes that the discard material tested has a high probability of becoming acid generating if stored in a surface impoundment for a significant amount of time. There is however a level of uncertainty regarding the magnitude of the acid generating potential in the outcome of the tests. Greater clarity is expected once the kinetic testing is completed.

It is further concluded that the waste rock (drill core) samples poses a lower environmental risk with only one out of twenty samples taken demonstrating significant acid generating potential.

Based on the discussion above, the modified sulphate concentrations presented in Table 10, will be applied during simulations.

The trace elements that leached from the discard and rock samples will be used to design an appropriate groundwater monitoring programme for the operations.

7.1.3 Discard management

Two possible discard management measures are considered for the project. The preferred option entails backfilling the discard material into mined-out pits. The alternative option is to construct a discard facility on surface. The position of the alternative is indicated on Figure 13.

According to the Scoping Report (ABS Africa, 2018), the following details are applicable to discard management:

- The preferred alternative is to dispose of discard from the wash plant in-pit as part of the on-going rehabilitation of the opencast mining areas.
- The possible surface engineered discard stockpile alternative will cover an area of 26,94 ha. If this alternative is implemented, the discard stockpile will be designed in compliance with the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015.
- For the purpose of the impact assessment presented in this report, two scenarios were tested

for the surface discard stockpile, namely an unlined and a lined facility.

- The rate at which leachate can infiltrate from the discard stockpile in the unlined scenario, will depend on the permeability of the soils underlying the facility. In the absence of site-specific measurements, the permeability of the weathered aquifer will be assigned to test this scenario.
- If the facility is to be lined, the type of liner will depend on the characteristics of the discard material and an assessment against the National Environmental Management: Waste Act (Act 59 of 2008) (NEM:WA),the Waste Classification and Management Regulations, as amended (R635) and the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015. This assessment falls outside the scope of the geohydrological study. A discussion of the results of static geochemical tests completed by Van Hille (2019) suggests that the samples analysed did exceed the TCT0 and LCT0 threshold values for a number of elements, but in these cases the values measured were significantly below the relevant TCT1 and LCT1 values. Under these conditions, it is likely that a surface discard stockpile may require at least a Class C liner (modified compacted clay liner), or a liner as prescribed by the professional engineer appointed to complete the designs for the facility. It is acknowledged that the liner requirements will depend on the outcome of a risk assessment and recommendations made by a competent person, as indicated in the the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015 For the purpose of the geohydrological impact assessment, a Class C liner will be evaluated.

In order to obtain a first approximation of the impact of a lined and unlined surface discard stockpile, literature-based leachate volumes were used. These are based on the work undertaken by Rowe (2012), as presented in Table 17. In order to complete the simulations, it was assumed that a Class C liner will be considered and that the construction controls are less than perfect in order to assess the worst case scenario. Under these conditions, the rate of recharge from the discard stockpile will be around 0.96% of the mean annual precipitation (MAP), which is less than the natural rate of recharge to the aquifers of 3% of MAP.

Table 17 Class C liner leakage volumes (after Rowe, 2012)

Liner installation conditions	Leakage volume		% of MAP
	m^3/s	m^3/d	
Tight control	1,48E-06	0,13	0,02
Less control	5,95E-05	5,14	0,96

7.1.4 Rehabilitation measures included during simulations

It was assumed that all surface infrastructure would be removed and rehabilitated upon mine closure, including PCDs and the plant area. The surface will be rehabilitated and made free-draining. Under these conditions, the rate of recharge would revert back to natural rates.

The overburden dumps will be continually backfilled into mined out pits during the operational phase. During simulations, it was assumed that rehabilitation would reduce the rate of recharge of rainwater to the facilities from 20% of MAP to 5% of MAP. This will in turn reduce the volume of contaminated leachate that could infiltrate from the overburden stockpiles to the underlying aquifers in future. At closure, it was assumed that all overburden stockpiles will be backfilled into mined-out pits and that the remnant surface areas would be rehabilitated, shaped and free draining. The rate of recharge to unrehabilitated and rehabilitated opencast mining areas were taken from Grobbelaar et al (2004), as summarised in Table 16.

Table 16 Recharge rates used during simulations (after Grobbelaar et al, 2004)

Mining area	Literature-based recharge rate (% of MAP)	Value used
Unrehabilitated spoils	30 – 80%	50%
Levelled spoils	15 – 30%	20%
Rehabilitated spoils	5 – 10%	5%

During long-term simulations, it was assumed that the adit will be backfilled, shaped and made free-draining. Under these conditions, the rate of recharge to the underground workings would revert to natural rates. It is further assumed that no subsidence will take place above the underground workings. This will be achieved through sound planning and the implementation of the necessary safety factors to ensure stability. As no subsidence of ground is expected above the underground workings, the rate of recharge to areas disturbed by underground mining was assumed to be 3% of MAP.

In the opencast mining areas, it is assumed that backfilling and shaping of the pits will reduce the rate of recharge, but not to natural rates. It is unlikely that rehabilitation of the disturbed areas would result in pre-mining recharge conditions.

7.2 Impact on groundwater availability

The impact on groundwater availability was assessed with the aid of the calibrated groundwater flow model prepared for the project.

As discussed earlier in this report, the model assumes average permeabilities for the rock formations that will be intersected during mining. The aquifers are however heterogeneous and variable groundwater seepage rates can therefore be expected. For example, if a water-bearing feature is intersected, the rate of groundwater seepage will increase. On average however, the aquifers present in the area are not considered strong, as suggested by the outcome of the hydrocensus and the results of the monitoring borehole drilling and testing programme.

The NE-SW trending lineaments indicated on the regional geological map and discussed earlier in the report, are however expected to act as preferential flow paths to groundwater. The intersection of these structures during mining could therefore result in increased groundwater inflow into the mining areas. Two of these lineaments transect the mining area. The northern-most lineament crosses through the largest pan, Pit 1 and Pit 6. It may also affect the eastern extremities of the proposed underground workings and the northwestern section of Pit 5. The southern-most lineament only cuts through Pit 11.

The rate of groundwater seepage is influenced by the depth and method of mining. Mining that takes place at shallow depths that intersects the shallow weathered aquifer may experience increased groundwater seepage rates, as these formations are expected to have higher permeabilities. Increased groundwater seepage rates are anticipated along the zone of transition from weathered to fresh rock.

Underground mining in the fractured rock aquifer is expected to experience groundwater seepage at lower rates, as the average permeability with depth is expected to decrease as the rock formations become tighter. Higher seepage rates will however be encountered if a water-bearing structure is intersected. In summary, the rate of groundwater seepage is influenced by the following factors:

- The extent of mining: groundwater seepage rates will increase for larger mining areas.
- Depth of mining: groundwater seepage rates to shallower mining areas are expected to be higher compared to deeper mining areas where the water-bearing fractures are expected to be tighter.
- The intersection of water-bearing features: the two main lineaments are expected to increase the groundwater seepage volumes if and when intersected during mining.
- Cumulative impact of mine dewatering: the rate of groundwater seepage may be high when new ground is broken, but may reduce as the aquifers around the mining areas are dewatered. Groundwater levels will also start to recover in areas where pits are backfilled and rehabilitated, thus affecting groundwater flow gradients and seepage rates.

- The cumulative impact of mining at the adjacent Msobo and Northern Coal mines. Although these mines are located inside the modelled area, no specific mining layout and schedules were available to include mining at these collieries during simulations.

7.2.1 Rate of groundwater seepage during the construction phase

During construction of the box cut and the adit to the underground workings from Pit 1, groundwater seepage to the mining areas will occur as the regional groundwater table will be intersected.

The volume of groundwater seepage to the first opencast strip and the construction of the adit of the underground workings are expected to be approximately 125 m^3/d in total. As the aquifers are heterogeneous, the volume may be lower (around 100 m^3/d) or higher (up to 400m^3/d), depending on whether water-bearing fractures are intersected. For the purpose of pollution control dam design, it is recommended that the dam size cater for around 100 m^3/d of groundwater over and above direct rainfall and runoff, as not all the groundwater will be dewatered to surface. The seepage is expected to be most prominent during the wet season, which means that over a year, approximately 18 000m^3 of groundwater may have to be contained during the construction phase to ensure safe and dry mining conditions.

7.2.2 Rate of groundwater seepage during the operational phase

The results of simulations to calculate the rate of groundwater seepage during the operational phase of mining are presented in Table 18 and Figure 14. The seepage rates presented are cumulative (total) volumes as mining progresses.

The volumes presented indicate the expected average groundwater seepage rates and a progressive increase in the indicated percentage points to evaluate uncertainty in the permeability of the rocks that may be intercepted during mining. It is unlikely that permeabilities 200% above average conditions would prevail over extensive sections of the mining areas. The possibility however exists that these volumes may be encountered in discrete zones over short periods of time until the fractures are dewatered.

It is also possible that the rate of groundwater seepage may be lower than the expected average conditions. Calculations were made to cater for this eventuality, as shown in Table 18.

Table 18 Estimated groundwater seepage rates (Unit: m^3/d)

Mining Schedule	Expected average	25% below average	25% above average	50% above average	100% above average	200% above average
Year 1	125	103	148	184	252	408
Year 2	114	97	134	158	212	318
Year 3	145	120	172	205	282	480
Year 4	186	148	221	265	367	624
Year 5	177	146	211	254	365	624
Year 6	154	130	181	215	293	483
Year 7	254	206	305	366	510	869
Year 8	277	223	332	398	554	931
Year 9	325	257	391	470	656	1099
Year 10	341	278	407	487	667	1028
Year 11	289	239	344	412	569	922
Year 12	278	216	343	407	552	840
Year 13	290	235	342	403	537	698
Year 14	278	225	337	393	522	578

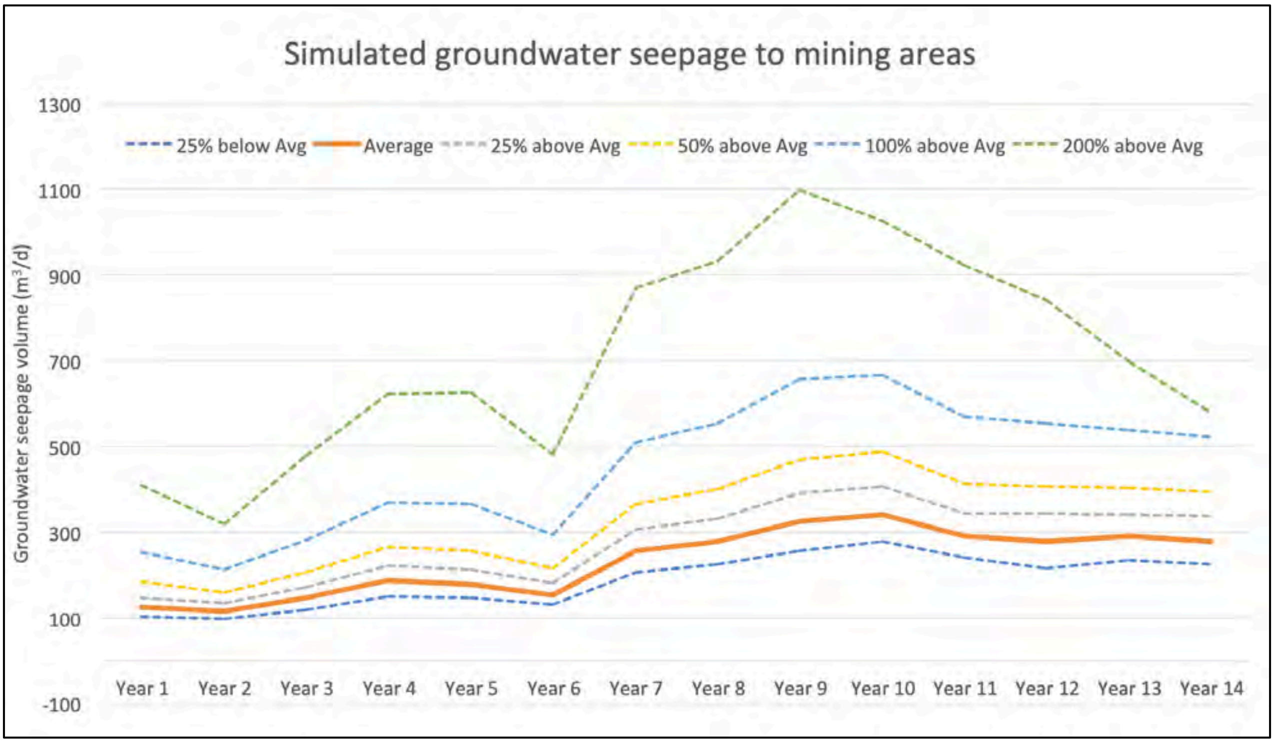


Figure 14 Simulated groundwater seepage to mining areas

The expected average volume of seepage that must be contained and managed during mining may vary between 100 and 340 m^3/d over the course of the operational phase. The volume of groundwater is expected to gradually increase during the operational phase and reach a maximum during Year 10. From Year 11, the volume is expected to decrease as underground mining reaches completion. At the end of life of mining, the total volume of groundwater that may seep to the mining areas is expected to be around 280 m^3/d on average. This volume may be as low as 225 m^3/d and as high as 578 m^3/d, depending on aquifer conditions. As the aquifers around the mining areas will be dewatered as mining progresses and mined out pits will be concurrently backfilled, it is unlikely that the higher groundwater seepage rates will be experienced during mining.

The groundwater may be contained in dedicated sumps in the pits and the underground workings, but it is expected that a portion of this water will have to be dewatered to surface from the mining areas to ensure safe mining conditions.

For the purpose of PCD design during the operational phase, it is recommended that provision is made for a total of 280 m^3/d of extraneous groundwater. This is equivalent to a total volume of 50 400 m^3/a at the end of the life of mine. The current surface layout plans cater for six PCDs across the operations. On average, each dam must therefore allow for the containment of around 8 400 m^3/a of groundwater seepage over and above direct rainfall and surface runoff.

7.2.3 Impact of mining on private groundwater users

The active removal of groundwater seepage from the mining areas will result in a lowering in groundwater levels in the surrounding aquifers. This will create a cone of depression around the mining area and will reverse groundwater flow towards areas where mine dewatering is taking place.

The cone of depression delineates the zone of influence that the proposed mining activities will have on groundwater availability, especially in private boreholes.

Due to the fact that concurrent rehabilitation will take place during opencast mining, the extent to which the aquifers may be dewatered will depend on where, how deep and how long the mining will take place. For this reason, the cone of depression changes on an annual basis as mining and rehabilitation progresses. In order to assess the maximum extent of the impact of mining on groundwater availability, the simulated drawdown cones for all fourteen years of mining were overlain and are presented in Figures 15 and 16 for the weathered and fractured rocks respectively.

It is shown that the most significant lowering in groundwater levels is associated with the northern sections of the mine, where the coal seams are deeper. In this area, groundwater levels may be lowered by up to 40m in the fractured rock aquifer. The weathered aquifer is expected to dry up in this area. In the southeastern section, the impact is expected to be less pronounced, as the depth of mining is shallower.

7.2.3.1 Impact on the shallow weathered aquifer, wetlands and springs

The extent over which groundwater levels could be lowered by 1m and more in the weathered aquifer is indicated in purple on Figure 15. This is considered the maximum zone of impact on groundwater levels in the weathered aquifer.

Wetlands that may be affected by the lowering of groundwater levels in the weathered aquifer, or by the total dewatering of the aquifer, are indicated on the figure. It is anticipated that the wetlands will not function optimally in these areas and may be permanently lost due to a decrease in groundwater availability as a result of mine dewatering. The most significant impact is expected in the central portions of the mining area around the largest pan. Preferential drawdown is also expected along the strike of the northern most lineament, which connects the mining areas with the largest pan.

It is further likely that spring KR_Spring 5 will be destroyed during mining at Pits 9 and 10. Mr Koos Jordaan owns this spring. It is currently fenced in and is used to supply water to animals on the farm. The spring was not sampled for chemical analysis as part of the fieldwork completed for the study and the flow rate is not currently known.

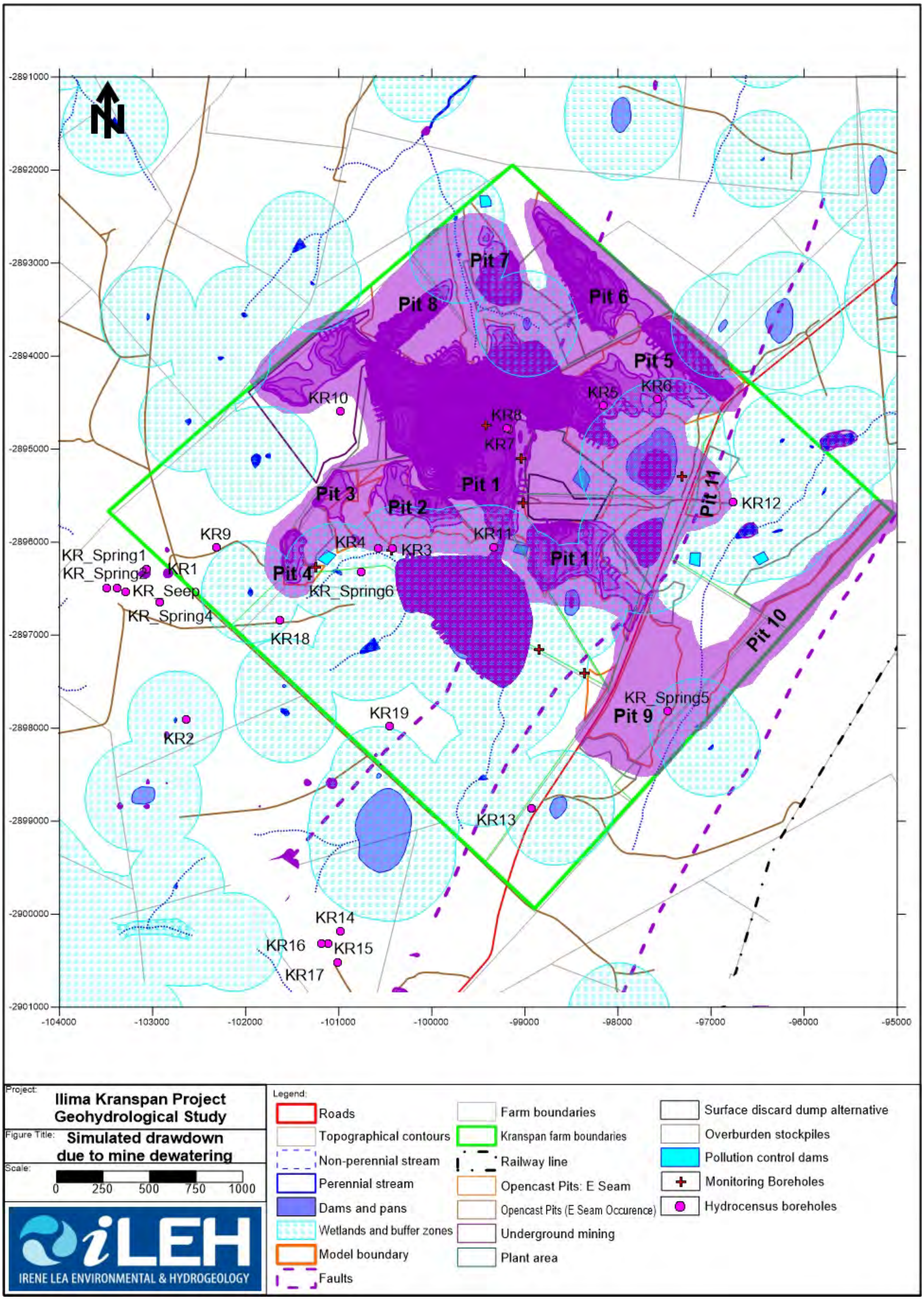


Figure 15 Extent of the dewatering zone of influence in the weathered aquifer

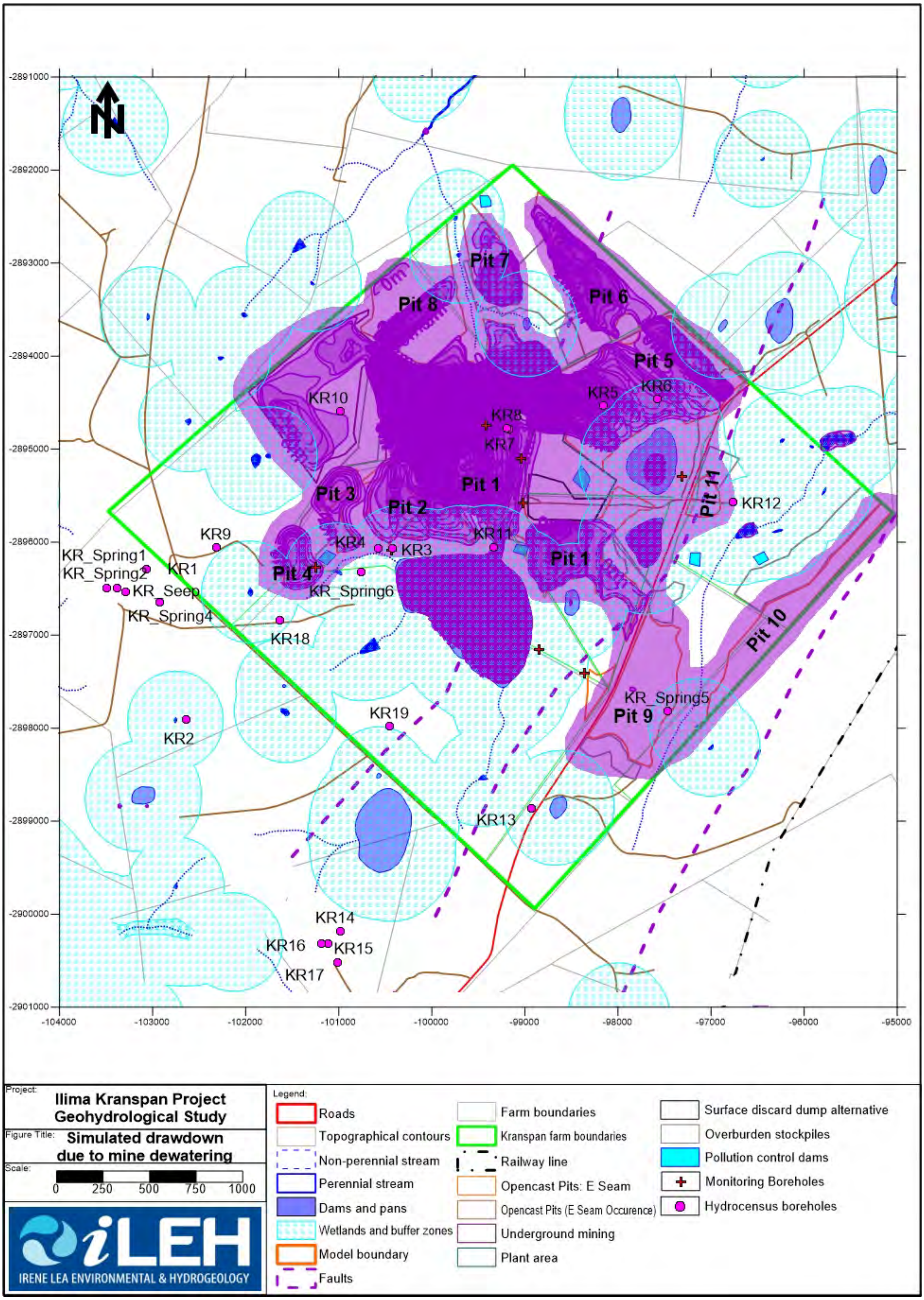


Figure 16 Extent of the dewatering zone of influence in the fractured rock aquifer

7.2.3.2 Impact on the fractured rock aquifer and private boreholes

The extent of the maximum anticipated cone of depression in the fractured rock aquifer is presented in Figure 16. As with the weathered aquifer, the most significant impact is expected in the central and northern parts of mining where the coal seam is deeper. Underground mining activities is also expected to have a more significant impact on groundwater levels due to the fact that it will be continually dewatered during the operational phase. In this area, groundwater levels may be lowered by up to 30m immediately above the underground workings. The extent to which this may impact on private boreholes will depend on the depth and construction of the borehole, details which are not currently available for the private boreholes.

The boreholes and springs that will be destroyed during opencast mining are listed in Table 19. Even though these boreholes will be destroyed, the assessment will address the impact of mining on each of these for comparative reasons.

Table 19 Private boreholes and springs that will be destroyed during opencast mining

BH ID	Owner	Current use
KR5	Jaco Papenfus	Open hole not in use
KR6	Jaco Papenfus	Open hole not in use
KR7	Jaco Papenfus	Submersible pump (not operational): supply to house and animals
KR8	Jaco Papenfus	Windpump not in use
KR_Spring5	Koos Jordaan	Fenced in: supply to animals

The extent of the cones of depression around the opencast pits are less pronounced due to their comparatively short lives and the effect of concurrent rehabilitation. The cones of depression are steep around the mining areas and do not extend significantly beyond 200m from the mining areas. This is due to the low average permeability of the matrix of the fractured rock aquifer.

As mentioned above, preferential drawdown is expected along the northern most lineament, which may result in a connection between the mining areas and the largest of the pans. Simulations suggest that a drawdown of up to 2m may occur along the lineament in the vicinity of the pan.

The impact of mine dewatering on the private boreholes are summarised in Table 20. It is shown that groundwater levels may be lowered by between 1 and 25m in the private boreholes. The timing of each impact is also indicated in the table. This is linked to the mine schedule that will be implemented.

The most significant impact on private boreholes is expected for boreholes KR7 and KR8 that belong to Mr Jaco Papenfus. Mining is expected to lower groundwater levels by up to 25m in these boreholes and the impact will most probably prevail over the life of the operations due to the proximity of the underground workings. Groundwater from borehole KR7 is not currently in use as the pump installed is not operational. The owner indicated during the hydrocensus that the borehole was previously used to supply the farm house and animals. There is a high risk that this borehole will dry up and will no longer be available for use by Mr Papenfus. As such, this impact is considered significant and should be managed with care, as detailed later in the report. Borehole KR8 is not in use.

Boreholes KR5 and 6 may experience a drawdown of 10m during Years 6 – 11 of mining. These two boreholes are not currently in use.

Lesser impacts are anticipated in boreholes KR3, KR4, KR10, KR11 and KR 12 and groundwater levels may be lowered by between 2 and 5m during mining. It is likely that this will not have a significant negative impact on the use of these boreholes. It is however prudent that the boreholes are effectively monitored to identify significant negative impacts timeously and to implement responsible groundwater management plans. These are discussed later in this report.

In summary, the impact on groundwater availability in private boreholes within the anticipated zone of influence in the fractured rock aquifer could have a significant negative impact. This is mainly due to the fact that farmers in the area are dependent on groundwater for water supply. Current farming activities and domestic use could temporarily cease over the life of the operations as a result of mine dewatering. Of most concern is the anticipated significant negative impact and possible loss of borehole KR7 belonging to Mr Jaco Papenfus.

The current rate of groundwater abstraction from the private boreholes in the zone of influence of mine dewatering is not currently known. It is important that this is established before mining commences in order to ensure that management of this impact is implemented in a responsible manner.

Table 20 Impact of mine dewatering on private boreholes

Affected BH	Owner Current Use	Current abstraction volume (l/hr)	Anticipated lowering in groundwater level (m)	Timing of impact (year of mining)
KR3	Rudi Prinsloo Windpump: supply to animals	Not available	<2	Year 3 – 5
KR4	Rudi Prinsloo Open borehole: not in use	Not available	<2	Year 3 – 5
KR5	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 – 11
KR6	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 - 11
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	Not available	<25	Year 1 - 14
KR8	Jaco Papenfus Windpump: not in use	Not available	<25	Year 1 - 14
KR10	Gysbert Klein Windpump: supply to animals	Not available	<5	Year 10 - 14
KR11	Rudi Prinsloo Windpump: supply to house and animals	Not available	<5	Year 1 – 5
KR12	Koos Jordaan Submersible pump: supply to house and animals	Not available	<2	Year 14

7.2.4 Cumulative impact on groundwater availability

As mentioned previously, two existing coal mines are located to the north and northwest of the proposed Kranspan project, namely Msobo and Northern Coal. At the time of compilation of this report, not information was available on the extent, depth and scheduling of mining in these areas. It was therefore not possible to include an assessment of the cumulative impact of mining on groundwater availability.

The extent of the cone of depression for the Kranspan project does not exceed the Mineral Rights Area significantly, as discussed above. For this reason, it is not likely that mining at the Kranspan project would significantly impact on groundwater levels to the north and northwest.

7.2.5 Impact of mining on groundwater quality during the operational phase

The impact of mining on groundwater quality during the operational phase was assessed at the hand of sulphate concentrations, based on the results of leach tests, as presented in Table 9. In order to do so, the maximum sulphate concentrations obtained from the leach tests were assigned to the mining areas and waste rock dumps. Based on the available information, sulphate concentrations of up to 250 mg/l are expected in the mining areas. This is equivalent to the SANS241:2015 drinking water standard for sulphate based on aesthetic considerations.

The backfilling of discard to the pits or the construction of a surface discard stockpile was not included in this assessment. Discard management was simulated separately and is discussed later in the report.

The simulated sulphate plumes at the end of the operational phase are presented in Figures 17 and 18. Under the prevailing conditions, sulphate concentrations are expected to increase to above 150 mg/l in all the mining areas, as shown. The extent of the zone of impact on groundwater quality is delineated in the two figures presented. Ambient sulphate concentrations are variable, but on average below 50 mg/l. An increase above 50 mg/l is therefore considered as the result of impact of mining.

Sulphate concentrations at the end of the operational phase in groundwater in the private boreholes within the delineated zone of influence is summarised in Table 21. The most significant impact at the end of life of mine is expected to occur in the vicinity of boreholes KR7 and 8, where sulphate concentrations may increase to above 100 mg/l. It is however noted that at these concentrations, the groundwater will still be usable and should not pose any health or aesthetic risks from a sulphate concentration perspective. Sulphate concentrations in the other boreholes in the zone of influence are not expected to exceed 100 mg/l.

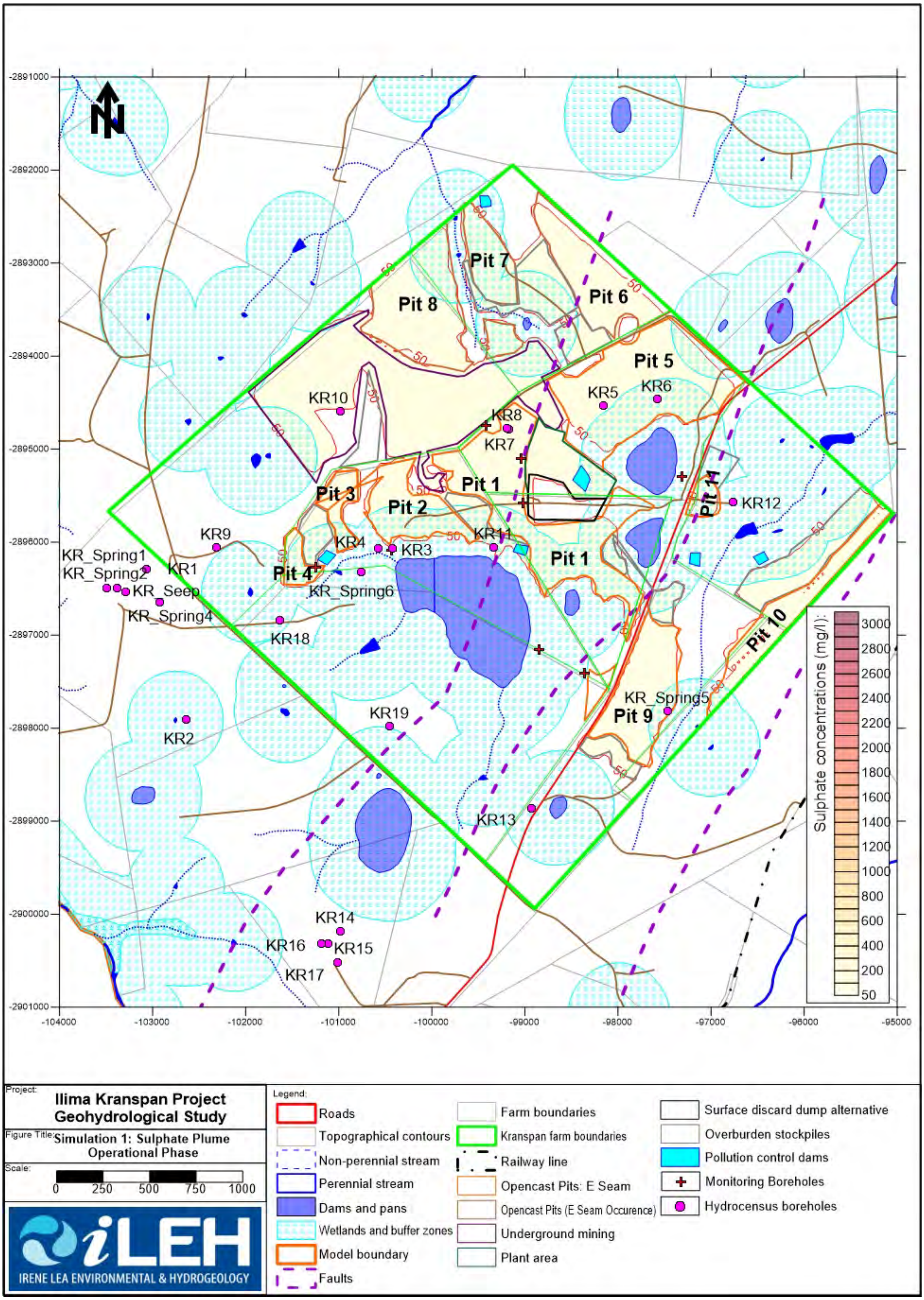


Figure 17 Simulated SO_4 plume at the end of the operational phase: weathered aquifer

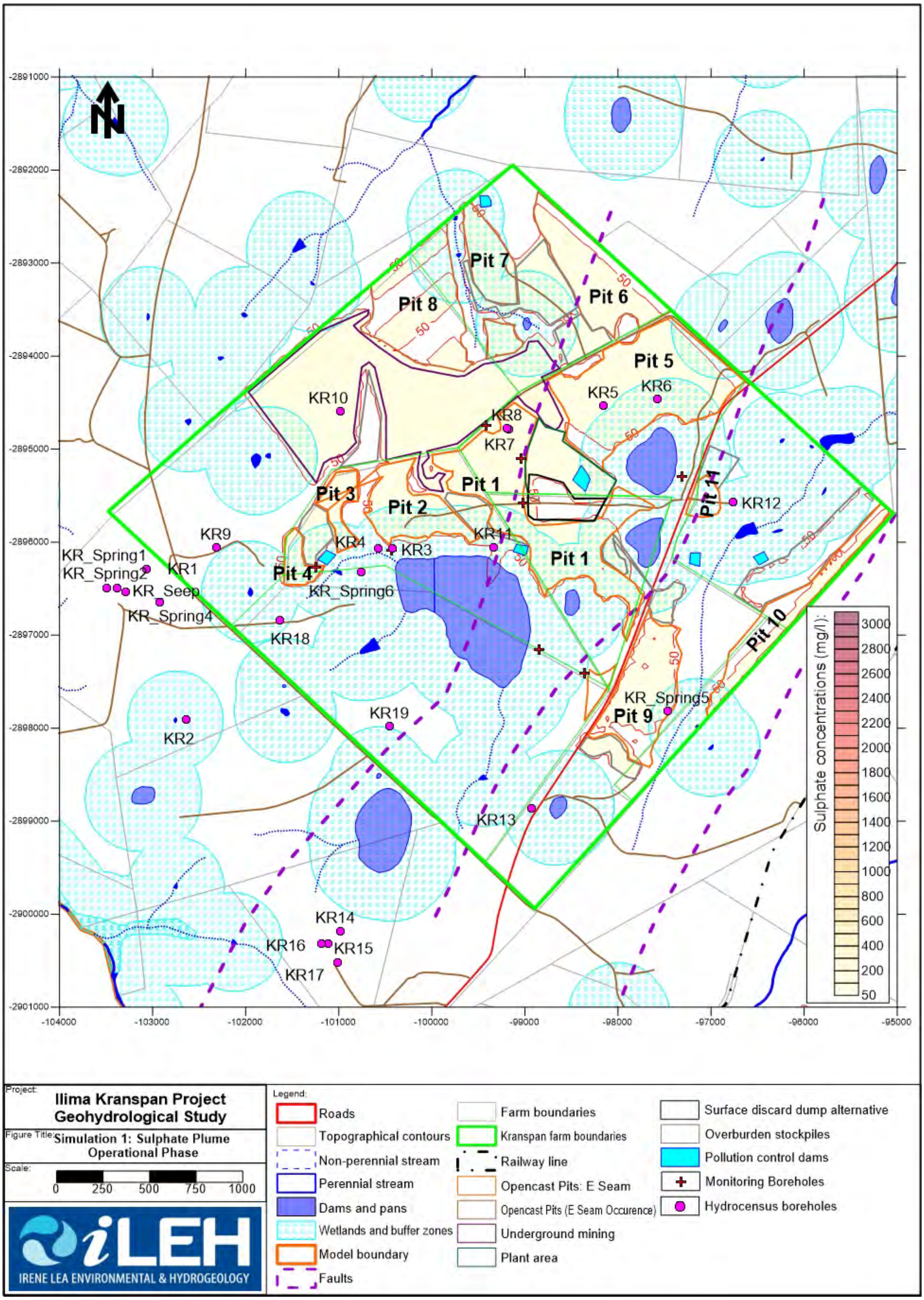


Figure 18 Simulated SO_4 plume at the end of the operational phase: fractured aquifer

Table 21 Impact on groundwater quality in private boreholes at the end of mining operations

BH ID	Owner Current groundwater use	Predicted SO_4 concentration (mg/l)
KR5	Jaco Papenfus Open borehole: not in use	<60
KR6	Jaco Papenfus Open borehole: not in use	<60
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	>100
KR8	Jaco Papenfus Windpump: not in use	>100
KR10	Gysbert Klein Windpump: supply to animals	<100
KR11	Rudi Prinsloo Windpump: supply to house and animals	<60
KR_Spring 5	Koos Jordaan Supply to farm animals	<80

7.3 Long-term impacts on groundwater

7.3.1 Rate of groundwater level recovery once mining is completed

Once mining and dewatering of the underground workings and pits ceases, groundwater levels will start to recover. The rate at which the groundwater levels will recover depends on the permeability of the aquifers, the depth and the extent of mining as well as the rate of recharge of rainwater.

Another factor that may play a role in the rate of groundwater level recovery is whether subsidence of ground above the underground workings will take place in future. This will increase the rate of recharge to the underground workings, thus affecting the rate of flooding. It is however assumed that no subsidence will take place and for this reason, average recharge rates were used over the underground workings during this assessment.

It is estimated that regionally groundwater levels will take approximately 30 – 50 years to recover, as demonstrated in Figure 19. During this time, groundwater flow will be reversed towards the mining areas, thus restricting the movement of contaminated groundwater from away from the mining areas.

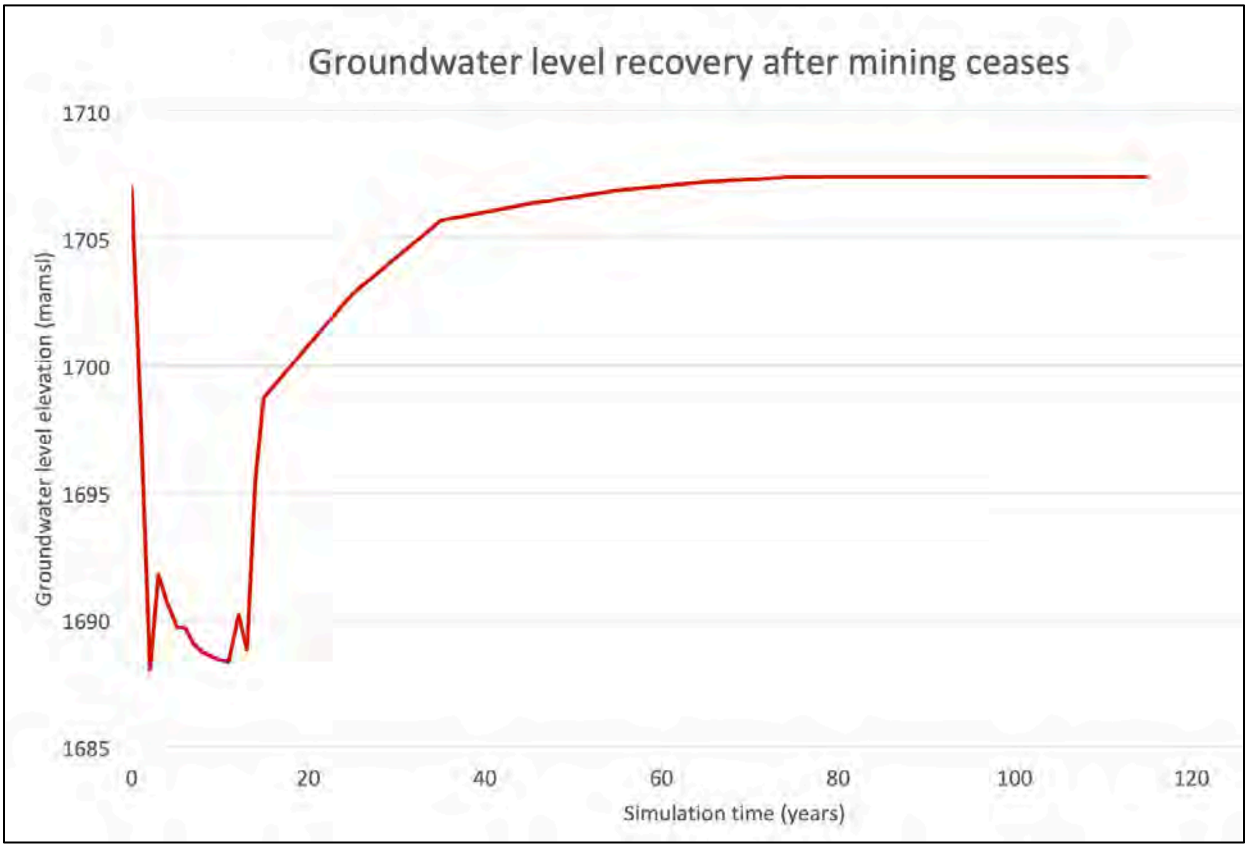


Figure 19 Anticipated regional rate of groundwater level recovery

7.3.2 The risk of decant

Decant from mining areas refers to the daylighting of mine void or underground water on surface, most often in the long-term. At mine closure, active mine dewatering ceases and groundwater levels start to recover, as discussed above. The likelihood of whether decant will take place, depends on the volume of water that enters the mining areas post closure. Inflow to the mining areas post closure will take place from two main sources, namely the recharge of rainwater and natural groundwater through flow. If this combined volume is higher than natural rates, it is likely that a mining area would decant. If the inflow volume is less than or equal to natural rates, it is unlikely that decant would take place.

The rate of groundwater inflow to the mining areas will be determined by the flow gradients, the permeability of the rock formations intersected and the area over which groundwater seepage will take place. Initially the inflow to the underground workings will be fast, post closure, due to steep flow gradients towards the mining area. As the mines start to flood, the gradients will become shallower as groundwater levels rise, which will reduce the volume of groundwater inflow to near natural conditions.

Comparatively, the volume that groundwater inflow contributes post closure is lower than the volume of water added through recharged of rainwater. The rate of recharge to the mining areas is therefore the main driving force behind decant.

With the available dataset and mine plan, it is concluded that the risk of decant from the underground workings is very low. If no subsidence takes place, the rate of recharge to the underground workings will remain close to natural rates. Under these conditions, underground water levels are not expected to rise above natural trends, thus eliminating the risk of decant.

Decant is however 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. These are indicated on Figure 20 and detailed in Table 22. 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 quality of the decant cannot be assessed with certainty with the static geochemical tests completed to date on the project. It is understood that kinetic testing is currently underway. The results of these tests will provide more insight into the long-term water qualities expected at the operations. 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 suitable for discharge. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

Table 22 Possible decant locations

Decant No	Pit	X Coordinate	Y Coordinate	Decant elevation (mamsl)	Time to possible decant (yrs)	Possible decant volume (m^3/a)
1	Pit 1	-98799	-2896533	1659	26	21873
2		-99224	-2895885	1672		
3		-97912	-2896949	1656		
4	Pit 2	-99579	-2895965	1665	16	7849
5		-100466	-2895956	1665		
6	Pit 3	-100963	-2896080	1666	14	2848
7	Pit 4	-101166	-2896267	1671	17	2257
8	Pit 5	-97885	-2894874	1661	19	23431
9		-97273	-2894688	1664		
10		-97850	-2893845	1667		
11	Pit 6	-97770	-2893668	1666	19	11732
12		-98861	-2892258	1668		
13	Pit 7	-99623	-2892453	1653	32	5118
14	Pit 8	-99881	-2892622	1652	39	15014
15	Pit 9	-97672	-2896808	1654	13	11908
16		-97362	-2896949	1653		
17	Pit 10	-96812	-2897180	1656	10	8078
18	Pit 11	-97282	-2895708	1655	6	1724
19	Pit 12	-99410	-2893606	1671	32	1635
20	Pit 13	-98045	-2897375	1663	13	1159

The most likely decant point at each pit is associated with the lowest topographical elevation. Five of the pits may have more than one decant point, due to small variations in the surface elevations of the pits and the error margin of the DTM used to assess the decant points. In all likelihood, decant will commence at the lowest topographical elevation at each of theses pits. Depending on the head that may build up inside the pits, decant may also occur from the other decant points identified.

Decant points 2 and 3 are linked to the fault zones that intersect the mining areas. If groundwater is under pressure in the faults (as the current fieldwork dataset suggests), decant may take place along the fault zone, even though the surface elevation of these positions are higher compared to the other decant points identified.

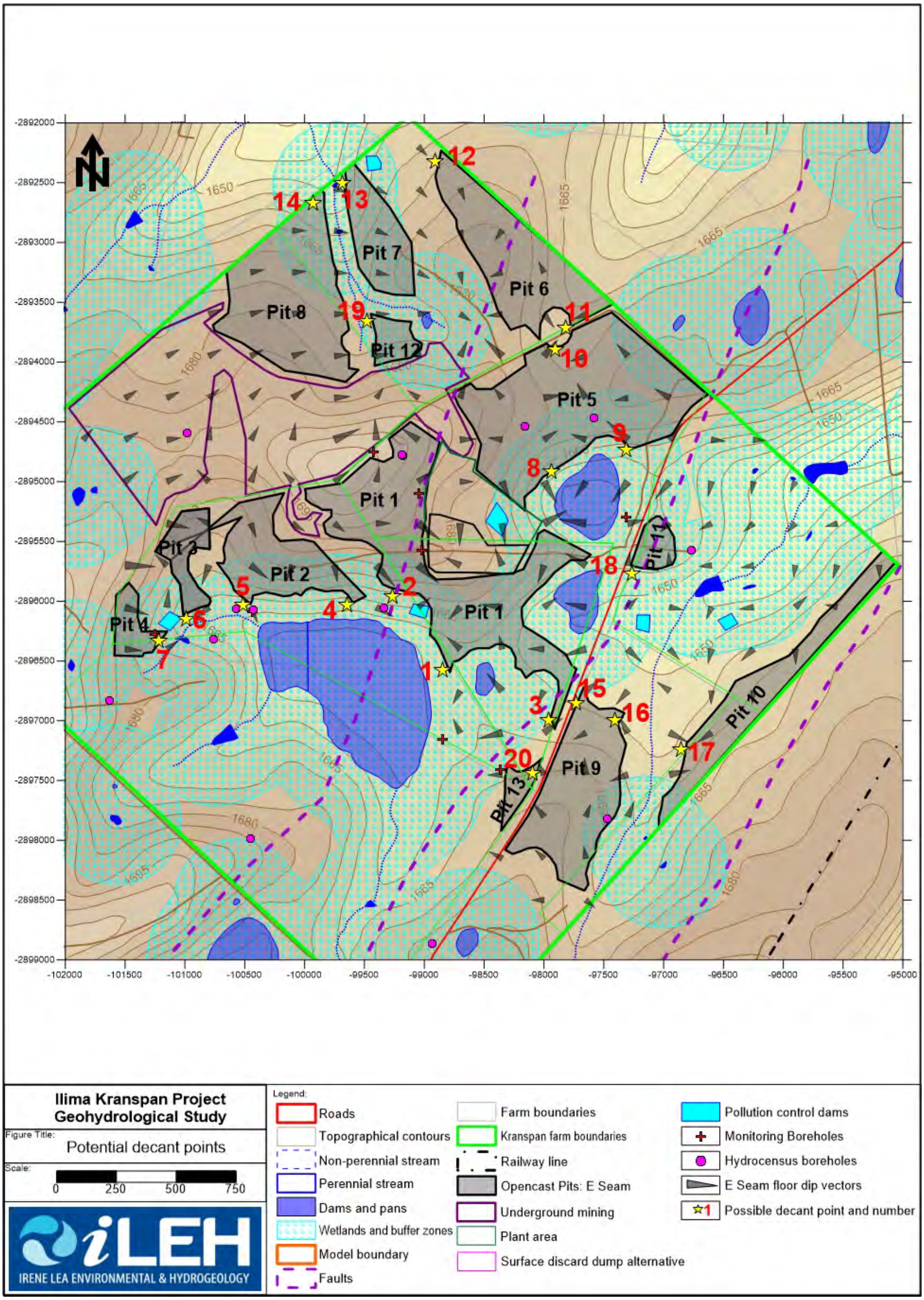


Figure 20 Possible decant locations

The most significant impact of decant will be on wetland functioning. As the decant points are all associated with low-lying areas, they are typically associated with wetlands. This is demonstrated in Figure 20, which shows that most of the decant points are within the delineated wetlands or their buffer zones.

The impact of decant quality on the wetlands is considered most significant. If the decant is not contained, the acidic pH conditions and high salt and trace metal concentrations are expected to kill the wetland fauna and flora. These impacts would most probably be irreversible in the long-term.

In addition to impacting negatively on wetlands, the unmanaged decant will also flow across land to the pans and non-perennial streams that drain the project area. As with the wetlands, the decant will negatively affect water quality in these surface water bodies and will most probably result in irreversible acidification and unacceptable salt loads.

Due to the fact that decant quality cannot be assessed with certainty with the existing dataset, a quantitative impact assessment cannot be undertaken.

It is possible that decant from Pits 6, 7 and 8 could impact on mining activities to the north of the Kranspan project, if it is not contained and managed.

7.3.3 Long-term impact on groundwater quality

The model was used to simulate the long-term impact of mining on groundwater quality. This was achieved at the hand of four scenarios, namely:

- Scenario 1: the long-term impact if all rehabilitation measures are implemented and deterioration in groundwater quality does not take place during the operational phase of mining. Post closure, sulphate concentrations were assumed to increase as a result of acidification, which is likely based on the results of static geochemical tests. The increase in sulphate concentration post closure is based on the author's experience in similar environments in the absence of the results of kinetic geochemical testing. The values used during simulations are presented in Table 10.
- Scenario 2: tests the impact of placing discard material into the mine-out pits. Although it is acknowledged that this will not take place in all of the pits as the volume of discard generated will be less than the void space available in all the pits, the model was used to see the impact of backfilling all the pits with discard. This will allow identification of pits that may be more suitable for backfill with discard. In order to complete this scenario, it was assumed that the discard material would acidify during the operational phase as well as post-closure resulting in an increase in sulphate concentrations. In the absence of more specific data, it was assumed that sulphate concentrations of up to 3000 mg/l would leach from the discard material. This assumption must be tested and re-evaluated once the results of the kinetic testing are available.
- Scenario 3: evaluates the impact of placing discard in a stockpile on surface within the plant area. The scenario assumes that the discard stockpile will not be lined and the rate of seepage would be governed by the permeability of the weathered aquifer.
- Scenario 4: test the effect of lining the discard stockpile with a Class C liner according to the discussion presented in Section 7.1.3.

The model was run for a period of 100 years after mining stops and the results presented and discussed below are provided for the impact on the shallow weathered as well as the deeper fractured rock aquifers.

7.3.3.1 Results of Scenario 1: Long-term impact if all rehabilitation measures are implemented

This scenario tests the long-term impact of mining on sulphate concentrations if all rehabilitation measures proposed are implemented. This scenario excludes placing discard into the pits or on a surface discard stockpile.

The simulated sulphate plumes 100 years after mining stops are presented in Figures 21 and 22 for the weathered and fractured rock aquifers under the assumptions made for Scenario 1. The sulphate concentrations were fluctuated according to the information presented in Table 10 during the simulation, as discussed above.

The simulations indicate that potential contamination is not expected to move significant distances from the Kranspan mining areas during this period. On average, the plumes do not move more than 300m from the mining areas during this period. This is due to two main factors, namely the low permeability of the aquifer matrices through which the contamination must flow and the effect of groundwater level recovery post mine closure. As discussed earlier, the groundwater levels may take between 30 – 50 years to recover after mine dewatering stops at the end of the life of mine.

The contamination moves mainly in a southwesterly direction towards the largest of the pans, but also moves towards the three smaller pans to the northeast. The model indicates that preferential flow of contamination will take place along the northern most lineament towards the largest of the pans. The plume can move up to 1km along the lineament towards the pan during the 100 year simulation period. Very limited movement of the plume takes place in a northerly and northeasterly direction along the lineaments. The main direction of flow is in a southerly to southeasterly direction, as indicated.

Sulphate concentrations within the mining area are expected to increase in the long-term. Within the backfilled pits, concentrations exceeding 1000 mg/l may be expected under the assumed conditions. Along the northern most lineament fault zone, sulphate concentrations may increase to above 400 mg/l where it intersects the largest pan. Sulphate concentrations along the edges of the pan not associated with the fault are not expected to exceed 150 mg/l for the scenario. The southeastern lineament transects Pit 11. Down gradient of this fault, sulphate concentrations may exceed 600 mg/l in the long-term, moving preferentially in a southerly direction.

The impact of the underground workings on groundwater quality will be confined to the fractured rock aquifer with little to no impact on the weathered aquifer in this area. In the immediate vicinity of the underground workings, sulphate concentrations in the fractured rock aquifer may increase to around 800 mg/l.

The impact of the conditions simulated during Scenario 1 for the wetlands, springs, streams and private boreholes are presented in Table 23. It is acknowledged that some of the wetlands, boreholes and springs will be destroyed during mining. The sulphate concentrations are however provided as reference and for comparison with other scenarios.

The impact of elevated sulphate concentrations on wetland functioning falls outside the scope of this study. It is however noted that under acid pH conditions with elevated salts and trace metal concentrations, the impact on wetlands is considered significant.

Groundwater with sulphate concentrations exceeding 250 mg/l is expected to have negative aesthetic impacts (taste, colouration and odour). Groundwater with sulphate concentrations exceeding 600 mg/l are expected to have adverse health impacts and will become unfit for use. These include boreholes KR5, KR6, KR7, KR8 and possibly KR11. Groundwater from KR_Spring5 will also not be fit for use.

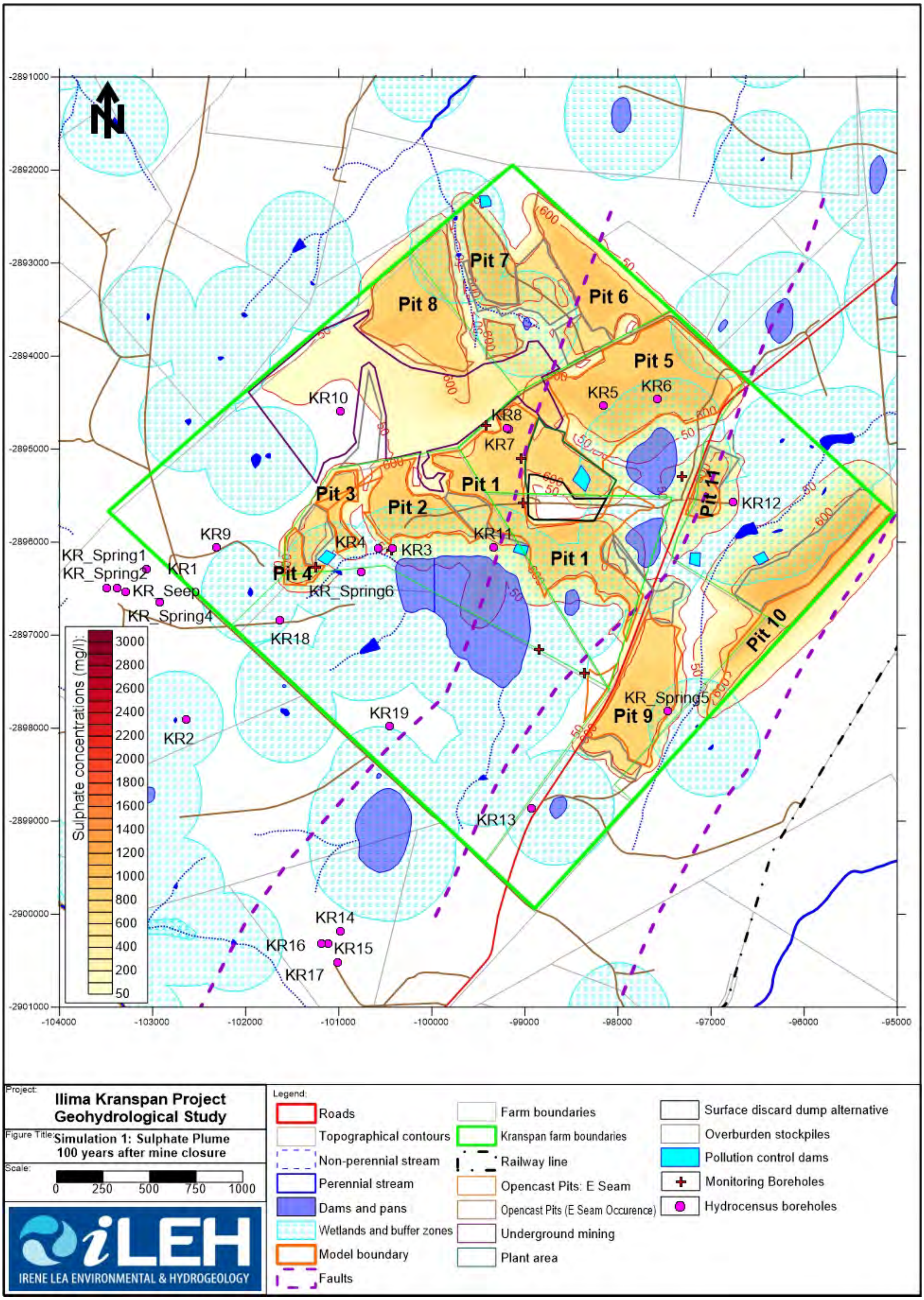


Figure 21: Scenario 1: Impact on the weathered aquifer 100 years after mining ceases

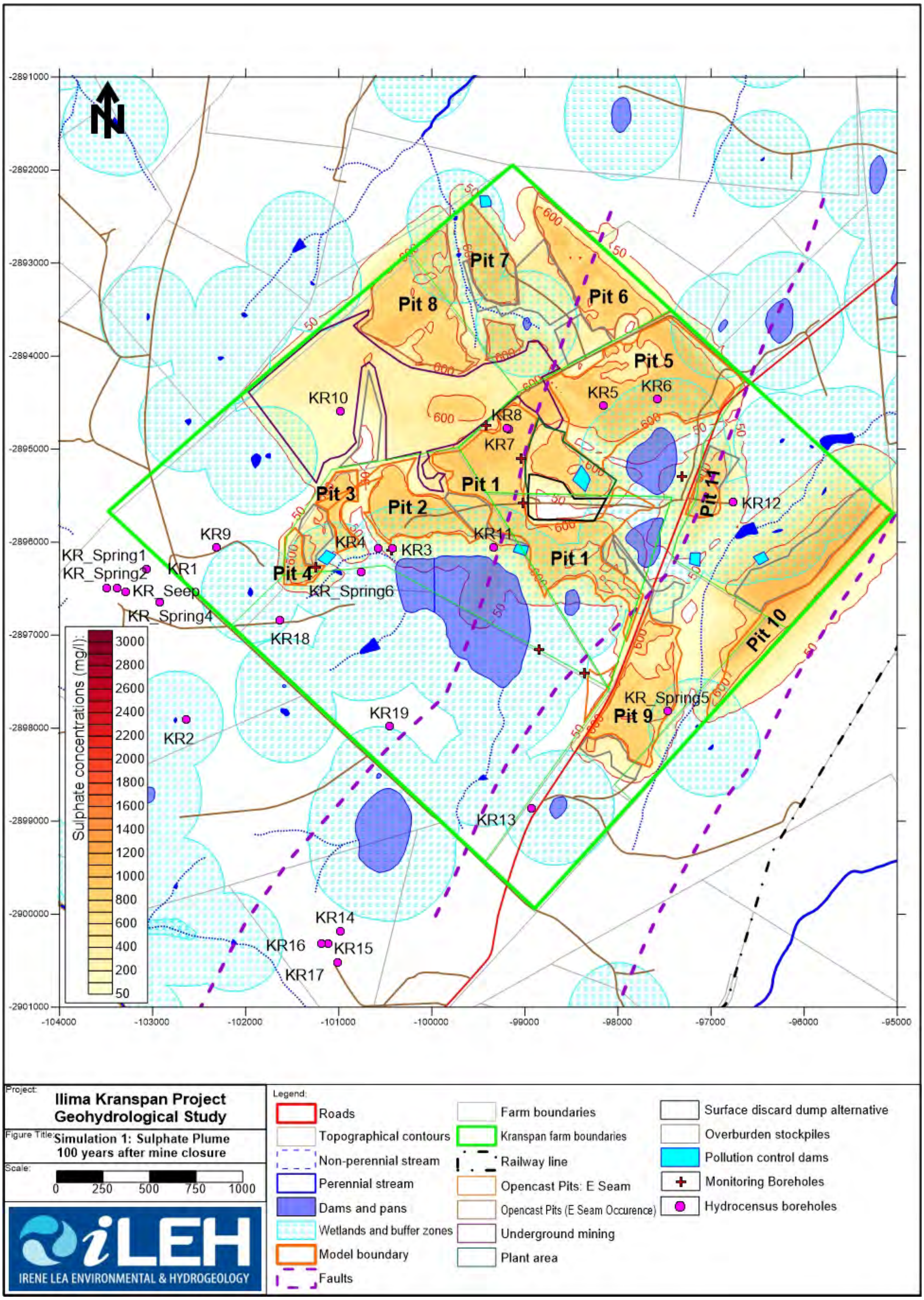


Figure 22 Scenario 1: Impact on the fractured rock aquifer 100 years after mining ceases

Table 23 Anticipated long-term sulphate concentrations at various receptors for Scenario 1

Pans and streams		Wetlands		Private boreholes and springs	
Description	SO_4 (mg/l)	Description	SO_4 (mg/l)	Description	SO_4 (mg/l)
Largest pan	150 - 400	Largest pan	400 - 900	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

7.3.3.2 Results of Scenario 2: Long-term impact if discard is backfilled into the pits

Scenario 2 tests the impact if discard material is backfilled into the pits during the operational phase of mining. It is unclear which pits would be earmarked for this activity. In order to complete a comprehensive impact assessment, it was assumed that all pits would be used for discard disposal. The surface discard stockpile is excluded from this scenario. Sulphate concentrations described in Table 10 were applied during the simulations. During the operational phase, it was assumed that sulphate concentrations of 3000mg/l could leach from the discard due to acidification of the material with time. This is based on the description of the source term presented in Section 3 of this report. This assumption must be tested and re-evaluated once the results of the kinetic geochemistry tests are available. The results of the simulations for the weathered and fractured rock aquifers are presented in Figures 23 and 24.

The simulated plumes indicate that if discard is backfilled into the pits, sulphate concentrations are expected to increase in both aquifers. Preferential flow along the northern most lineament will result in the plume moving up to 1,1km from the mining areas for this scenario. The plume may also move up to 500m from the pits during the 100 year simulation period.

Sulphate concentrations within the backfilled pits may increase to above 1300 mg/l in the long-term for this scenario. This is expected to have a significant negative impact on the quality of decant from the pits in the long-term. Along the northern most lineament, sulphate concentrations may increase to above 600 mg/l at the largest pan. Away from the fault, the plume at the largest pan may increase to above 300 mg/l in the long-term. A summary of the long-term impact of this scenario on the receptors identified for the project is presented in Table 24. It is shown that groundwater with sulphate concentrations exceeding 600 mg/l is expected in boreholes KR5, KR6, KR7 and KR11 for this scenario. These boreholes will no longer be fit for use.

Table 24 Anticipated long-term sulphate concentrations at various receptors for Scenario 2

Pans and streams		Wetlands		Private boreholes and springs	
Description	SO_4 (mg/l)	Description	SO_4 (mg/l)	Description	SO_4 (mg/l)
Largest pan	300 - 600	Largest pan	400 - 1200	KR_Spring5	800
Smallest pan	350	Pits 7 & 8	350 - 1000	KR3	450
Smallest NE pan	300	Pit 5	400 - 1200	KR4	50
Largest NE pan	200 - 400	Pit 11	200 - 1000	KR5	1200
Non-perennial stream Pit 10	70	Pit 10	150 - 1100	KR6	1000
Non-perennial stream Pit 7 & 8	300 - 600	Pit 9	450 - 1000	KR7	1200
Non-perennial stream Largest Pan	70			KR8	1200
				KR10	300
				KR11	900

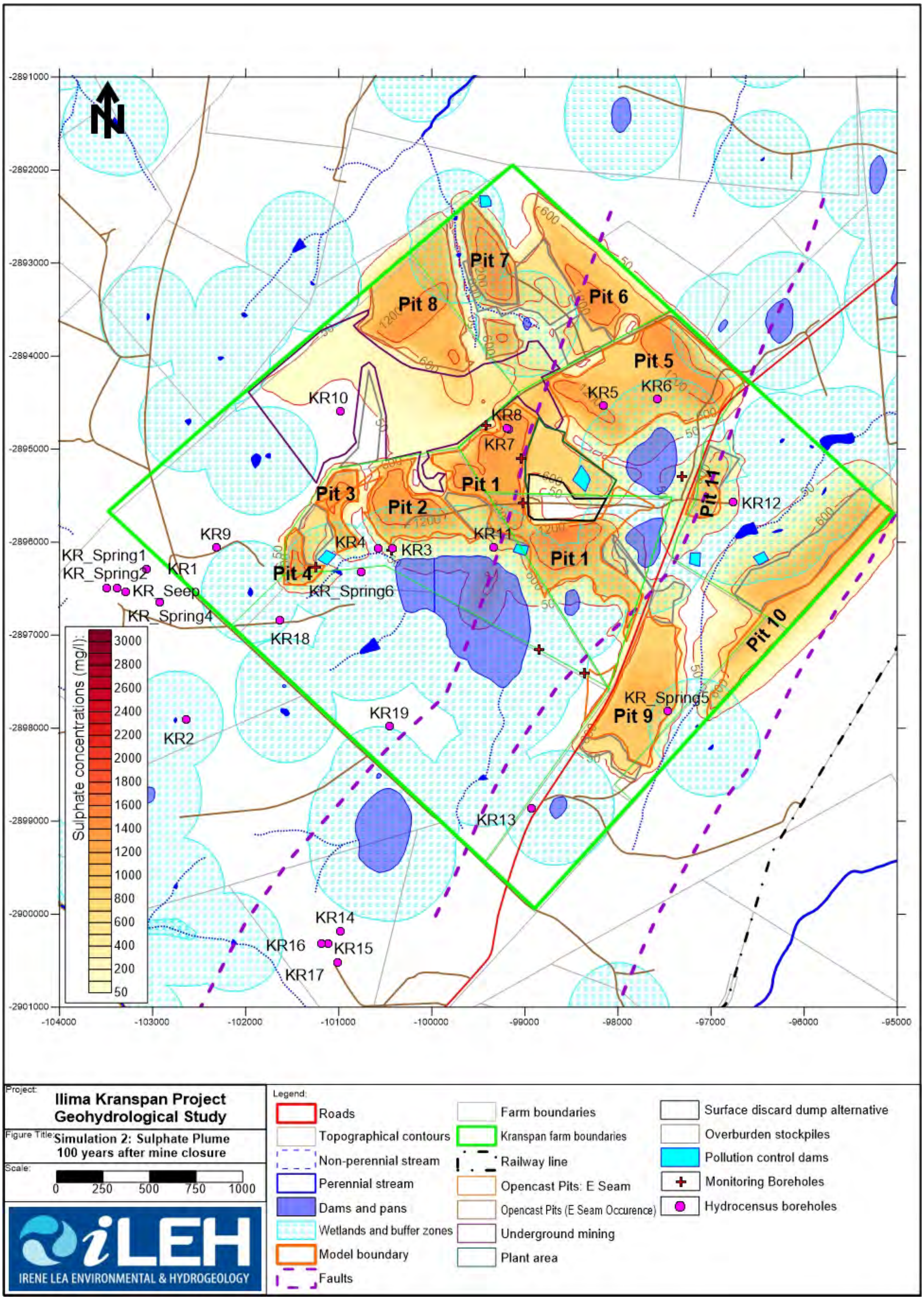


Figure 23 Scenario 2: Impact on the weathered aquifer 100 years after mining ceases

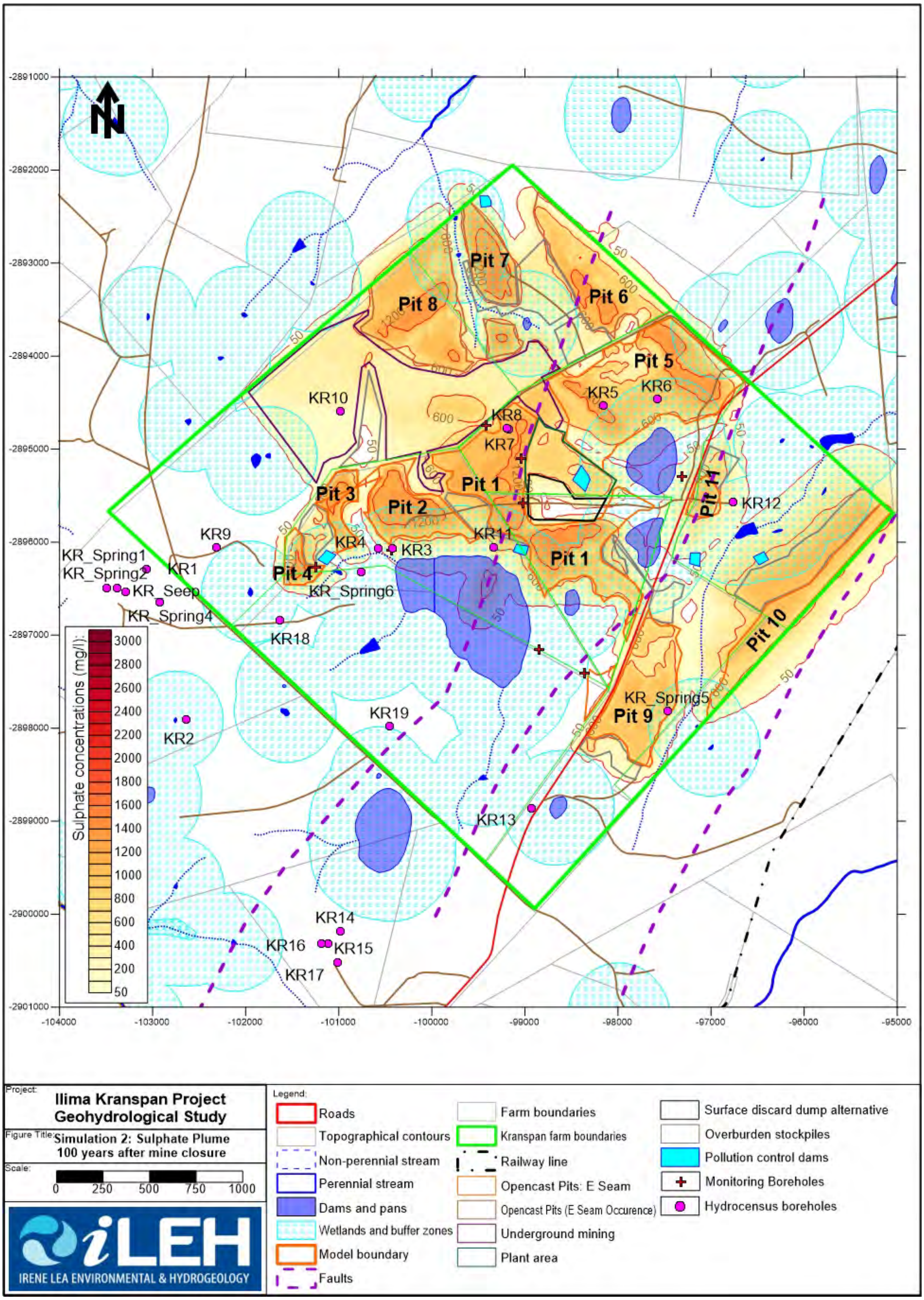


Figure 24 Scenario 2: Impact on the fractured aquifer 100 years after mining ceases

If the preferred discard management measure is to backfill the material to the pits, the following must be taken into consideration:

- The quality of decant from the pits post closure will be negatively affected by this activity. It is not possible to say with certainty what the decant quality will look like with the available dataset, but modelling results suggests that sulphate concentrations may increase by 30% in the long-term inside the pits. The preliminary results of the kinetic testing indicates that the discard material will most likely acidify in the long-term, which will compound the impact on groundwater quality, the wetlands and private boreholes.
- The pits around the largest pan should not be used for discard backfilling due to the anticipated negative long-term impact on the pan and the wetlands in this area. One of the known preferential flow paths to groundwater transects the pan and the mining area and for this reason it is not recommended that additional contamination potential is introduced in this area. The pits that should not be used for discard backfill due to proximity to the largest pan, wetlands and the presence of a preferential groundwater flow path include:
    - Pit 1, Pit 2, Pit 3, Pit 4 and Pit 9
- In addition, Pits 6 and 11 should also not be used for discard backfill due to the fact that the lineaments (preferential groundwater flow paths) transect the pits.
- It is furthermore not recommended that discard is placed in Pits 7, 8 and 10 due to the fact that they are situated immediately adjacent to non-perennial streams that drain the mining area. Should decant take place from these pits in the long-term, the streams will be directly impacted.
- Based on the current understanding of the project site, the only pit that can be considered for discard backfill is Pit 5. The pit is however not ideal, as it is situated adjacent to the second largest pan and two of the decant points identified will drain towards the pan. If discard is however placed in the bottom of the northern most section of this pit, leachate may be contained more successfully than in the other pits. The coal floor contours suggest that the seam dips in a northerly direction and that this would be the deepest point of the pit. It is however noted that interflow between Pits 5 and 6 are possible in this area. It is important to maintain the boundary strip along the farm portion boundary in this area to avoid that from happening.
- It is strongly recommended that this assessment is tested and possibly re-evaluated once the results of the kinetic geochemistry testing are available.

7.3.3.3 Results of Scenarios 3 and 4: Long-term impact if discard is stockpiled on surface

These two scenarios test the impact if a surface discard stockpile is constructed as an alternative to placing discard into the pits. As discussed earlier, two alternatives were evaluated, namely unlined (Scenario 3) and a lined (Scenario 4) discard stockpile. The remainder of the mining area was simulated under the same assumptions as those discussed for Scenario 1.

The results for both simulations are presented in Figures 25 and 26 for the weathered and fractured rock aquifers.

As expected, an unlined facility will result in a significant increase in sulphate concentrations in the immediate vicinity of the discard stockpile in the long-term. Sulphate concentrations may increase to above 2500 mg/l in the weathered aquifer in the immediate vicinity of the discard facility in this case. It is further possible that the plume may reach the lineament to the west of the discard stockpile and that contamination from the discard stockpile may flow preferentially along the fault towards the largest pan in the southwest. Sulphate concentrations in the fault may increase to above 800 mg/l in the long-term as a result. Where the fault intersects the pan, sulphate concentrations of above 400 mg/l may be expected.

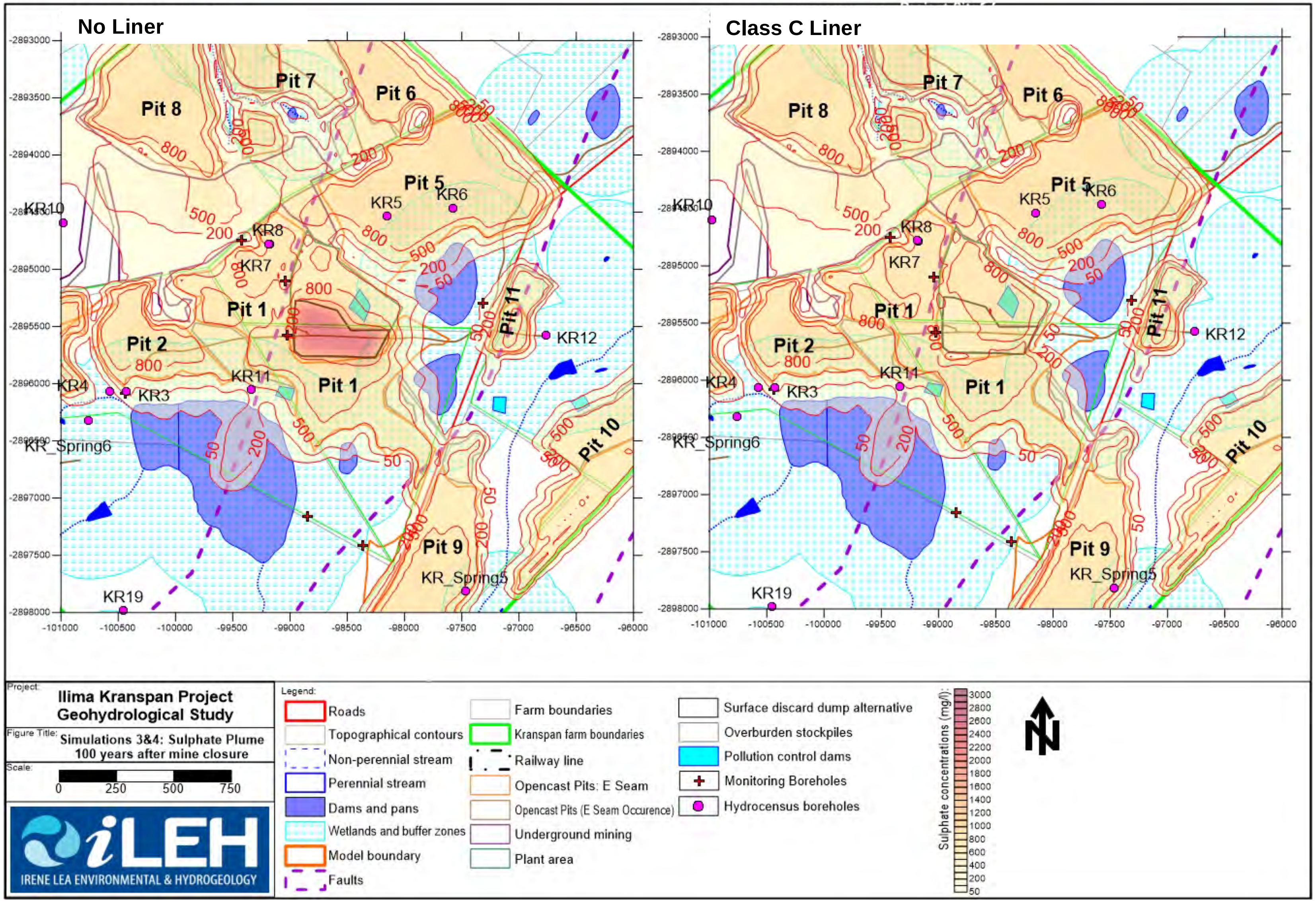


Figure 25 Scenarios 3 and 4: Impact on the weathered aquifer 100 years after mining ceases

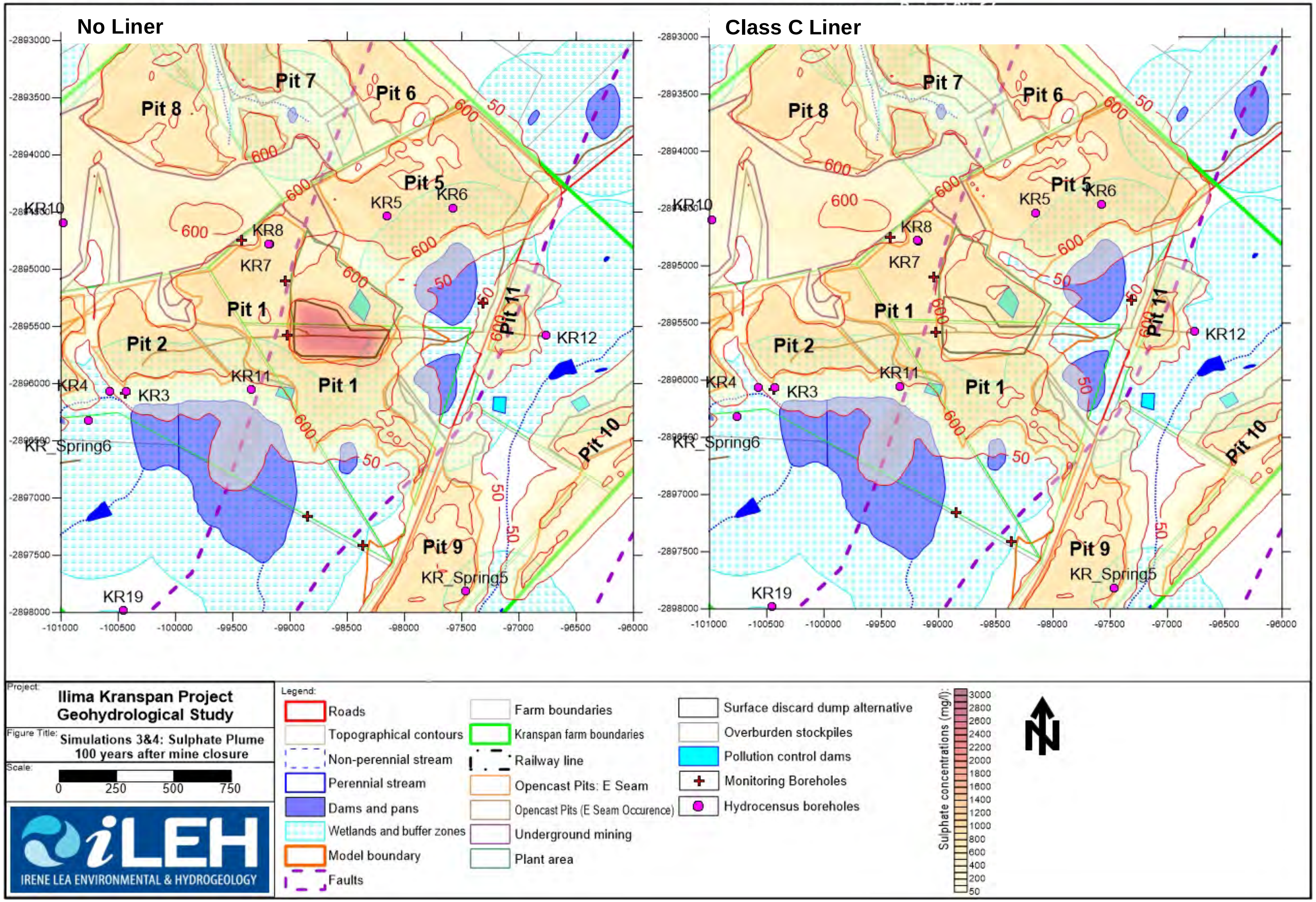


Figure 26 Scenarios 3 and 4: Impact on the fractured aquifer 100 years after mining ceases

The distance that the plumes may migrate from the mining areas are not expected to vary significantly in the unfractured aquifers for the two scenarios. The rate at which the plumes will move are affected by the recovery of groundwater levels post closure and the permeability of the rock formations, both of which will not be impacted on by the placement of the discard dump on surface.

It is expected that leachate from the unlined discard stockpile will be captured in the backfilled Pit 1 and will to a certain extent be contained in the pit until such time that it is flooded. The placement of an unlined discard stockpile up gradient of Pit 1 is therefore expected to have a negative impact on decant quality in the long-term. This impact cannot be quantified with certainty with the existing dataset. Due to the proximity of Pit 1 to the largest pan and the wetlands associated with it, this will result in significant negative impacts in the long-term.

If the discard dump is lined with a Class C liner, the most significant positive impact on sulphate concentrations is expected in the immediate vicinity of the discard dump. For this scenario, sulphate concentrations are expected to remain below 900 mg/l at the stockpile. Groundwater quality will however still be affected by the mining activities in this area and lining of the facility will not mitigate the regional impact of mining on groundwater quality. For this scenario, the discard facility is not expected to have a noticeable impact on pitwater and decant quality associated with Pit 1.

A comparison of anticipated long-term sulphate concentrations for the two scenarios are presented in Tables 25 and 26. It is shown that the most significant impact of an unlined discard facility is that of increased sulphate concentrations in groundwater reaching the wetlands associated with the largest pan.

Table 25 Anticipated long-term sulphate concentrations at various receptors for Scenario 3

Pans and streams		Wetlands		Private boreholes and springs	
Description	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**
Largest pan	200 - 450	Largest pan	400 - 1100	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

Table 26 Anticipated long-term sulphate concentrations at various receptors for Scenario 4

Pans and streams		Wetlands		Private boreholes and springs	
Description	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**
Largest pan	150 - 400	Largest pan	400 - 900	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

With regards to the placement of discard on surface, the following is noted:

- The most significant impact of an unlined discard stockpile will be on the weathered aquifer , the pan and the wetlands present down gradient of the facility.
- It is furthermore anticipated that an unlined discard stockpile will have a negative impact on pit water quality and thus long-term decant quality at Pit 1.
- With time after the simulation period of 100 years, the contamination that will leach from an unlined discard dump will however migrate towards the pan. This will result in an increased salt load to the pan.
- A lined facility is not expected to add significantly to sulphate contamination. Groundwater quality in the long-term will however still be impacted on by the surrounding mining activities.
- The discard facility design should take cognisance of the position of the fault zone and if necessary, must be moved to ensure that it does not overly the fault, if this is identified as the preferred alternative for discard management.

7.3.4 Anticipated salt load to the wetlands, pans and streams

The information presented above was used to assess the long-term sulphate salt load on the wetlands, pans and streams present in and down gradient of the mining areas. In order to do so, the sulphate concentrations reported above was multiplied with the average volume of groundwater that would seep into the affected areas over a year. The results are presented in Table 27.

The table presents the average sulphate concentrations within the affected area. It is noted that the concentrations will vary across each area, but for the purpose of the calculation average values were used. The estimated volume of groundwater seepage to each affected area is also presented. These values were used to calculate the average sulphate salt load in tonnes per year.

It is shown that the sulphate load associated with Scenario 2 (backfilling the pits with discard), results in the highest salt load. It is however noted that Scenario 2 represents an over-estimation, as not all the pits would be backfilled with discard, as discussed above. If only Pit 5 is backfilled with discard, only the salt load to the smallest NE Pit may increase from 0,4 to 1,1 tonnes of sulphate per annum.

The calculations further indicate that a Class C liner installed at the surface discard stockpile (Scenario 4), would result in a 9% decrease in the total salt load from the mining area, which is equivalent to 3 tonnes of sulphate per annum.

It is strongly recommended that the information presented in Table 27 is updated and re-assessed, as necessary, once the results of the kinetic geochemistry tests are available.

Table 27 Estimated salt loads

Description	Average SO_4 (mg/l)				Estimated volume (m^3/a)	Salt load (t/a)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Pans and streams									
Largest pan	275	450	325	275	41245	11,3	18,6	13,4	11,3
Smallest pan	200	350	200	200	657	0,1	0,2	0,1	0,1
Smallest NE pan	100	300	100	100	3778	0,4	1,1	0,4	0,4
Largest NE pan	225	300	225	225	3869	0,9	1,2	0,9	0,9
Non-perrenial stream Pit 10	50	70	50	50	5400	0,3	0,4	0,3	0,3
Non-perrenial stream Pit 7 & 8	300	450	300	300	4500	1,4	2,0	1,4	1,4
Non-perennial stream Largest Pan	50	70	50	50	900	0,05	0,06	0,05	0,05
Wetlands									
Largest pan	650	800	750	650	9736	6,3	7,8	7,3	6,3
Pits 7 & 8	400	675	400	400	6912	2,8	4,7	2,8	2,8
Pit 5	650	800	650	650	4702	3,1	3,8	3,1	3,1
Pit 11	600	600	600	600	2822	1,7	1,7	1,7	1,7
Pit 10	550	625	550	550	4748	2,6	3,0	2,6	2,6
Pit 9	650	725	650	650	2030	1,3	1,5	1,3	1,3

8 PROPOSED GROUNDWATER MANAGEMENT MEASURES

8.1 Groundwater objectives and targets

The following objectives and targets are proposed for groundwater management at the operations:

- Implement a management plan aimed at reducing and/or eliminating adverse impacts on the receptors identified. These include existing private groundwater users, wetlands, the pans, rivers and streams.
- Track and record the progress of implementation of all groundwater management measures.
- Implement sufficient monitoring procedures to measure the effectiveness of groundwater management measures in both mine and private boreholes located within the delineated zones of influence.
- Analyse the information obtained from all monitoring programmes against compliance targets to establish trends.
- Should the trends indicate adverse impacts on groundwater levels and/or quality, implement suitable measures within the shortest possible time to remediate and/or eliminate such adverse impacts identified.

8.2 Over-arching groundwater management measures

Ilima should implement a number of broad over-arching groundwater management measures in order to minimise impacts on groundwater during all phases of mining. Most of these form part of good house-keeping measures, as detailed in Table 28.

Table 28 General groundwater management measures

Planning Phase
Ensure that sufficient information is available on all private boreholes inside the zones of influence to quantify existing groundwater use and demand. This information will form the basis for future assessments.
Plan for and provide sufficient budget to implement the groundwater monitoring programme before any mining starts.
Develop sound operating procedures that takes cognisance of impacts associated with groundwater, including spill procedures, dam design, mine residue deposit design, oil and diesel storage area design, on-site environmental incident reporting, etc.
Adjust the mine plan and surface layout to avoid areas with shallow groundwater tables, including wetlands.
Develop sound surface runoff management plans to ensure that all dirty runoff is contained and diverted to the PCDs.
Ensure that PCDs are designed and lined to contain all dirty water generated to prevent overflows and spillages.
Construction Phase
Implement and maintain a groundwater monitoring programme in mine and private boreholes situated in the zones of influence identified for the mining areas.
Implement sound house-keeping measures to prevent and clean spills, address leaks and undertake regular inspections. Ensure that the record-keeping procedure is in place and that instructions given are carried out.
Measure rainfall daily on site.
Operational Phase
Complete regular inspections of PCD, specifically noting incidences of overflow and leakage. If the latter is identified, measures must be taken to rectify non-compliances immediately.
Maintain sound house-keeping measures to prevent spills and leaks.
Maintain the groundwater monitoring programme in mine and private boreholes located
Replace groundwater monitoring boreholes that may be destroyed during mining.
Measure rainfall daily on site
Record all groundwater-related complaints and deal with each complaint within the agreed upon timeframe.
Develop a sound rehabilitation plan to ensure that long-term impacts are minimised
Plan for mine closure by completing a final groundwater impact assessment at least five years before closure.
Decommissioning and Closure Phase
Complete all rehabilitation to a satisfactory level, focussing specifically on the final rehabilitation of the pits, sealing the adits and rehabilitation of the surface discard dump, if implemented and constructed. Effective rehabilitation of these areas must aim to reduce the rate of recharge of rainwater as far as possible. No ponding must be allowed over rehabilitated areas.
Plan for and budget to continue with the groundwater monitoring period for a minimum of two years after mine closure. The continued need for groundwater monitoring will depend on the outcome of the final mine closure groundwater impact assessment.

8.3 Measures to address impacts on groundwater availability

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater levels and the availability of groundwater to private users:

- The volume and quality of groundwater that is currently abstracted from private boreholes within the delineated zone of influence must be established before mining commences. These boreholes are listed in Table 20. This is a critical step in understanding what impact mining will have on these boreholes and must be use as a basis for managing the loss of any groundwater to private users during mining. In order to achieve this, pumping tests should be completed on the identified boreholes to establish borehole yield. A groundwater sample must be taken from each borehole and submitted for chemical analysis according to the details provided in Table 6.
- An attempt must be made to measure the flow of KR_Spring5 in order to establish baseline conditions. A sample must also be taken from the spring for chemical analysis. These tests must be completed prior to the commencement of mining and must be used as a basis for entering into negotiations with the owner regarding the potential loss of this spring during mining.
- Negotiations must be entered into with the owners of private boreholes that will be destroyed during opencast mining. These boreholes are listed in Table 19.
- A dedicated groundwater monitoring programme must be implemented in all private boreholes within the delineated zone of influence. These boreholes are listed in Table 20. This monitoring programme must include groundwater level and quality measurements. Should monitoring information indicate adverse impacts, Ilima must enter into negotiations with the affected landowners to negotiate alternative water supply options of equivalent quantity and quality.
- Feedback must be provided to owners of boreholes within the affected zones regarding progress made with mining activities, rehabilitation and the outcome of monitoring programmes on a quarterly basis when groundwater monitoring will take place to ensure that they are informed of aspects of mining that may be of significance.
- The volume of water pumped from underground to surface during the operational phase must be recorded. This information must be used to update the impact assessment presented in this report, as necessary.
- If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration.
- If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assume that no subsidence will take place over the underground workings.
- Surface and underground rehabilitation measures must be designed to minimise the risk of decant . In order to do so, the adit must be sealed upon mine closure and concurrent rehabilitation of the opencast pits must be maintained throughout the life of mining.
- Groundwater levels must be monitored on a monthly basis in the dedicated monitoring boreholes. This information together with daily on-site rainfall measurements must be used to improve the understanding of the rate of recharge as well as of aquifer parameters like storage coefficients and specific yield.
- The numerical model used in this assessment should be updated, verified and re-calibrated on a regular basis as monitoring information becomes available.
- The final model must be prepared at least five years prior to mine closure to ensure that predictions of long-term impacts are undertaken with the highest possible level of confidence.

8.4 Measures to address impacts on groundwater quality

The geochemical static leach tests completed on discard samples prepared from the Kranspan coal indicate that low concentrations of sulphate are expected to leach from the material under the conditions of the test, as discussed in Section 3 and indicated in Table 9. As mentioned, kinetic leach tests and geochemical modelling are currently underway, which will improve the understanding of long-term leachate quality associated with the discard material. Van Hille (2019) however states that the discard material is likely to acidify based on an acid base accounting assessment. If this were to happen, a deterioration in leachate quality is expected. In the absence of this information at the time of compilation of the report, the groundwater impact assessment was based on a worse case scenario, which assumed oxidation of the discard material during the operational phase and post-closure of the operations. This approach is in line with the requirements of the precautionary principle. Ilima is however committed to implementing a number of measures to reduce the risk of groundwater contamination associated with the handling of the discard material on site. For example, for the preferred option of in-pit discard disposal, restrictions are placed on the pit location and depth to which the discard can be backfilled. With the implementation of these management measures, the rate and extent to which the discard could oxidise will be reduced. The resultant discard leachate could therefore be of better quality than what was used in this report. If the leachate associated with the discard is of better quality, the resultant impact on groundwater quality will be reduced. For this reason, it is recommended that the groundwater quality impact assessment is revised once the results of the kinetic tests and geochemical modelling are available.

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater quality:

- Dedicated monitoring boreholes must be maintained in the two lineaments that transect the mining area. Boreholes 1-130, 1-130b, 5-110 and 5-110b are suitable for this and are situated down gradient of the plant area. Boreholes 6-220 and 6-220b are also situated on one of the lineaments. Based on the available information, it is anticipated that borehole KR11 is also situated on this fault and should therefore be included in the monitoring programme. If any of these boreholes are destroyed during mining, they must be replaced.
- Surface infrastructure, like the plant and the alternative discard stockpile option, must be positioned off the lineaments. Prior to the establishment of these areas, a geophysical survey must be completed to pin-point the faults. The positions of boreholes 1-130 and 5-110 can be used as a guideline in this regard.
- If the preferred discard disposal method is backfilling into mined out pits, only Pit 5 should be considered. It is preferable that discard is placed in the bottom of the northern most part of this pit to contain seepage and limit impacts. The boundary pillar between Pits 5 and 6 must be kept in place to avoid inter-pit flow of leachate associated with the discard. A groundwater monitoring borehole must be drilled down gradient of the area where discard is backfilled to the pit in order to monitoring the impact of this on groundwater quality.
- Prior to the implementation of either a surface discard stockpile of in-pit disposal of the discard, a geochemical study must be completed to evaluate the impact of placement of the discard material. In this study, it was assumed that leachate from the discard would deteriorate according to the description in Section 3 of this report. These assumptions must be confirmed and re-assessed once the results of the kinetic geochemical tests are available. In addition, it is recommended that geochemical modelling is undertaken to establish the potential quality of leachate if the discard is placed at the bottom of the pit and flooded to eliminate contact with oxygen. Conversely, the impact on leachate quality should be assessed if the discard is placed above the coal seam level and remains in contact with oxygen and water. In the latter instance, it is likely that the quality of leachate will deteriorate. Once the outcome of this study is available, the contaminant transport simulations presented in this report must be re-assessed.
- If the surface discard stockpile alternative is implemented, 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. This facility must be designed according to legal requirements.

- If the option to backfill discard to Pit 5 is implemented, it is important that measures are put in place to monitor and control in-pit water levels. The discard must be placed in the northern section of this pit, where the coal floor contours dip away from the nearby downstream pan and wetlands. The volume of discard that can be placed in this area must be assessed as part of the design phase for this option to determine whether or not it would be sufficient for the life of the operations. Seepage that collects in the portion of Pit 5 that is used for discard disposal should be removed through a penstock or similar measures indicated by the professional engineer appointed to design the facility. A groundwater monitoring borehole should be drilled to the north of this area (between Pits 5 and 6) to monitor the impact of placing discard in this area. This borehole must be drilled prior to the commencement of this activity. The designs for the facility must furthermore take cognisance of the potential decant point that was identified in this area of Pit 5. Potential decant at this position post closure of the facility can be mitigated by creating a PCD or a return water dam in this area to contain seepage and potential decant. It is noted that the pit is not likely to decant if it is kept open for discard disposal during the operational phase of mining. The risk of decant in the long-term can be controlled with the penstock or similar water collection system identified during the design stage of the facility and/or contained in the proposed PCD.
- Once the kinetic geochemical test results are available, the impact assessment presented in this report should be updated and amended, as necessary.
- A monitoring programme must be implemented to establish underground water quality during the life of operations. This information must be used to update the long-term impact of mining on groundwater quality presented in this report.
- Updated contaminant transport simulations must be undertaken once this information is available in order to improve the confidence levels in long-term predictions. These simulations must be completed at least five years prior to mine closure to ensure that effective measures are developed to manage long-term impacts.

8.5 Measures to address impacts associated with decant

The following specific measures are recommended to minimise and/or eliminate the impacts associated with decant:

- If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assume that no subsidence will take place.
- If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration.
- The quality of decant cannot be assessed without completing kinetic leach tests and geochemical modelling. It is however generally assumed that the quality of decant will be poor and should not be allowed to flow uncontrolled into the environment. Should this be allowed to happen, the poor quality water will have a negative impact on surface water, soil and wetlands.
- Surface and underground rehabilitation measures must be designed to minimise the risk of decant . Opencast mining areas and box cuts must be backfilled, shaped and made free draining to limit the rate of recharge of rainwater to the absolute minimum.
- Measures must be taken during the operational phase of mining to contain all decant anticipated. The PCDs must be sized to take decant volumes into consideration and cutoff trenches and berms must be put in place to divert decant to the PCDs. The planning and possible re-sizing of PCDs must be completed prior to mine closure.

9 GROUNDWATER MONITORING PROGRAMME

9.1 Objectives of the monitoring programme

Groundwater monitoring for the project should be undertaken to meet the following objectives:

- To measure the impacts of mining on groundwater levels and quality.
- To detect short- and long-term water level and quality trends.
- To calculate aquifer parameters, like the rate of recharge and storage coefficients.
- To recognise changes in groundwater characteristics, to enable analysis of their causes and to trigger the appropriate groundwater management response.
- To check the accuracy of predicted impacts.
- To use the information gathered for model calibration and/or verification.
- To develop improved practices and procedures for groundwater protection.

9.2 Monitoring locations

A groundwater monitoring programme must be implemented in all of the dedicated monitoring boreholes drilled as part of this assessment. These boreholes are listed in Tables 2 and 3.

All private boreholes that fall within the affected zones of influence must be included in the routine mine monitoring programme. These boreholes are listed in Tables 20 and 21.

The following additional monitoring boreholes are recommended:

- A shallow and deep monitoring borehole set down gradient of the northern section of Pit 5, should the option of backfilling discard to this pit be opted for. The deep borehole must be sited using geophysical methods and must be drilled to the depth of mining in this part of the pit. The borehole must be screened from top to bottom. The shallow borehole must be drilled to the depth of weathering.
- A dedicated shallow and deep monitoring borehole set must be drilled on the northern most lineament near the position of the private borehole KR11. The construction of these boreholes must adhere to that presented in Tables 2 and 3. The objective of this borehole is to monitor preferential flow of contamination from the mining areas towards the largest pan.
-

9.3 Monitoring requirements

The parameters to be included during monitoring as well as the proposed frequency of monitoring are presented in Table 29.

Table 29 Groundwater monitoring requirements in private and mine monitoring boreholes

Monitoring parameter	Element for analysis	Monitoring frequency
Depth to groundwater level	Groundwater level	Monthly
Water quality	All elements included in Table 7	Quarterly
Spring flow	Actual spring flow rates, where possible. If not, record the visual condition of all springs listed above	Quarterly
Spring water quality	All elements included in Table 7	Quarterly
Rainfall	Rain depth (mm)	Daily on site

All monitoring information must be entered into a spreadsheet for record keeping and analysis. Copies of the certificates of analyses must be kept on file for inspection.

If significant exceedances are recorded during the monitoring programme, the following actions should be taken:

- Log the exceedances in the incident reporting system within 24-hours of it occurring.
- Report the exceedances to the Environmental and General Managers as well as to the regulatory authority.
- Undertake an investigation to identify causes of the exceedances.
- Consult with any landowner or affected party that may be impacted by the exceedances to determine their concerns and to negotiate remedial actions.
- Implement the necessary remedial actions according to the outcome of the investigation and consultation with the affected parties.
- Track the incident until completion.

Regular monitoring reports must be prepared for internal use as well as for submission to the authorities, as required by the operations' water use licenses.

10 REFERENCES

ABS Africa, 2018. Ilima Coal Company – Kranspan Project – Draft Scoping Report – Application for Environmental Authorisation, Waste Management License and Integrated Water Use Licence, Carolina, Mpumalanga, dated November 2018.

DWS BPG G4, 2008. Best Practice Guideline G4: Impact Prediction, Best Practice Guidelines for Water Resource Protection in the South African Mining Industry, December 2008.

DWAF, 2000. Quality of Domestic Water Supplies: Volume 2: Sampling Guide, prepared as part of a Water Research Commission study, First Edition

DWAF, 1996. South African Water Quality Guidelines: Volume 1 – Domestic Use, Second Edition.

DWAF & Water Research Commission, First Edition 2000: Quality of Domestic Water Supplies: Volume 2: Sampling Guide.

Grobbelaar, R, Usher, B, Cruywagen, L-M, De Necker, E and Hodgson, FDI, 2004. Long-term impact of intermine flow from collieries in the Mpumalanga Coalfields, Water Research Commission Report No 1056/1/04, ISBN 1-77005-220-8, dated September 2004.

Hodgson, FDI and Kranz RM, 1998. Groundwater quality deterioration in the Olifants River Catchment above the Loskop Dam with specialised investigation in the Witbank Dam Sub-Catchment, Water Research Commission Report 291/1/98.

Ilima, 2018. Ilima Coal Company (Pty) Ltd – Kranspan Project – Mining Works Programme, dated September 2018.

Peens & Associates, 2019. Kranspan Coal Mine – Hydrological Specialist Report, Reference No 0155_KRANSPAN_HYDROLOGICAL SPECIALIST REPORT, Second Draft Report, dated 18 February 2019.

Rowe, R. K., 2012. Short- and long-term leakage through composite liners. The 7th Arthur Casagrande lecture, Canadian Geotechnical Journal, Vol 49, pp 141 – 169.

SABS, 2015. South African National Standards SANS 241-1:2015. SA Drinking Water Standards.

Van Hille, R. 2019. Report on Static Test Data for Discard Coal and Waste Rock Samples – Kranspan, dated April 2019.

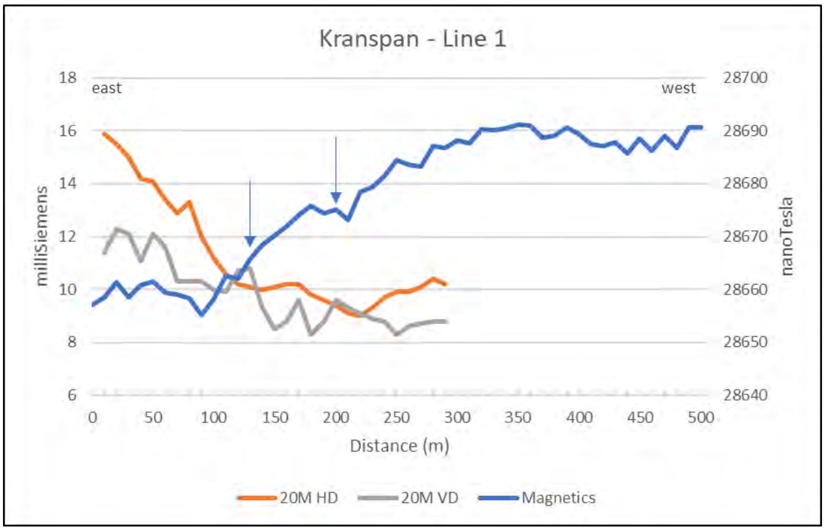
Appendix 1 – Hydrocensus information

Site ID	Farm	Owner	Lat (WGS84)	Long (WSG84)	Elevation (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/h)	Sampled	Pump type	Use	Note
KR1	Vaalbank Ptn 8	Rudi Prinsloo	26°10'18,8" S	29°58'08,7" E	1743	19,24	0,20	1723,56	--	--	no	windpump	House & animals	Windpump close to house and trig beacon
KR2	Vaalbank Ptn 8	Rudi Prinsloo	26°11'11,6" S	29°58'23,6" E	1725	pumping	--	--	--	--	no	windpump	Animals	Windpump behind school on farm.
KR3	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,4" S	29°59'43,8" E	1664	closed	0,27	--	--	--	yes	windpump	Animals	Rusted windpump on western edge of large pan
KR4	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,2" S	29°59'38,6" E	1662	12,00	0,12	1649,88	--	--	no	open hole	None	Open hole next to cement dam fed by borehole KR3
KR5	Kranspan Ptn 3	Jaco Papenfus	26°09'23,2" S	30°01'06,0" E	1678	blocked near surface	0,18	--	--	--	no	open hole	None	Open hole next to access road to Jaco. Old windpump frame in veld
KR6	Kranspan Ptn 3	Jaco Papenfus	26°09'21,0" S	30°01'26,7" E	1681	blocked at 2m	0,40	--	--	--	no	open hole	None	Dolomite borehole?
KR7	Kranspan Ptn 3	Jaco Papenfus	26°09'30,9" S	30°00'29,2" E	1708	22,38	0,13	1685,49	--	--	no	submerc	House & animals	Pump not operational. Close to old windpump next to house
KR8	Kranspan Ptn 3	Jaco Papenfus	26°09'30,8" S	30°00'28,7" E	1708	17,77	0,00	1690,23	--	--	no	windpump	None	Old windpump next to house
KR9	Kranspan Ptn 4	Gysbert Klein	26°10'11,6" S	29°58'35,7" E	1722	14,00	0,06	1707,94	--	--	no	windpump	Animals	Seems to be out of order - rusted.
KR10	Kranspan Ptn 4	Gysbert Klein	26°09'24,4" S	29°59'24,3" E	1694	closed	0,00	--	--	--	no	windpump	Animals	
KR11	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,2" S	30°00'23,1" E	1662	closed	0,50	--	--	--	yes	windpump	House & animals	Water supply to Jaco Papenfus house. Windpump on northern edge of big pan
KR12	Kranspan Ptn 8	Koos Jordaan	26°09'57,2" S	30°01'55,7" E	1661	blocked at 22m	0,00	--	--	--	yes	submerc	House and animals	Near house and cement dam
KR13	Kranspan Ptn RE	Koos Jordaan	26°11'43,5" S	30°00'36,8" E	1678	blocked at 3m	0,00	--	--	--	no	windpump	None	Used to be for animals. Next to tar road and old house.
KR14	Vaalbank Ptn RE	Koos Jordaan	26°12'25,9" S	29°59'22,8" E	1703	pumping	0,28	--	30	--	yes	solar submerc	House & animals	
KR15	Vaalbank Ptn RE	Koos Jordaan	26°12'30,2" S	29°59'17,9" E	1710	obstructions	0,16	--	30	--	no	submerc	House & animals	Main BH to house
KR16	Vaalbank Ptn RE	Koos Jordaan	26°12'30,3" S	29°59'15,3" E	1712	3,80	0,16	1708,04	30	--	no	open hole	None	Suspect bricks in hole. Obstructed
KR17	Vaalbank Ptn RE	Koos Jordaan	26°12'36,9" S	29°59'21,3" E	1724	13,86	0,10	1710,04	30	--	no	open hole	None	Close to house and workshops
KR18	Kranspan Ptn 6	Kobus Papenfus	26°10'37,0" S	29°59'00,2" E	1682	closed	0,03	--	--	--	yes	windpump	Animals	
KR19	Kranspan Ptn 6	Kobus Papenfus	26°11'14,6" S	29°59'42,3" E	1685	closed	0,10	--	--	--	yes	windpump	Animals	
KR_ Spring1	Vaalbank Ptn 8	Rudi Prinsloo	26°10'25,5" S	29°57'53,2" E	1711	0,00	0,00	1711,00	--	--	no	none	Animals	Spring at house. Not flowing but water in brick ring

Site ID	Farm	Owner	Lat (WGS84)	Long (WSG84)	Elevation (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/h)	Sam pled	Pump type	Use	Note
KR_ Spring2	Vaalbank Ptn 8	Rudi Prinsloo	26°10'25,5" S	29°57'57,3" E	1708	0,00	0,00	1708,00	--	--	no	none	Animals	Spring at house. Not flowing. Dry
KR_ Spring3	Vaalbank Ptn 8	Rudi Prinsloo	26°10'53,4" S	29°57'24,6" E	1648	0,00	0,00	1648,00	--	1000	yes	none	Animals	Strong flowing spring. Discharges into large cement dam
KR_ Spring4	Vaalbank Ptn 8	Rudi Prinsloo	26°10'30,5" S	29°58'13,7" E	1730	0,00	0,00	1730,00	--	--	no	none	House & animals	Low flow. Wetlands downstream. Near staff houses
KR_ Spring5	Kranspan Ptn 8	Koos Jordaan	26°11'09,9" S	30°01'29,8" E	1659	0,00	0,00	1659,00	--	--	no	none	Animals	Fenced.
KR_ Spring6	Kranspan Ptn 6	Kobus Papenfus	26°10'20,5" S	29°59'31,8" E	1662	0,00	0,00	1662,00	--	--	no	none	Animals	Not flowing
KR_ Seep	Vaalbank Ptn 8	Rudi Prinsloo	26°10'26,9" S	29°58'00,6" E	1718	0,00	0,00	1718,00	--	--	no	none	Animals	Not flowing

Appendix 2 – Results of the Geophysical Survey

Line 1:

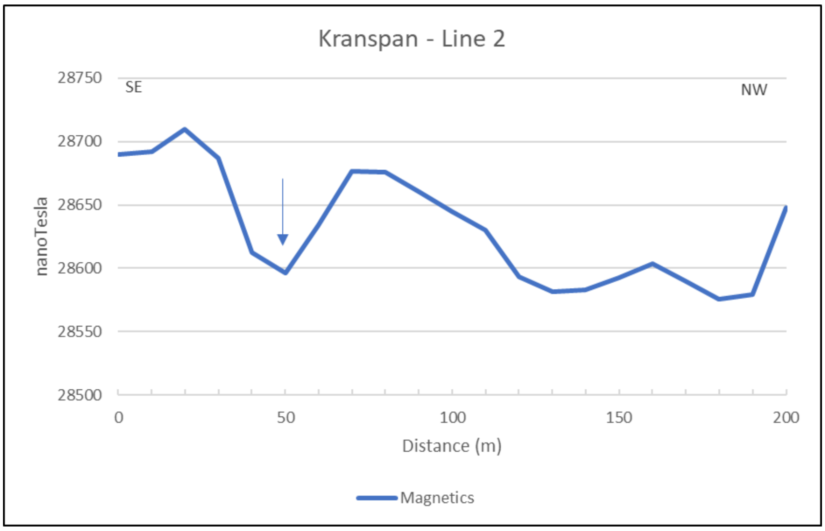


Line 1:	Latitude	Longitude	Notes
Line start coordinates:	S 26.165744°	E 30.010750°	WGS84
Line end coordinates:	S 26.165837°	E 30.006092°	
Line orientation:			East to West
Possible geological feature-1:	S 26.165775°	E 30.009571°	Line 1-130
Possible geological feature-2:	S 26.165791°	E 30.008895°	Line 1-200

Line 1 focused on identifying a north-south trending fault that runs through the big pan on Kranspan. The line was surveyed approximately 600m from the northern edge of the pan along a farm road.

Two geophysical anomalies were identified – at station 130m and at station 200m. Based on the step in the Mag data and also more conductive zone at station 130m it has been assumed that station 130m is potentially the fault. A second possible fractured zone is at station 200m.

Line 2:

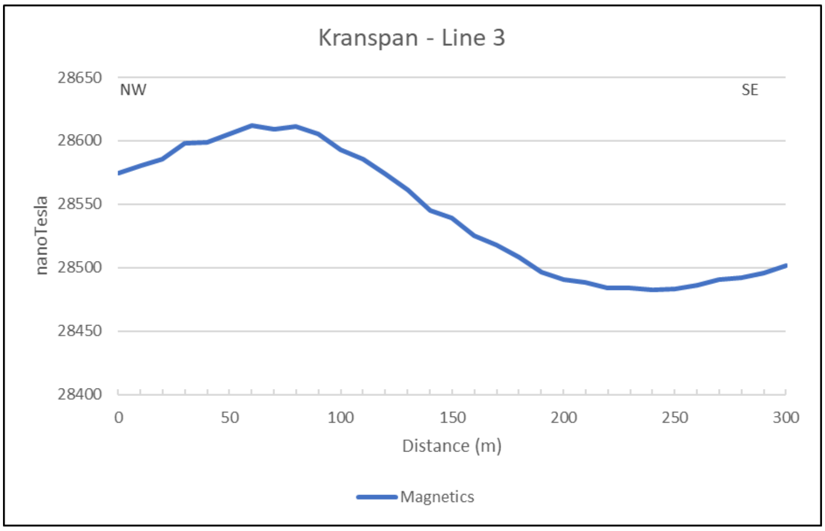


Line 2:	Latitude	Longitude	Notes
Line start coordinates:	S 26.172206°	E 29.987668°	WGS84
Line end coordinates:	S 26.171040°	E 29.986125°	
Line orientation:			Southeast to Northwest
Possible geological feature-1:	S 26.171920°	E 29.987260°	Line 2-50

Line 2 focused on identifying a possible dolerite dyke that that was pointed out by Rudolph Schoeler. It was mentioned that the dyke was identified during the exploration drilling and has a northeast-southwest orientation.

A geophysical anomaly was identified at station 50m. It has been assumed that the negative anomaly represents the dyke position. GWA suspects that this could be the edge of a diabase sill.

Line 3:

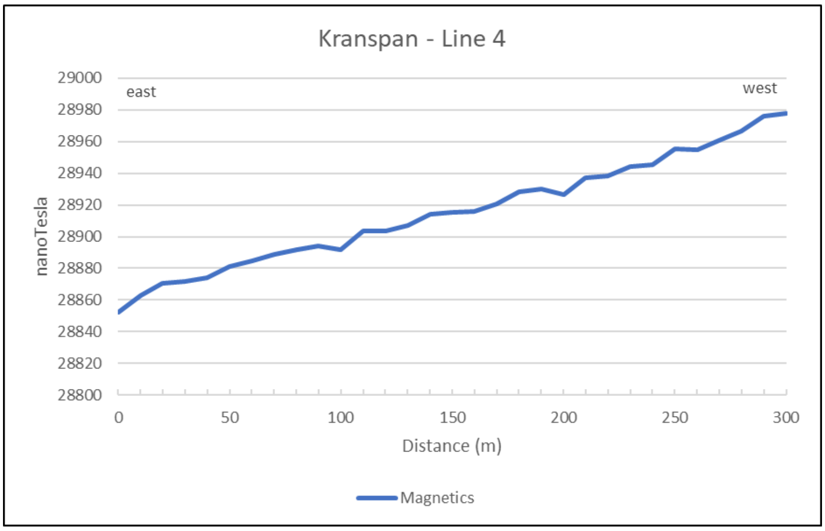


Line 3:	Latitude	Longitude	Notes
Line start coordinates:	S 26.169342°	E 29.992084°	WGS84
Line end coordinates:	S 26.171659°	E 29.993181°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	No drilling position was marked		

Line 3 focused on identifying a possible dolerite dyke that that was pointed out by Rudolph Schoeler. The line was run to define a possible strike direction for the anomaly identified on Line 2.

A geophysical anomaly was identified along the whole length of the line. It has been assumed that the line does not cross the possible dyke at a 90° angle, but runs along the possible structure at a low angle.

Line 4:

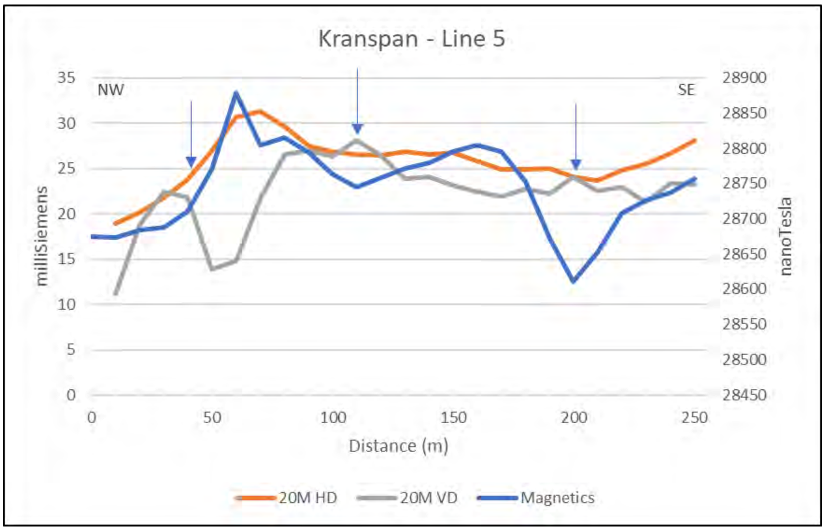


Line 4:	Latitude	Longitude	Notes
Line start coordinates:	S 26.154929°	E 30.032469°	WGS84
Line end coordinates:	S 26.155123°	E 30.029478°	
Line orientation:			East to West
Possible geological feature-1:	No drilling position was marked		

Line 4 focused on identifying the north-south trending fault that runs parallel and close to the main tar road.

No geophysical anomalies were identified and it was concluded that the fault does no cross at the selected position, but possibly further east. The line could not be extended due to the tar road, fences and houses on the opposite side of the road.

Line 5:

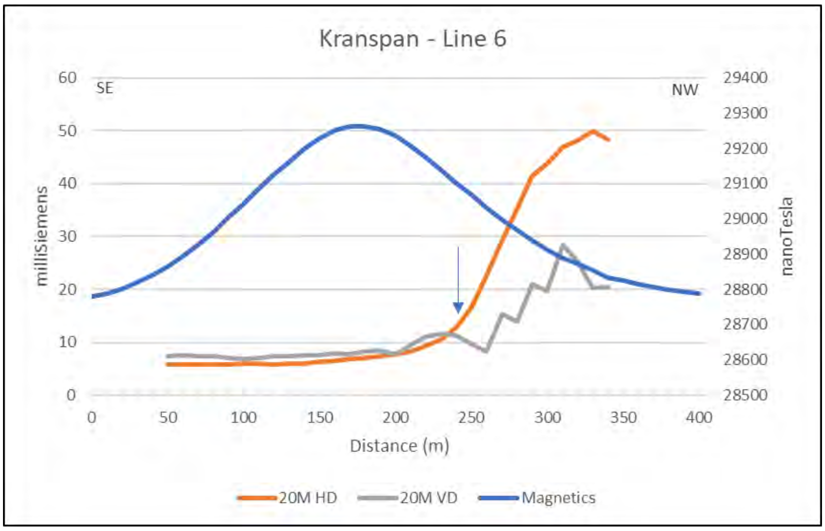


Line 5:	Latitude	Longitude	Notes
Line start coordinates:	S 26.160924°	E 30.008474°	WGS84
Line end coordinates:	S 26.162119°	E 30.101328°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	S 26.161107°	E 30.008883°	Line 5-40
Possible geological feature-2:	S 26.161470°	E 30.009393°	Line 5-110
Possible geological feature-3:	S 26.161883°	E 30.009967°	Line 5-200

Line 5 focused on identifying the north-south trending fault that runs through the big pan on Kranspan, as well as a possible sill contact.

Three geophysical anomalies were identified – at stations 40m, 110m and 200m. It has been assumed that station 40m is the sill contact; then there is a weathered zone (possible fracture) at 110m, and the fault at station 200m.

Line 6:

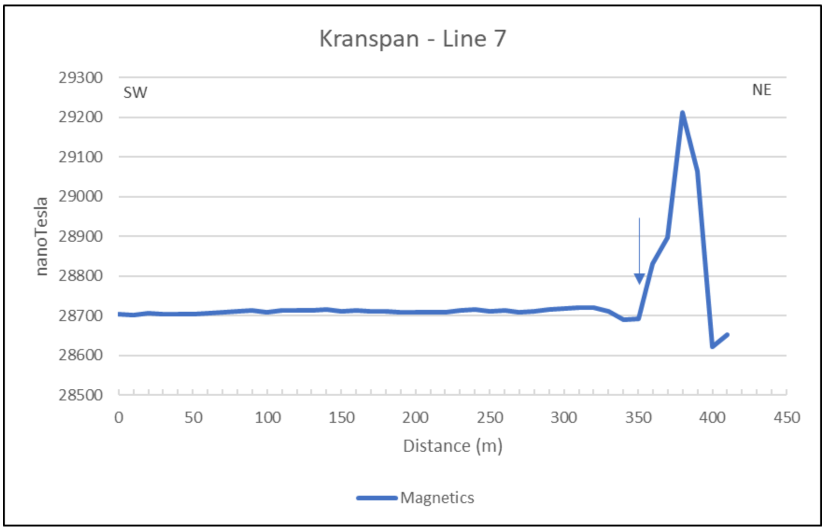


Line 6:	Latitude	Longitude	Notes
Line start coordinates:	S 26.183345°	E 30.017885°	WGS84
Line end coordinates:	S 26.181594°	E 30.014559°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	S 26.182365°	E 30.016054°	Line 6-220

Line 6 focused on identifying the north-south trending fault that runs parallel and close to the main tar road.

A geophysical anomaly was identified at station 220m. Based on the magnetic data it could be that the geophysical survey was run at an angle across the fault. Based on the step in the EM data and also more conductive zone towards the end of the line it has been assumed that station 220m is potentially the fault. The end of the line is also in a lower lying area with possible clay.

Line 7:

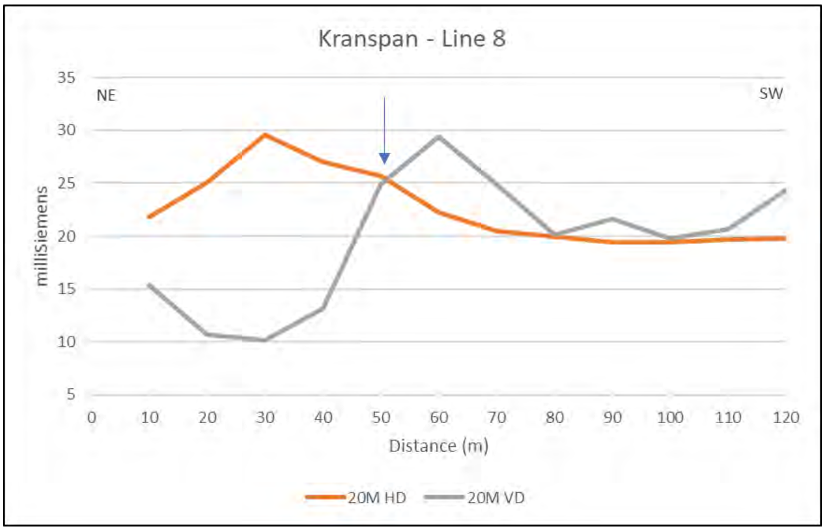


Line 7:	Latitude	Longitude	Notes
Line start coordinates:	S 26.160350°	E 30.002856°	WGS84
Line end coordinates:	S 26.158197°	E 30.006255°	
Line orientation:			Southwest to Northeast
Possible geological feature-1:	S 26.158489°	E 30.005771°	Line 7-350

Line 7 focused on identifying a possible sill as identified by the Client.

A geophysical anomaly was identified at station 350m. Based on the positive Mag anomaly it was assumed that this is the edge of the sill. A fence and buildings stopped the line from extending further north. The drill position was not marked at this point. A second line (Line 8) was run to determine a strike direction.

Line 8:



Line 8:	Latitude	Longitude	Notes
Line start coordinates:	S 26.158172°	E 30.006146°	WGS84
Line end coordinates:	S 26.158723°	E 30.005019°	
Line orientation:			Northeast to Southwest
Possible geological feature-1:	S 26.158387°	E 30.005689°	Line 8-50

Line 8 focused on identifying the orientation of the sill contact identified on Line 7.

A geophysical anomaly was identified at station 50m. Based on the step in the EM data and change in conductivity at station 50m it has been assumed that this is potentially the edge of the sill. The drill position was not marked at this point, but moved 10m away into a grass patch.

Appendix 3 – Monitoring Borehole Drilling Results

Water Monitoring Borehole: Line 2-50
Drilled by : WJ Water Drilling
Date Drilled: 10-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	5	Laterite and clay
5	25	Brown clay
25	50	Sandstone/shale interbedded. Competent material

Additional Comments:
a bit of of water at 5m and approximately 1000liters per hour on 35m.

Photo of Line 2-50:

Water Monitoring Borehole: Line 1-130
Drilled by : WJ Water Drilling
Date Drilled: 12-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	3	Brown laterite and weathered sandstone
3	10	competent shale and sandstone layer
10	25	white sandstone - competent
25	40	carbonacoues shale and coal - competent
40	50	Competent sandstone.

Additional Comments:
no major water to report

Photo of Pan Monitoring 2:

Water Monitoring Borehole: Line 5-110
Drilled by : WJ Water Drilling
Date Drilled: 13-Dec-18
Logged by: A Davis
Date Logged: 14-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	2	brown sand/soil
2	4	weathered sandstone brown
4	7	white siltstone weathered
7	8	sandstone brown competent
8	10	shale
10	12	carbonaceous shale
12	15	sandstone brown slightly weathered
15	20	doleritic zone
20	25	sandtsone and shale
25	35	sandstone possible fracture zone
35	45	carbonaceous shale with some sandstone
45	50	Competent sandstone.

Additional Comments:

1,500 liters per hour is estimated at 15m and on 10,000 liters per hour is estimated at 35m.

Water Monitoring Borehole: Line 6-220
Drilled by : WJ Water Drilling
Date Drilled: 11-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	5	weathered sandstone.
5	10	sandstone - appears competent
10	13	carbonaceous shale - competent
13	33	white sandstone - appears competent
33	50	sandstone very wet.

Additional Comments:
At 15m approximately 1000liters per hour and at 45m approximately 2500liters per hour.

Photo of Line 6-220:

Water Monitoring Borehole: Pan Monitoring 1
Drilled by : WJ Water Drilling
Date Drilled: 10-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	5	Black clay
5	9	Grey sandstone, shale layer. Appears weathered
9	47	white sandstone layer. Appears weathered
47	50	Dolerite

Additional Comments:
Approximately 2000liters per hour on 30m

Photo of Pan Monitoring 1:

Water Monitoring Borehole: Pan Monitoring 2
Drilled by : WJ Water Drilling
Date Drilled: 11-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	20	Black clay material
20	50	white sandstone - appears slightly weathered.

Additional Comments:
No major water could be reported, however, very clayey.

Photo of Pan Monitoring 2:

Water Monitoring Borehole: Pan Monitoring 3
Drilled by : WJ Water Drilling
Date Drilled: 13-Dec-18
Logged by: A Davis
Date Logged: 14-Dec-18
EOH: 50m

From	To	Description
(m)	(m)	
0	15	white loose sand
15	20	Carbonaceous shale and sand
20	50	sandstone, very weathered.

Additional Comments:
The flow rate is in excess of 10,000liters per hour.

Photo of Pan Monitoring 3:

Water Monitoring Borehole:	Line 8 Site
Drilled by :	WJ Water Drilling
Date Drilled:	13-Dec-18
Logged by:	A Davis
Date Logged:	14-Dec-18
EOH:	50m

From (m)	To (m)	Description
0	6	brown sand/soil
6	9	highly weathered sandstone
9	15	competent sandstone and shale
15	19	carbonaceous shale
19	20	sandstone
20	22	carbonaceous shale
22	27	sandstone competent
27	32	doleritic zone
32	35	dolerite and coal
35	50	very wet shale and sandstone

Additional Comments:

1000 liters per hour is estimated at approximately 35m on the deep hole.		
Approximately 5000 liters per hour is estimated on 13m on the shallow hole.		

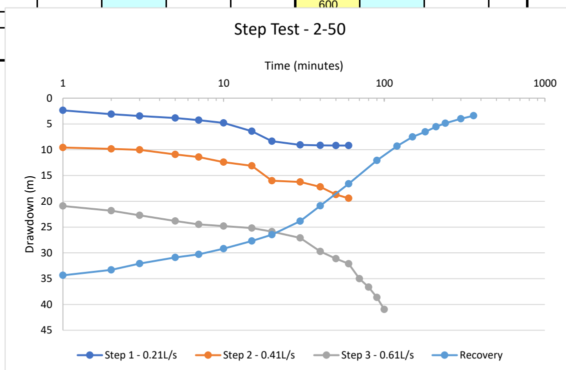
Appendix 4 – Aquifer Testing Results

Borehole Number	2-50	**Lat**	26,1719
BH Diameter	17mm	**Long**	29,98728
Collar Height	0.31m		
BH Depth	48.59m		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **4,22**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,37	**6,59**		9,57	**13,79**		20,91	**25,13**					1	34,35	**38,57**
2	3,11	**7,33**		9,84	**14,06**	**0,32**	21,82	**26,04**					2	33,29	**37,51**
3	3,46	**7,68**		10,03	**14,25**		22,71	**26,93**	**0,66**				3	32,07	**36,29**
5	3,84	**8,06**	**0,21**	10,91	**15,13**	**0,39**	23,83	**28,05**	**0,63**				5	30,89	**35,11**
7	4,25	**8,47**	**0,35**	11,41	**15,63**	**0,41**	24,47	**28,69**	**0,6**				7	30,3	**34,52**
10	4,8	**9,02**		12,4	**16,62**	**0,4**	24,79	**29,01**	**0,64**				10	29,18	**33,4**
15	6,41	**10,63**	**0,32**	13,11	**17,33**	**0,39**	25,19	**29,41**	**0,61**				15	27,7	**31,92**
20	8,35	**12,57**	**0,3**	16,02	**20,24**	**0,44**	25,87	**30,09**	**0,63**				20	26,48	**30,7**
30	9,06	**13,28**	**0,25**	16,24	**20,46**	**0,42**	27,1	**31,32**	**0,62**				30	23,85	**28,07**
40	9,15	**13,37**	**0,21**	17,21	**21,43**	**0,41**	29,71	**33,93**	**0,65**				40	20,88	**25,1**
50	9,17	**13,39**	**0,2**	18,69	**22,91**	**0,42**	31,13	**35,35**	**0,6**				60	16,6	**20,82**
60	9,19	**13,41**	**0,21**	19,41	**23,63**	**0,4**	32,11	**36,33**	**0,64**				90	12,08	**16,3**
70							35,01	**39,23**	**0,64**				120	9,3	**13,52**
80							36,65	**40,87**	**0,59**				150	7,51	**11,73**
90							38,64	**42,86**	**0,61**				180	6,52	**10,74**
100							40,95	**45,17**	**0,59**				210	5,56	**9,78**
110													240	4,86	**9,08**
120													300	4	**8,22**
130													360	3,41	**7,63**
140													420		
150													480		
160													540		
170													600		
180															

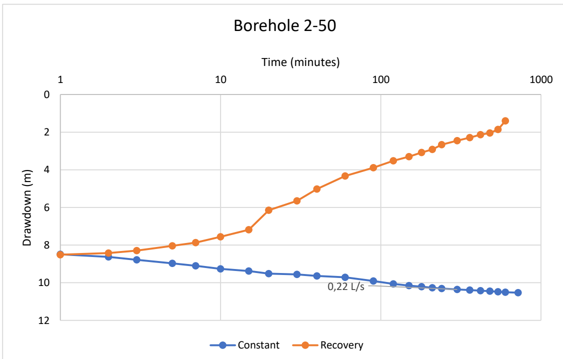


CONSTANT DISCHARGE

WL at start of test **7,63**

Monitoring Borehole
BH No 2-50M
SWL 4,52

				recovery		
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**
1	8,49	**16,12**		8,51	**16,14**	**0**
2	8,63	**16,26**		8,42	**16,05**	**0**
3	8,78	**16,41**		8,29	**15,92**	**0**
5	8,97	**16,6**		8,04	**15,67**	**0**
7	9,1	**16,73**	**0,25**	7,87	**15,5**	**0**
10	9,26	**16,89**	**0,23**	7,56	**15,19**	**0**
15	9,38	**17,01**	**0,21**	7,18	**14,81**	**0**
20	9,52	**17,15**	**0,24**	6,15	**13,78**	**0**
30	9,56	**17,19**	**0,2**	5,65	**13,28**	**0**
40	9,64	**17,27**	**0,24**	5,02	**12,65**	**0**
60	9,71	**17,34**	**0,24**	4,33	**11,96**	**0**
90	9,91	**17,54**	**0,22**	3,89	**11,52**	**0**
120	10,06	**17,69**	**0,21**	3,52	**11,15**	**0**
150	10,15	**17,78**	**0,24**	3,3	**10,93**	**0**
180	10,21	**17,84**	**0,25**	3,08	**10,71**	**0**
210	10,27	**17,9**	**0,21**	2,92	**10,55**	**0**
240	10,31	**17,94**	**0,23**	2,66	**10,29**	**0**
300	10,36	**17,99**	**0,24**	2,45	**10,08**	**0**
360	10,39	**18,02**	**0,24**	2,29	**9,92**	**0**
420	10,42	**18,05**	**0,21**	2,13	**9,76**	**0**
480	10,45	**18,08**	**0,2**	2,04	**9,67**	**0**
540	10,48	**18,11**	**0,22**	1,86	**9,49**	**0**
600	10,5	**18,13**	**0,23**	1,4	**9,03**	**0**
720	10,53	**18,16**	**0,24**			**0**
840						
960						
1080						
1200						
1320						
1440						
2280						
2880						
3480						
3900						
4320						

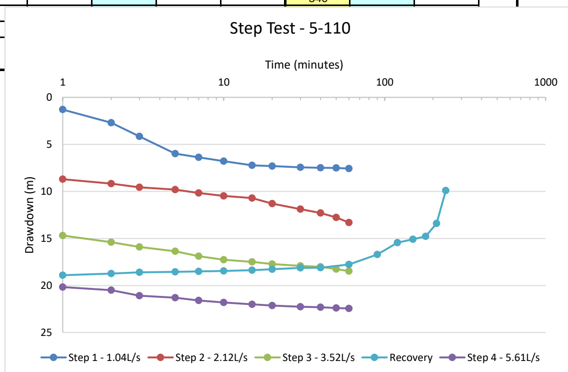


Borehole Number	5-110	**Lat**	26,16145
BH Diameter	170mm	**Long**	30,00941
Collar Height	0,52		
BH Depth	48		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **4,99**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	1,3	**6,29**		8,7	**13,69**		14,69	**19,68**		20,17	**25,16**		1	18,91	**23,9**
2	2,7	**7,69**		9,17	**14,16**	**1,99**	15,4	**20,39**		20,49	**25,48**		2	18,74	**23,73**
3	4,15	**9,14**	**1,06**	9,56	**14,55**		15,9	**20,89**	**3,46**	21,08	**26,07**		3	18,6	**23,59**
5	5,99	**10,98**	**1,05**	9,8	**14,79**	**2,16**	16,37	**21,36**	**3,57**	21,3	**26,29**	**5,61**	5	18,56	**23,55**
7	6,37	**11,36**	**1,02**	10,16	**15,15**	**2,11**	16,89	**21,88**	**3,55**	21,6	**26,59**	**5,6**	7	18,51	**23,5**
10	6,79	**11,78**	**1,03**	10,47	**15,46**	**2,14**	17,26	**22,25**	**3,54**	21,8	**26,79**	**5,61**	10	18,45	**23,44**
15	7,22	**12,21**	**1,04**	10,7	**15,69**	**2,13**	17,49	**22,48**	**3,53**	22	**26,99**	**5,58**	15	18,37	**23,36**
20	7,3	**12,29**	**1,04**	11,3	**16,29**	**2,15**	17,72	**22,71**	**3,54**	22,14	**27,13**	**5,61**	20	18,27	**23,26**
30	7,43	**12,42**	**1,04**	11,89	**16,88**	**2,16**	17,91	**22,9**	**3,54**	22,26	**27,25**	**5,62**	30	18,12	**23,11**
40	7,49	**12,48**	**1,03**	12,29	**17,28**	**2,13**	18,02	**23,01**	**3,55**	22,31	**27,3**	**5,59**	40	18,11	**23,1**
50	7,51	**12,5**	**1,04**	12,76	**17,75**	**2,12**	18,26	**23,25**	**3,52**	22,39	**27,38**	**5,61**	60	17,76	**22,75**
60	7,57	**12,56**	**1,05**	13,31	**18,3**	**2,12**	18,47	**23,46**	**3,54**	22,44	**27,43**	**5,6**	90	16,7	**21,69**
70													120	15,44	**20,43**
80													150	15,09	**20,08**
90													180	14,78	**19,77**
100													210	13,4	**18,39**
110													240	9,9	**14,89**
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

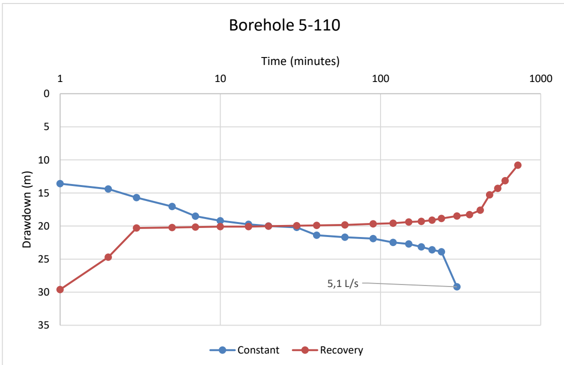


CONSTANT DISCHARGE

WL at start of test **14,89**

Monitoring Borehole
BH No 5-110
SWL 6,44

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	13,6	**28,49**		29,6	**44,49**	**0**	
2	14,4	**29,29**		24,71	**39,6**	**0**	
3	15,7	**30,59**		20,3	**35,19**	**0**	
5	17,05	**31,94**	**5,26**	20,22	**35,11**	**0**	
7	18,52	**33,41**	**5,19**	20,17	**35,06**	**0**	0
10	19,2	**34,09**	**5,13**	20,1	**34,99**	**0**	0
15	19,75	**34,64**	**5,14**	20,08	**34,97**	**0**	0
20	20	**34,89**	**5,12**	20,03	**34,92**	**0**	0
30	20,21	**35,1**	**5,11**	19,96	**34,85**	**0**	0
40	21,39	**36,28**	**5,1**	19,91	**34,8**	**0**	0
60	21,68	**36,57**	**5,13**	19,84	**34,73**	**0**	0
90	21,9	**36,79**	**5,14**	19,68	**34,57**	**0**	0
120	22,49	**37,38**	**5,1**	19,57	**34,46**	**0**	0
150	22,71	**37,6**	**5,13**	19,4	**34,29**	**0**	0
180	23,15	**38,04**	**5,14**	19,29	**34,18**	**0**	0
210	23,59	**38,48**	**5,12**	19,11	**34**	**0**	0
240	23,9	**38,79**	**5,11**	18,86	**33,75**	**0**	0
300	29,19	**44,08**	**5,1**	18,5	**33,39**	**0**	0
360				18,29	**33,18**	**0**	0
420				17,61	**32,5**	**0**	0
480				15,29	**30,18**	**0**	0
540				14,3	**29,19**	**0**	0
600				13,16	**28,05**	**0**	0
720				10,81	**25,7**	**0**	0
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

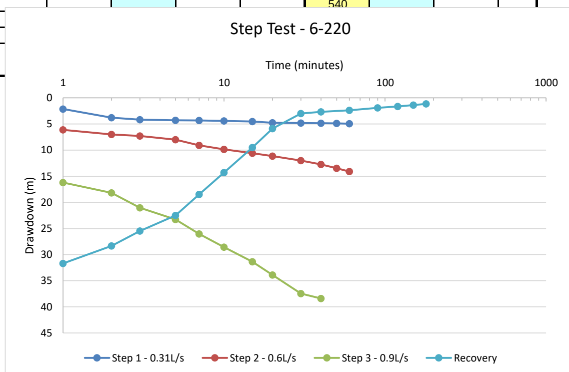


Borehole Number	6-220	**Lat**	26,18233
BH Diameter	170mm	**Long**	30,016
Collar Height	0,48		
BH Depth	49,61		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **5,3**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,14	**7,44**		6,13	**11,43**		16,21	**21,51**					1	31,69	**36,99**
2	3,81	**9,11**		7	**12,3**		18,19	**23,49**					2	28,34	**33,64**
3	4,18	**9,48**		7,3	**12,6**	**0,44**	21,04	**26,34**					3	25,47	**30,77**
5	4,3	**9,6**	**0,32**	8,02	**13,32**		23,29	**28,59**	**0,81**				5	22,5	**27,8**
7	4,34	**9,64**	**0,28**	9,1	**14,4**	**0,66**	26,04	**31,34**	**0,93**				7	18,49	**23,79**
10	4,41	**9,71**	**0,3**	9,86	**15,16**	**0,61**	28,57	**33,87**	**0,86**				10	14,3	**19,6**
15	4,53	**9,83**	**0,27**	10,59	**15,89**	**0,57**	31,36	**36,66**	**0,92**				15	9,51	**14,81**
20	4,76	**10,06**	**0,33**	11,17	**16,47**	**0,62**	33,9	**39,2**	**0,91**				20	5,89	**11,19**
30	4,83	**10,13**	**0,32**	12	**17,3**	**0,6**	37,46	**42,76**	**0,9**				30	3	**8,3**
40	4,86	**10,16**	**0,3**	12,74	**18,04**	**0,58**	38,4	**43,7**	**0,86**				40	2,69	**7,99**
50	4,9	**10,2**	**0,31**	13,49	**18,79**	**0,6**							60	2,38	**7,68**
60	4,95	**10,25**	**0,39**	14,11	**19,41**	**0,61**							90	1,91	**7,21**
70													120	1,64	**6,94**
80													150	1,39	**6,69**
90													180	1,16	**6,46**
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

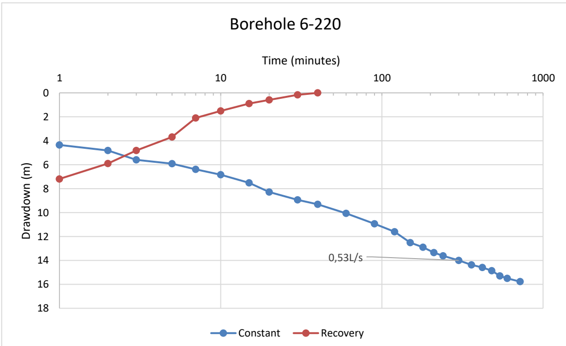


CONSTANT DISCHARGE

WL at start of test **6,46**

Monitoring Borehole
BH No 6-220
SWL 3,13

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	4,35	**10,81**		7,19	**11,5**	**0**	
2	4,81	**11,27**		5,9	**10,35**	**0**	
3	5,6	**12,06**		4,81	**9,74**	**0**	
5	5,91	**12,37**	**0,23**	3,69	**8,63**	**0**	
7	6,39	**12,85**		2,1	**7,51**	**0**	0,2
10	6,84	**13,3**	**0,5**	1,51	**6,67**	**0**	0,18
15	7,51	**13,97**	**0,54**	0,89	**6,07**	**0**	0,17
20	8,29	**14,75**	**0,55**	0,58	**5,96**	**0**	0,15
30	8,94	**15,4**	**0,54**	0,166	**5,89**	**0**	0,145
40	9,31	**15,77**	**0,46**	0	**5,71**	**0**	0,14
60	10,06	**16,52**	**0,53**		**5,65**	**0**	0,136
90	10,94	**17,4**	**0,49**		**5,46**	**0**	0,131
120	11,6	**18,06**	**0,55**		**5,29**	**0,03**	0,127
150	12,51	**18,97**	**0,54**		**5,14**	**0,05**	0,125
180	12,9	**19,36**	**0,53**		**5**	**0,08**	0,123
210	13,34	**19,8**	**0,51**		**4,8**	**0,09**	0,121
240	13,61	**20,07**	**0,53**		**4,71**	**0,11**	0,119
300	14	**20,46**	**0,54**		**4,43**	**0,13**	0,116
360	14,37	**20,83**	**0,53**		**4,31**	**0,16**	0,113
420	14,59	**21,05**	**0,55**		**4,07**	**0,17**	0,112
480	14,86	**21,32**	**0,53**		**3,81**	**0,19**	0,11
540	15,29	**21,75**	**0,54**		**3,6**	**0,21**	0,096
600	15,5	**21,96**	**0,53**		**3,39**	**0,23**	0,094
720	15,77	**22,23**	**0,55**		**3,19**	**0,25**	0,091
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

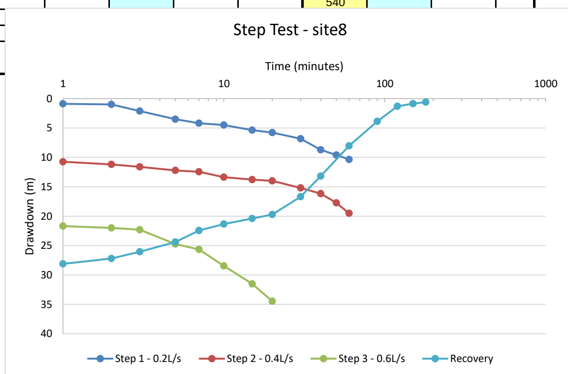


Borehole Number	8 Site	**Lat**	26,15827
BH Diameter	170mm	**Long**	30,00564
Collar Height	0,4		
BH Depth	49,03		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **9,71**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	0,89	**10,6**		10,74	**20,45**		21,69	**31,4**					1	28,12	**37,83**
2	0,99	**10,7**		11,2	**20,91**		22	**31,71**	**0,61**				2	27,19	**36,9**
3	2,12	**11,83**		11,61	**21,32**		22,31	**32,02**					3	26,06	**35,77**
5	3,51	**13,22**	**0,21**	12,21	**21,92**	**0,36**	24,73	**34,44**	**0,6**				5	24,4	**34,11**
7	4,19	**13,9**	**0,22**	12,45	**22,16**	**0,4**	25,66	**35,37**	**0,53**				7	22,44	**32,15**
10	4,51	**14,22**	**0,2**	13,36	**23,07**	**0,41**	28,46	**38,17**	**0,64**				10	21,35	**31,06**
15	5,37	**15,08**	**0,22**	13,79	**23,5**	**0,36**	31,51	**41,22**	**0,59**				15	20,39	**30,1**
20	5,79	**15,5**	**0,23**	13,99	**23,7**	**0,39**	34,47	**44,18**	**0,6**				20	19,71	**29,42**
30	6,82	**16,53**	**0,2**	15,19	**24,9**	**0,41**							30	16,69	**26,4**
40	8,71	**18,42**	**0,21**	16,17	**25,88**	**0,4**							40	13,17	**22,88**
50	9,59	**19,3**	**0,2**	17,72	**27,43**	**0,39**							60	8,02	**17,73**
60	10,35	**20,06**	**0,2**	19,52	**29,23**	**0,4**							90	3,86	**13,57**
70													120	1,31	**11,02**
80													150	0,86	**10,57**
90													180	0,6	**10,31**
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

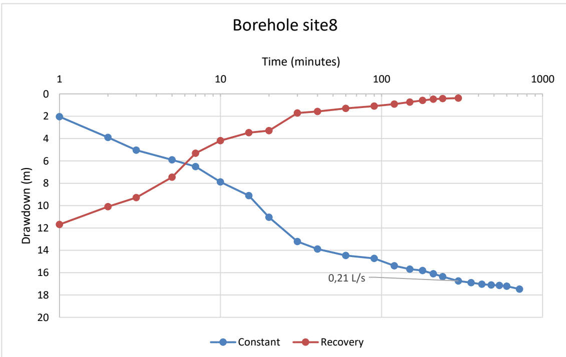


CONSTANT DISCHARGE

WL at start of test **10,31**

Monitoring Borehole
BH No PM-3
SWL 5,54

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	2,04	**12,35**		11,69	**22**	**0**	0
2	3,9	**14,21**		10,1	**20,41**	**0**	0
3	5,04	**15,35**	**0,31**	9,29	**19,6**	**0**	0
5	5,91	**16,22**		7,46	**17,77**	**0**	0
7	6,51	**16,82**	**0,26**	5,31	**15,62**	**0**	0
10	7,89	**18,2**	**0,2**	4,19	**14,5**	**0**	0
15	9,1	**19,41**	**0,25**	3,47	**13,78**	**0**	0
20	11,04	**21,35**	**0,24**	3,29	**13,6**	**0**	0
30	13,21	**23,52**	**0,2**	1,71	**12,02**	**0**	0
40	13,89	**24,2**	**0,21**	1,57	**11,88**	**0**	0
60	14,47	**24,78**	**0,22**	1,3	**11,61**	**0**	0
90	14,72	**25,03**	**0,17**	1,09	**11,4**	**0**	0
120	15,39	**25,7**	**0,24**	0,91	**11,22**	**0**	0
150	15,69	**26**	**0,23**	0,74	**11,05**	**0**	0
180	15,81	**26,12**	**0,2**	0,59	**10,9**	**0**	0
210	16,1	**26,41**	**0,23**	0,47	**10,78**	**0**	0
240	16,36	**26,67**	**0,24**	0,42	**10,73**	**0**	0
300	16,74	**27,05**	**0,23**	0,38	**10,69**	**0**	0
360	16,9	**27,21**	**0,22**			**0**	0
420	17,04	**27,35**	**0,2**			**0**	0
480	17,11	**27,42**	**0,23**			**0**	0
540	17,15	**27,46**	**0,21**			**0**	0
600	17,21	**27,52**	**0,21**			**0**	0
720	17,47	**27,78**	**0,24**			**0**	0
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

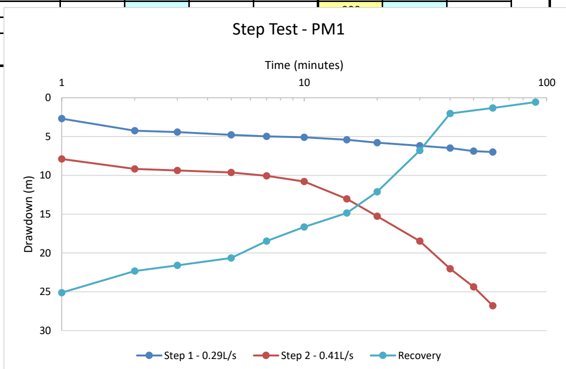


Borehole Number	PM-1	**Lat**	26,17026
BH Diameter	170mm	**Long**	29,99402
Collar Height	0,56		
BH Depth	39,7		
Pump Depth	27,88		

STEP DRAWDOWN

Static W/L **0,9**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,69	**3,59**		7,89	**8,79**								1	25,11	**26,01**
2	4,25	**5,15**		9,18	**10,08**	**0,49**							2	22,32	**23,22**
3	4,42	**5,32**		9,36	**10,26**	**0,45**							3	21,6	**22,5**
5	4,78	**5,68**	**0,34**	9,62	**10,52**	**0,41**							5	20,65	**21,55**
7	4,97	**5,87**	**0,31**	10,06	**10,96**	**0,46**							7	18,47	**19,37**
10	5,09	**5,99**	**0,29**	10,79	**11,69**	**0,4**							10	16,64	**17,54**
15	5,42	**6,32**	**0,34**	13,02	**13,92**	**0,42**							15	14,85	**15,75**
20	5,78	**6,68**	**0,33**	15,26	**16,16**	**0,41**							20	12,12	**13,02**
30	6,19	**7,09**	**0,28**	18,47	**19,37**	**0,44**							30	6,8	**7,7**
40	6,48	**7,38**	**0,29**	22,02	**22,92**	**0,39**							40	2,03	**2,93**
50	6,87	**7,77**	**0,29**	24,36	**25,26**	**0,4**							60	1,31	**2,21**
60	6,99	**7,89**	**0,28**	26,8	**27,7**	**0,41**							90	0,56	**1,46**
70													120		
80													150		
90													180		
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170													[illegible]		
180															

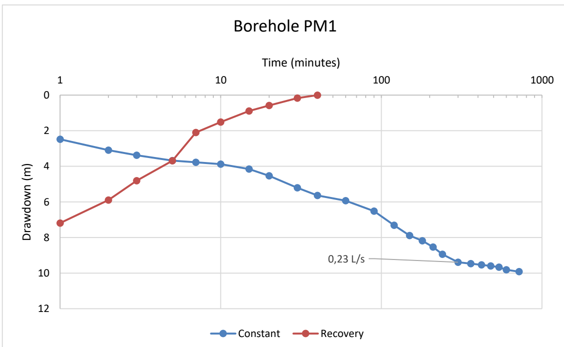


CONSTANT DISCHARGE

WL at start of test **1,46**

Monitoring Borehole
BH No PM-1
SWL 1,04

				recovery		
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**
1	2,48	**3,94**		7,19	**8,65**	**0**
2	3,09	**4,55**		5,9	**7,36**	**0**
3	3,38	**4,84**	**0,31**	4,81	**6,27**	**0**
5	3,68	**5,14**	**0,26**	3,69	**5,15**	**0**
7	3,77	**5,23**	**0,22**	2,1	**3,56**	**0**
10	3,88	**5,34**	**0,21**	1,51	**2,97**	**0**
15	4,15	**5,61**	**0,2**	0,89	**2,35**	**0**
20	4,53	**5,99**	**0,21**	0,58	**2,04**	**0**
30	5,21	**6,67**	**0,24**	0,166	**1,626**	**0**
40	5,64	**7,1**	**0,2**	0	**1,46**	**0**
60	5,93	**7,39**	**0,21**			**0**
90	6,52	**7,98**	**0,2**			**0**
120	7,31	**8,77**	**0,24**			**0**
150	7,89	**9,35**	**0,2**			**0**
180	8,18	**9,64**	**0,21**			**0**
210	8,54	**10**	**0,22**			**0**
240	8,94	**10,4**	**0,23**			**0**
300	9,39	**10,85**	**0,21**			**0**
360	9,47	**10,93**	**0,23**			**0**
420	9,54	**11**	**0,24**			**0**
480	9,6	**11,06**	**0,21**			**0**
540	9,67	**11,13**	**0,22**			**0**
600	9,81	**11,27**	**0,23**			**0**
720	9,92	**11,38**	**0,24**			**0**
840						
960						
1080						
1200						
1320						
1440						
2280						
2880						
3480						
3900						
4320						



Borehole Number	PM-3	**Lat**	26,16337
BH Diameter	170mm	**Long**	30,0267
Collar Height	0,82		
BH Depth	47,61		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **4,98**

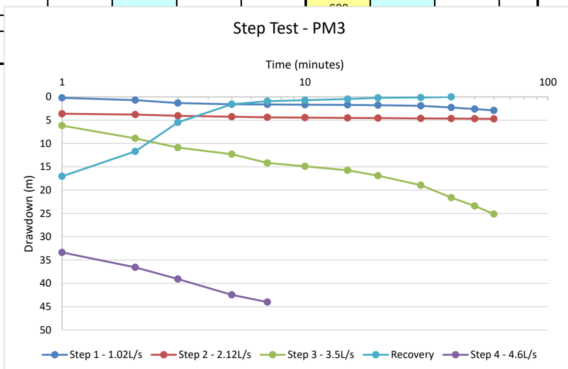
	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	0,2	**5,18**		3,61	**8,59**		6,17	**11,15**		28,39	**33,37**		1	17,04	**22,02**
2	0,69	**5,67**		3,8	**8,78**		8,9	**13,88**		31,61	**36,59**		2	11,69	**16,67**
3	1,31	**6,29**		4,04	**9,02**	**1,89**	10,86	**15,84**	**3,46**	34,09	**39,07**	**4,67**	3	5,47	**10,45**
5	1,59	**6,57**	**0,98**	4,26	**9,24**	**1,99**	12,3	**17,28**	**3,41**	37,49	**42,47**	**4,6**	5	1,57	**6,55**
7	1,63	**6,61**		4,4	**9,38**	**2,19**	14,16	**19,14**	**3,53**	39,04	**44,02**	**4,39**	7	0,91	**5,89**
10	1,68	**6,66**	**1,04**	4,46	**9,44**	**2,16**	14,91	**19,89**	**3,46**				10	0,69	**5,67**
15	1,71	**6,69**	**1,03**	4,5	**9,48**	**2,17**	15,74	**20,72**	**3,55**				15	0,47	**5,45**
20	1,79	**6,77**	**1,02**	4,55	**9,53**	**2,16**	16,91	**21,89**	**3,48**				20	0,2	**5,18**
30	1,92	**6,9**	**0,96**	4,61	**9,59**	**2,1**	18,96	**23,94**	**3,5**				30	0,13	**5,11**
40	2,26	**7,24**	**1,03**	4,66	**9,64**	**2,13**	21,61	**26,59**	**3,52**				40	0	
50	2,62	**7,6**	**1,02**	4,69	**9,67**	**2,14**	23,39	**28,37**	**3,5**				60		
60	2,9	**7,88**	**1,04**	4,72	**9,7**	**2,12**	25,14	**30,12**	**3,57**				90		
70													120		
80													150		
90													180		
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170													[illegible]		
180															

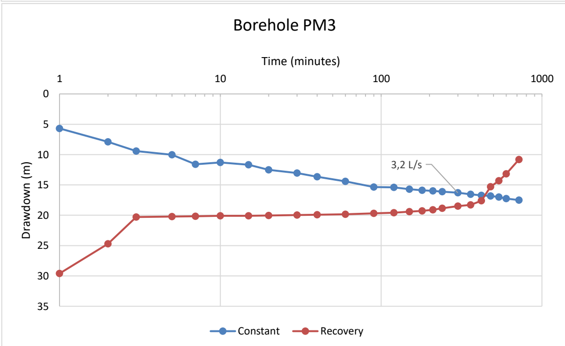
CONSTANT DISCHARGE

WL at start of test **4,98**

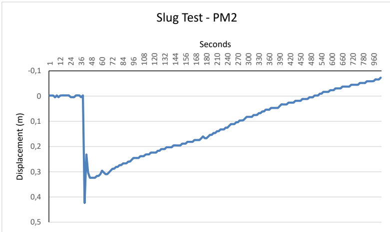
Monitoring Borehole
BH No PM-3
SWL 5,54

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	5,69	**10,67**		29,6	**34,58**	**0**	2,1
2	7,9	**12,88**		24,71	**29,69**	**0**	1,86
3	9,41	**14,39**		20,3	**25,28**	**0**	1,6
5	10,04	**15,02**	**3,57**	20,22	**25,2**	**0**	1,04
7	11,61	**16,59**		20,17	**25,15**	**0**	0,86
10	11,29	**16,27**	**3,39**	20,1	**25,08**	**0**	0,71
15	11,68	**16,66**	**3,26**	20,08	**25,06**	**0,29**	0,6
20	12,51	**17,49**	**3,27**	20,03	**25,01**	**0,52**	0,55
30	13,04	**18,02**	**3,25**	19,96	**24,94**	**0,64**	0,51
40	13,64	**18,62**	**3,26**	19,91	**24,89**	**0,93**	0,46
60	14,42	**19,4**	**3,23**	19,84	**24,82**	**1,08**	0,4
90	15,34	**20,32**	**3,21**	19,68	**24,66**	**1,36**	0,37
120	15,4	**20,38**	**3,23**	19,57	**24,55**	**1,61**	0,34
150	15,7	**20,68**	**3,2**	19,4	**24,38**	**1,85**	0,31
180	15,87	**20,85**	**3,22**	19,29	**24,27**	**1,97**	0,28
210	15,98	**20,96**	**3,23**	19,11	**24,09**	**2,08**	0,27
240	16,1	**21,08**	**3,24**	18,86	**23,84**	**2,15**	0,25
300	16,3	**21,28**	**3,23**	18,5	**23,48**	**2,24**	0,22
360	16,54	**21,52**	**3,24**	18,29	**23,27**	**2,4**	0,19
420	16,73	**21,71**	**3,21**	17,61	**22,59**	**2,69**	0,18
480	16,82	**21,8**	**3,23**	15,29	**20,27**	**2,91**	0,16
540	17	**21,98**	**3,2**	14,3	**19,28**	**3,09**	0,15
600	17,26	**22,24**	**3,21**	13,16	**18,14**	**3,16**	0,13
720	17,5	**22,48**	**3,23**	10,81	**15,79**	**3,29**	0,1
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							





Casing Height	**0.48m**
Casing Diameter	**177mm**
Slug Diameter	**80mm**
Slug Length	**1.05m**
Comments	
Sensor SN	**2815007**
Sensor Type	**Data**
Sensor Name	**In-Situ Sensor -1**
File Name	**PM2**
# Records	**191**



Statistical Data		**Pressure(m H2O)**	**Temperature(degC)**
	Sensor Range	300 psia	-40 - +125 degC
	Minimum	-0,0731	17,25
	Maximum	0,4236	17,75
	Mean	0,1043	17,51
	Variance	0,0143	0,021
	Std Deviation	0,11959	0,145

Rec #	**Date/Time**	**Pressure(m H2O)**	**Temperature(degC)**	
1	1/17/2019 14:01:38	-0,0022	17,31	1
2	1/17/2019 14:01:40	-0,0024	17,38	2
3	1/17/2019 14:01:42	-0,0024	17,38	4
4	1/17/2019 14:01:44	0,0047	17,38	6
5	1/17/2019 14:01:46	-0,0026	17,44	8
6	1/17/2019 14:01:48	0,0045	17,44	10
7	1/17/2019 14:01:50	-0,0024	17,38	12
8	1/17/2019 14:01:52	-0,0026	17,44	14
9	1/17/2019 14:01:54	-0,0026	17,44	16
10	1/17/2019 14:01:56	-0,0026	17,44	18
11	1/17/2019 14:01:58	-0,0026	17,44	20
12	1/17/2019 14:02:00	-0,0026	17,44	22
13	1/17/2019 14:02:02	0,0045	17,44	24
14	1/17/2019 14:02:04	0,0045	17,44	26
15	1/17/2019 14:02:06	0,0045	17,44	28
16	1/17/2019 14:02:08	-0,0026	17,44	30
17	1/17/2019 14:02:10	-0,0028	17,5	32
18	1/17/2019 14:02:12	-0,0028	17,5	34
19	1/17/2019 14:02:14	0,0043	17,5	36
20	1/17/2019 14:02:16	-0,0028	17,5	38
21	1/17/2019 14:02:18	0,4236	17,5	40
22	1/17/2019 14:02:20	0,2317	17,5	42
23	1/17/2019 14:02:22	0,3028	17,5	44
24	1/17/2019 14:02:24	0,3241	17,5	46
25	1/17/2019 14:02:26	0,3241	17,5	48
26	1/17/2019 14:02:28	0,3239	17,56	50
27	1/17/2019 14:02:30	0,3241	17,5	52
28	1/17/2019 14:02:32	0,3168	17,56	54
29	1/17/2019 14:02:34	0,3168	17,56	56
30	1/17/2019 14:02:36	0,3097	17,56	58
31	1/17/2019 14:02:38	0,2955	17,56	60
32	1/17/2019 14:02:40	0,3024	17,63	62
33	1/17/2019 14:02:42	0,3095	17,63	64
34	1/17/2019 14:02:44	0,3095	17,63	66
35	1/17/2019 14:02:46	0,3024	17,63	68
36	1/17/2019 14:02:48	0,2953	17,63	70
37	1/17/2019 14:02:50	0,2882	17,63	72
38	1/17/2019 14:02:52	0,2882	17,63	74
39	1/17/2019 14:02:54	0,2809	17,69	76
40	1/17/2019 14:02:56	0,2809	17,69	78
41	1/17/2019 14:02:58	0,2738	17,69	80
42	1/17/2019 14:03:00	0,2738	17,69	82
43	1/17/2019 14:03:02	0,2669	17,63	84
44	1/17/2019 14:03:04	0,2669	17,63	86
45	1/17/2019 14:03:06	0,2667	17,69	88
46	1/17/2019 14:03:08	0,2598	17,63	90
47	1/17/2019 14:03:10	0,2598	17,63	92
48	1/17/2019 14:03:12	0,2527	17,63	94
49	1/17/2019 14:03:14	0,2454	17,69	96
50	1/17/2019 14:03:16	0,2454	17,69	98
51	1/17/2019 14:03:18	0,2454	17,69	100
52	1/17/2019 14:03:20	0,2456	17,63	102
53	1/17/2019 14:03:22	0,2383	17,69	104
54	1/17/2019 14:03:24	0,2383	17,69	106
55	1/17/2019 14:03:26	0,2383	17,69	108
56	1/17/2019 14:03:28	0,2314	17,63	110
57	1/17/2019 14:03:30	0,2312	17,69	112
58	1/17/2019 14:03:32	0,2312	17,69	114
59	1/17/2019 14:03:34	0,2241	17,69	116
60	1/17/2019 14:03:36	0,2241	17,69	118
61	1/17/2019 14:03:38	0,2241	17,69	120
62	1/17/2019 14:03:40	0,2241	17,69	122
63	1/17/2019 14:03:42	0,217	17,69	124
64	1/17/2019 14:03:44	0,217	17,69	126
65	1/17/2019 14:03:46	0,2099	17,69	128
66	1/17/2019 14:03:48	0,2099	17,69	130
67	1/17/2019 14:03:50	0,2099	17,69	132
68	1/17/2019 14:03:52	0,2027	17,69	134
69	1/17/2019 14:03:54	0,2027	17,69	136
70	1/17/2019 14:03:56	0,2027	17,69	138
71	1/17/2019 14:03:58	0,2027	17,69	140
72	1/17/2019 14:04:00	0,1956	17,69	142
73	1/17/2019 14:04:02	0,1955	17,75	144
74	1/17/2019 14:04:04	0,1956	17,69	146
75	1/17/2019 14:04:06	0,1956	17,69	148
76	1/17/2019 14:04:08	0,1956	17,69	150
77	1/17/2019 14:04:10	0,1885	17,69	152
78	1/17/2019 14:04:12	0,1885	17,69	154
79	1/17/2019 14:04:14	0,1885	17,69	156
80	1/17/2019 14:04:16	0,1814	17,69	158
81	1/17/2019 14:04:18	0,1814	17,69	160
82	1/17/2019 14:04:20	0,1814	17,69	162
83	1/17/2019 14:04:22	0,1814	17,69	164
84	1/17/2019 14:04:24	0,1743	17,69	166
85	1/17/2019 14:04:26	0,1743	17,69	168
86	1/17/2019 14:04:28	0,1743	17,69	170
87	1/17/2019 14:04:30	0,1743	17,69	172

88	1/17/2019 14:04:32	0,1672	17,69	174
89	1/17/2019 14:04:34	0,1601	17,69	176
90	1/17/2019 14:04:36	0,1672	17,69	178
91	1/17/2019 14:04:38	0,1672	17,69	180
92	1/17/2019 14:04:43	0,1603	17,63	185
93	1/17/2019 14:04:48	0,1534	17,56	190
94	1/17/2019 14:04:53	0,1534	17,56	195
95	1/17/2019 14:04:58	0,1463	17,56	200
96	1/17/2019 14:05:03	0,1463	17,56	205
97	1/17/2019 14:05:08	0,1392	17,56	210
98	1/17/2019 14:05:13	0,1393	17,5	215
99	1/17/2019 14:05:18	0,1322	17,5	220
100	1/17/2019 14:05:23	0,1322	17,5	225
101	1/17/2019 14:05:28	0,1322	17,5	230
102	1/17/2019 14:05:33	0,1251	17,5	235
103	1/17/2019 14:05:38	0,1253	17,44	240
104	1/17/2019 14:05:43	0,1182	17,44	245
105	1/17/2019 14:05:48	0,1111	17,44	250
106	1/17/2019 14:05:53	0,1111	17,44	255
107	1/17/2019 14:05:58	0,1109	17,5	260
108	1/17/2019 14:06:03	0,104	17,44	265
109	1/17/2019 14:06:08	0,104	17,44	270
110	1/17/2019 14:06:13	0,0969	17,44	275
111	1/17/2019 14:06:18	0,0965	17,56	280
112	1/17/2019 14:06:23	0,0963	17,63	285
113	1/17/2019 14:06:28	0,0896	17,5	290
114	1/17/2019 14:06:33	0,0825	17,5	295
115	1/17/2019 14:06:38	0,0825	17,5	300
116	1/17/2019 14:06:43	0,0823	17,56	305
117	1/17/2019 14:06:48	0,0823	17,56	310
118	1/17/2019 14:06:53	0,075	17,63	315
119	1/17/2019 14:06:58	0,075	17,63	320
120	1/17/2019 14:07:03	0,0748	17,69	325
121	1/17/2019 14:07:08	0,0677	17,69	330
122	1/17/2019 14:07:13	0,0677	17,69	335
123	1/17/2019 14:07:18	0,0608	17,63	340
124	1/17/2019 14:07:23	0,061	17,56	345
125	1/17/2019 14:07:28	0,0539	17,56	350
126	1/17/2019 14:07:33	0,0539	17,56	355
127	1/17/2019 14:07:38	0,054	17,5	360
128	1/17/2019 14:07:43	0,0469	17,5	365
129	1/17/2019 14:07:48	0,0469	17,5	370
130	1/17/2019 14:07:53	0,0469	17,5	375
131	1/17/2019 14:07:58	0,0469	17,5	380
132	1/17/2019 14:08:03	0,0469	17,5	385
133	1/17/2019 14:08:08	0,0398	17,5	390
134	1/17/2019 14:08:13	0,0327	17,5	395
135	1/17/2019 14:08:18	0,0329	17,44	400
136	1/17/2019 14:08:23	0,0329	17,44	405
137	1/17/2019 14:08:28	0,0329	17,44	410
138	1/17/2019 14:08:33	0,0258	17,44	415
139	1/17/2019 14:08:38	0,0258	17,44	420
140	1/17/2019 14:08:43	0,0258	17,44	425
141	1/17/2019 14:08:48	0,0258	17,44	430
142	1/17/2019 14:08:53	0,0187	17,44	435
143	1/17/2019 14:08:58	0,0187	17,44	440
144	1/17/2019 14:09:03	0,0187	17,44	445
145	1/17/2019 14:09:08	0,0187	17,44	450
146	1/17/2019 14:09:13	0,0116	17,44	455
147	1/17/2019 14:09:18	0,0116	17,44	460
148	1/17/2019 14:09:23	0,0116	17,44	465
149	1/17/2019 14:09:28	0,0116	17,44	470
150	1/17/2019 14:09:33	0,0047	17,38	475
151	1/17/2019 14:09:38	0,0047	17,38	480
152	1/17/2019 14:09:48	0,0047	17,38	490
153	1/17/2019 14:09:58	-0,0024	17,38	500
154	1/17/2019 14:10:08	-0,0024	17,38	510
155	1/17/2019 14:10:18	-0,0024	17,38	520
156	1/17/2019 14:10:28	-0,0095	17,38	530
157	1/17/2019 14:10:38	-0,0093	17,31	540
158	1/17/2019 14:10:48	-0,0165	17,31	550
159	1/17/2019 14:10:58	-0,0165	17,31	560
160	1/17/2019 14:11:08	-0,0165	17,31	570
161	1/17/2019 14:11:18	-0,0165	17,31	580
162	1/17/2019 14:11:28	-0,0236	17,31	590
163	1/17/2019 14:11:38	-0,0236	17,31	600
164	1/17/2019 14:11:48	-0,0236	17,31	610
165	1/17/2019 14:11:58	-0,0307	17,31	620
166	1/17/2019 14:12:08	-0,0307	17,31	630
167	1/17/2019 14:12:18	-0,0307	17,31	640
168	1/17/2019 14:12:28	-0,0305	17,25	650
169	1/17/2019 14:12:38	-0,0378	17,31	660
170	1/17/2019 14:12:48	-0,0376	17,25	670
171	1/17/2019 14:12:58	-0,0378	17,31	680
172	1/17/2019 14:13:08	-0,0378	17,31	690
173	1/17/2019 14:13:18	-0,0378	17,31	700
174	1/17/2019 14:13:28	-0,0449	17,31	710
175	1/17/2019 14:13:38	-0,0447	17,25	720
176	1/17/2019 14:13:48	-0,0449	17,31	730
177	1/17/2019 14:13:58	-0,0449	17,31	740
178	1/17/2019 14:14:08	-0,0447	17,25	750
179	1/17/2019 14:14:18	-0,052	17,31	760
180	1/17/2019 14:14:28	-0,052	17,31	770
181	1/17/2019 14:14:38	-0,052	17,31	780
182	1/17/2019 14:15:08	-0,0518	17,25	810
183	1/17/2019 14:15:38	-0,0589	17,25	840
184	1/17/2019 14:16:08	-0,0589	17,25	870
185	1/17/2019 14:16:38	-0,0589	17,25	900
186	1/17/2019 14:17:08	-0,0589	17,25	930
187	1/17/2019 14:17:38	-0,0595	17,44	960
188	1/17/2019 14:18:08	-0,0662	17,31	990
189	1/17/2019 14:18:38	-0,066	17,25	1020
190	1/17/2019 14:19:08	-0,066	17,25	1050
191	1/17/2019 14:19:38	-0,0731	17,25	1080

Appendix 5 – Laboratory Certificates of Analyses

WATERLAB

WATERLAB (Pty) Ltd

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

23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

sanas Testing Laboratory T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 01 - 21 **Date completed:** 2019 - 02 – 13

Project number: 1000 **Report number: 80221** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**

Address: P.O Box 343 Dunnotter 1590 **e-mail: irene@ileh.co.za**

Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification				
		BH 2-50	1-130B	KR3	KR11	KR12
Sample Number		52697	52698	52699	52700	52701
pH – Value at 25°C	WLAB065	9.2	8.9	7.9	8.0	7.7
Electrical Conductivity in mS/m at 25°C	WLAB002	53.4	25.0	31.0	48.5	41.9
Total Dissolved Solids at 180°C	WLAB003	425	215	216	375	365
Total Alkalinity as $CaCO_3$	WLAB007	284	120	116	156	128
P-Alkalinity as $CaCO_3$	WLAB023	52	15	<5	<5	<5
Bicarbonate as HCO_3	WLAB023	219	109	141	190	156
Total Hardness as $CaCO_3$	WLAB051	<5	75	47	139	27
Chloride as Cl	WLAB046	9	5	16	58	35
Sulphate as SO_4	WLAB046	<2	9	22	8	20
Fluoride as F	WLAB014	0.9	1.0	0.6	0.2	0.6
Nitrate as N	WLAB046	0.1	0.1	0.5	0.1	2.7
Nitrite as N	WLAB046	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen as N*	WLAB025	1.0	0.6	0.8	0.9	3.2
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1	<0.1	0.2
Kjeldahl Nitrogen *	WLAB025	0.8	0.6	<0.5	0.8	0.6
Free & Saline Ammonia as N	WLAB046	0.7	0.6	0.2	0.5	0.6
ICP-MS Scan *	WLAB050	See Attached Report: 80221-A				
% Balancing *	---	97.2	96.3	96.2	97.6	96.4

Ard van de Wetering

Technical Signatory

Page 1 of 2

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 01 - 21 **Date completed:** 2019 - 02 – 13
Project number: 1000 **Report number: 80221** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail:** irene@ileh.co.za
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**			
		KR14	**KR18**	**KR19**	**KR Spring 3**
Sample Number		52702	52703	52704	52705
pH – Value at 25°C	WLAB065	8.8	8.6	7.7	5.7
Electrical Conductivity in mS/m at 25°C	WLAB002	25.2	26.3	31.2	4.8
Total Dissolved Solids at 180°C	WLAB003	255	177	285	21
Total Alkalinity as $CaCO_3$	WLAB007	100	136	80	<5
P-Alkalinity as $CaCO_3$	WLAB023	10	10	<5	<5
Bicarbonate as HCO_3	WLAB023	99	142	98	5
Total Hardness as $CaCO_3$	WLAB051	42	71	94	7
Chloride as Cl	WLAB046	14	3	2	7
Sulphate as SO_4	WLAB046	14	5	69	3
Fluoride as F	WLAB014	0.2	0.2	0.7	<0.2
Nitrate as N	WLAB046	0.3	0.7	0.2	0.2
Nitrite as N	WLAB046	0.2	<0.05	<0.05	<0.05
Total Nitrogen as N*	WLAB025	1.6	1.4	1.4	0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1	<0.1
Kjeldahl Nitrogen *	WLAB025	1.1	0.7	1.1	<0.5
Free & Saline Ammonia as N	WLAB046	1.1	0.2	0.2	0.2
ICP-MS Scan *	WLAB050	See Attached Report: 80221-A			
% Balancing *	---	95.2	98.3	99.8	97.9

*** = Not SANAS Accredited**
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

Ard van de Wetering

Technical Signatory

Page 2 of 2

WATERLAB

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

sanas Testing Laboratory
T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 02 - 05 **Date completed:** 2019 - 02 – 26
Project number: 1000 **Report number: 80642** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail: irene@ileh.co.za**
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**		
		PM1	**PM2**	**PM3**
Sample Number		54202	54203	54204
pH – Value at 25°C	WLAB065	5.7	8.8	6.6
Electrical Conductivity in mS/m at 25°C	WLAB002	25.0	74.9	32.5
Total Dissolved Solids at 180°C	WLAB003	113	453	300
Total Alkalinity as $CaCO_3$	WLAB007	12	304	136
P-Alkalinity as $CaCO_3$	WLAB023	<5	48	<5
Bicarbonate as HCO_3	WLAB023	15	253	166
Total Hardness as $CaCO_3$	WLAB051	53	27	55
Chloride as Cl	WLAB046	44	68	22
Sulphate as SO_4	WLAB046	28	6	6
Fluoride as F	WLAB014	<0.2	1.7	0.4
Nitrate as N	WLAB046	2.5	<0.1	<0.1
Nitrite as N	WLAB046	<0.05	0.6	<0.05
Total Nitrogen as N*	WLAB025	2.5	0.6	<0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	0.1
Kjeldahl Nitrogen *	WLAB025	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	WLAB046	<0.1	<0.1	<0.1
ICP-MS Scan *	WLAB050	See Attached Report: 80642-A		
% Balancing *	---	96.4	94.5	97.0

Ard van de Wetering

Technical Signatory

The information contained in this report is relevant only to the sample/samples supplied to **WATERLAB (Pty) Ltd**. Any further use of the above information is not the responsibility of **WATERLAB (Pty) Ltd**. Except for the full report, part of this report may not be reproduced without written approval of **WATERLAB (Pty) Ltd**. Details of sample conducted by Waterlab (PTY) Ltd according to WLAB/Sampling Plan and Procedures/SOP are available on request.

Page 1 of 2

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283
Persequor Park, 0020
Tel: +2712 – 349 – 1066
Fax: +2712 – 349 – 2064
e-mail: admin@waterlab.co.za

T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 02 - 05 **Date completed:** 2019 - 02 – 26
Project number: 1000 **Report number: 80642** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail:** irene@ileh.co.za
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification		
		Site 08	5-110	6-220
Sample Number		54205	54206	54207
pH – Value at 25°C	WLAB065	7.2	7.6	7.6
Electrical Conductivity in mS/m at 25°C	WLAB002	28.4	29.3	26.3
Total Dissolved Solids at 180°C	WLAB003	200	180	120
Total Alkalinity as $CaCO_3$	WLAB007	120	160	128
P-Alkalinity as $CaCO_3$	WLAB023	<5	<5	<5
Bicarbonate as HCO_3	WLAB023	146	195	156
Total Hardness as $CaCO_3$	WLAB051	95	105	20
Chloride as Cl	WLAB046	8	5	12
Sulphate as SO_4	WLAB046	19	3	<2
Fluoride as F	WLAB014	0.2	0.2	1.0
Nitrate as N	WLAB046	<0.1	<0.1	<0.1
Nitrite as N	WLAB046	0.4	<0.05	<0.05
Total Nitrogen as N*	WLAB025	<0.5	<0.5	<0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1
Kjeldahl Nitrogen *	WLAB025	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	WLAB046	<0.1	<0.1	0.1
ICP-MS Scan *	WLAB050	See Attached Report: 80642-A		
% Balancing *	---	97.8	96.7	93.0

*** = Not SANAS Accredited**
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

Ard van de Wetering

Technical Signatory

The information contained in this report is relevant only to the sample/samples supplied to **WATERLAB (Pty) Ltd**. Any further use of the above information is not the responsibility of **WATERLAB (Pty) Ltd**. Except for the full report, part of this report may not be reproduced without written approval of **WATERLAB (Pty) Ltd**. Details of sample conducted by Waterlab (PTY) Ltd according to WLAB/Sampling Plan and Procedures/SOP are available on request.

WATERLAB

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : 1000
Client : Irene Lea Environmental
Report Number : 80221-A

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
BH2-50	52697	< 0.010	0,115	< 0.010	< 0.010	0,079	0,014	< 0.010	< 0.010	1	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	0,895	< 0.010	< 0.010	0,059	0,190	< 0.010	< 0.010	15	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	0,183	< 0.010	< 0.010	0,042	0,042	< 0.010	< 0.010	11	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.100	< 0.010	< 0.010	0,016	0,261	< 0.010	< 0.010	29	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.100	< 0.010	< 0.010	0,026	0,195	< 0.010	< 0.010	6	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	0,150	< 0.010	< 0.010	0,060	0,135	< 0.010	< 0.010	10	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.100	< 0.010	< 0.010	0,030	0,093	< 0.010	< 0.010	18	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.100	< 0.010	< 0.010	0,024	0,089	< 0.010	< 0.010	20	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	1,44	< 0.010	< 0.010	< 0.010	0,060	< 0.010	< 0.010	1	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,058	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	5,89	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	< 0.010	0,052	< 0.010	< 0.010	< 0.010	3,27	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,210	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,033	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,161	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,177	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,350	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,257	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	1,2	< 0.010	< 0.010	< 0.010	< 1	< 0.025	< 0.010	127	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	8,0	< 0.010	< 0.010	< 0.010	10	0,186	< 0.010	17	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	3,1	< 0.010	< 0.010	< 0.010	5	< 0.025	< 0.010	46	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	4,1	< 0.010	< 0.010	< 0.010	18	0,084	< 0.010	38	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	5,2	< 0.010	< 0.010	< 0.010	3	< 0.025	< 0.010	73	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	3,2	< 0.010	< 0.010	< 0.010	5	< 0.025	< 0.010	32	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	4,2	< 0.010	< 0.010	< 0.010	8	< 0.025	< 0.010	27	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	7,6	< 0.010	< 0.010	< 0.010	13	0,160	< 0.010	20	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	1,9	< 0.010	< 0.010	< 0.010	1	< 0.025	< 0.010	4	< 0.010

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pr (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	0,116	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	0,015	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Sc (mg/L)	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)
BH2-50	52697	< 0.010	< 0.010	9,1	< 0.010	< 0.010	0,034	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	2,0	< 0.010	< 0.010	0,187	< 0.010	< 0.010	< 0.010	< 0.010	0,013	< 0.010
KR3	52699	< 0.010	< 0.010	5,3	< 0.010	< 0.010	0,089	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	14,3	< 0.010	< 0.010	0,410	< 0.010	< 0.010	< 0.010	< 0.010	0,010	< 0.010
KR12	52701	< 0.010	< 0.010	5,8	< 0.010	< 0.010	0,188	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	21	< 0.010	< 0.010	0,106	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	21	< 0.010	< 0.010	0,179	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	9,8	< 0.010	< 0.010	0,220	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	6,9	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,021	< 0.010

Sample Origin	Sample ID	Tm (mg/L)	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,029	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,033	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,068	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,062	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,032	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,028	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,065	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,056	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,029	< 0.010

WATERLAB

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : 1000
Client : Irene Lea Environmental and Hydrogeology
Report Number : 80642-A

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
PM1	54202	< 0.010	0,124	< 0.010	< 0.010	< 0.010	0,228	< 0.010	< 0.010	9	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	0,350	< 0.010	< 0.010	0,048	0,106	< 0.010	< 0.010	6	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.100	< 0.010	< 0.010	< 0.010	0,107	< 0.010	< 0.010	12	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	0,171	< 0.010	< 0.010	0,011	0,167	< 0.010	< 0.010	22	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.100	< 0.010	< 0.010	0,013	0,156	< 0.010	< 0.010	28	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.100	< 0.010	< 0.010	0,032	0,136	< 0.010	< 0.010	5	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	2,77	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	1,34	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	1,44	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	7,47	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,077	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,197	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	3,7	< 0.010	< 0.010	< 0.010	9	0,067	< 0.010	18	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	17,7	< 0.010	< 0.010	< 0.010	4	0,065	< 0.010	144	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	7,4	< 0.010	< 0.010	< 0.010	9	0,110	< 0.010	40	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	6,6	< 0.010	< 0.010	< 0.010	13	0,096	< 0.010	13	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	3,3	< 0.010	< 0.010	< 0.010	14	0,079	< 0.010	13	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	3,6	< 0.010	< 0.010	< 0.010	3	0,030	< 0.010	45	< 0.010

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pr (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	0,013	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	0,215	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	0,053	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Sc (mg/L)	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)
PM1	54202	< 0.010	< 0.010	3,9	< 0.010	< 0.010	0,050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	1,6	< 0.010	< 0.010	0,141	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	34,8	< 0.010	< 0.010	0,054	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	15,8	< 0.010	< 0.010	0,150	< 0.010	< 0.010	< 0.010	< 0.010	0,011	< 0.010
5-110	54206	< 0.010	< 0.010	12,0	< 0.010	< 0.010	0,112	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	7,5	< 0.010	< 0.010	0,041	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Tm (mg/L)	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,055	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,028	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,027	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,038	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,020	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,021	< 0.010

HERITAGE IMPACT ASSESSMENT

REQUIRED UNDER SECTION 38(8) OF THE NHRA (No. 25 OF 1999)

FOR THE PROPOSED KRANSPAN COLLIERY, MPUMALANGA PROVINCE

Type of development:

Mine

Client:

ABS Africa (Pty) Ltd

Client information:

Paul Furniss

E – Mail: paul@abs-africa.com

Applicant:

Ilima Coal Company (Pty) Ltd.

HCAC - Heritage Consultants
Private Bag X 1049
Suite 34
Modimolle
0510
Tel: 082 373 8491
Fax: 086 691 6461
E-Mail: jaco.heritage@gmail.com

Report Author:
Mr. J. van der Walt

Project Reference:
HCAC Project number 2181106
Report date:
February 2019

Approval Page

Project Name	**Ilima Coal Company Kranspan Project**
Report Title	Heritage Impact Assessment for the proposed Ilima Coal Company Kranspan Project
Authority Reference Number	MP30/5/1/2/2/10224MR
Report Status	Draft Report
Applicant Name	Ilima Coal

	Name	**Qualifications and Certifications**	**Date**
Archaeologist	Jaco van der Walt	MA Archaeology PhD Candidate ASAPA #159 APHP # 114	January 2019
Archaeologist	Ruan van der Merwe	BA Hons Archaeology	January 2019
Archival Specialist	Liesl Bester	BHCS Honours	January 2019
Palaeontology	Dr Barry Millsteed	B.Sc Geology (Hons), Ph.D Geology,	January 2019

DOCUMENT PROGRESS

Distribution List

Date	Report Reference Number	Document Distribution	Number of Copies
4 February 2019	2181106	ABS Africa (Pty) Ltd	Electronic Copy

Amendments on Document

Date	Description of Amendment
20 Feb 2019	Addressed comments from client – editing and queries.
24 April 2019	Added impact assessment of Wash Plant alternatives.

Indemnity and Conditions Relating to this Report

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints, relevant to the type and level of investigation undertaken. Therefore, HCAC reserves the right to modify aspects of the report including the recommendations if and when new information becomes available from ongoing research or further work in this field or pertaining to this investigation.

Although HCAC exercises due care and diligence in rendering services and preparing documents, HCAC accepts no liability, and the client, by receiving this document, indemnifies HCAC against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by HCAC and by the use of the information contained in this document.

This report must not be altered or added to without the prior written consent of the author. This also refers to electronic copies of this report which are supplied for the purposes of inclusion as part of other reports, including main reports. Similarly, any recommendations, statements or conclusions drawn from or based on this report must refer to this report. If these form part of a main report relating to this investigation or report, this report must be included in its entirety as an appendix or separate section to the main report.

Copyright

The client, on acceptance of any submission by HCAC and on condition that the client pays to HCAC the full price for the work as agreed, shall be entitled to use for its own benefit:

- The results of the project;
- The technology described in any report; and
- Recommendations delivered to the client.

Should the applicant wish to utilise any part of, or the entire report, for a project other than the subject project, permission must be obtained from HCAC to do so. This will ensure validation of the suitability and relevance of this report on an alternative project.

REPORT OUTLINE

Appendix 6 of the GNR 982 EIA Regulations, 2014 [as amended] provides the requirements for specialist reports undertaken as part of the environmental authorisation process. In line with this, Table 1 provides an overview of Appendix 6 together with information on how these requirements have been met.

Table 1. Specialist Report Requirements.

Requirement from Appendix 6 of GNR 982 EIA Regulations, 2014 [as amended]	Chapter
(a) Details of - (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Section a Section 12
(b) Declaration that the specialist is independent in a form as may be specified by the competent authority	*Declaration of Independence*
(c) Indication of the scope of, and the purpose for which, the report was prepared	Section 1
(cA)an indication of the quality and age of base data used for the specialist report	Section 3.4 and 7.1.
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	9
(d) Duration, Date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.4
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 3
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 8 and 9
(g) Identification of any areas to be avoided, including buffers	Section 9
(h) Map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers	Section 8
(I) Description of any assumptions made and any uncertainties or gaps in knowledge	Section 3.7
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity **including identified alternatives on the environment** or activities;	Section 9
(k) Mitigation measures for inclusion in the EMPr	Section 9 and 10
(l) Conditions for inclusion in the environmental authorisation	Section 9 and 10
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 9 and 10
(n) Reasoned opinion - (i) as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 10.2
(o) Description of any consultation process that was undertaken during the course of preparing the specialist report	Section 6
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Refer to EIA report
(q) Any other information requested by the competent authority	Section 10

Executive Summary

Ilima Coal Company (Pty) Ltd. (Ilima Coal) has appointed ABS Africa (Pty) Ltd to undertake environmental authorisations associated with the proposed Kranspan Coal Project. The mining right area is located on nine portions of the Farm Kranspan 49IT, Mpumalanga Province, approximately 13 km south-west of the town of Carolina. The planned operations entail both surface and underground mining as well as the establishment of various mine support infrastructure within the proposed mining right area.

HCAC was appointed by ABS Africa (Pty) Ltd to conduct a Heritage Impact Assessment of the project footprint (study area) to determine the presence of cultural heritage sites and the impact of the proposed project on these non-renewable resources. The study area was assessed both on desktop level and by a field survey. The field survey was conducted as a non-intrusive pedestrian survey to cover the extent of the footprint of the mine surface layout.

The study area is characterised by extensive maize fields that have been cultivated from prior to 1966. These agricultural activities would have impacted on surface indicators of heritage sites. However, several sites were still intact and recorded during the survey (Table 2).

In terms of the built environment (Section 34 of the NHRA) nine ruins were recorded (KP 6, KP 9, KP 11, KP 12, KP 13, KP 15, KP 17, KP 21, KP 22). Apart from KP 11, 15 and 17 that will not be directly impacted on the other ruins are all located in the preferred plant and opencast area. Although these ruins' potential to contribute to aesthetic, historic, scientific and social aspects is low, if confirmed to be older than 60 years these features are protected by legislation and must be assessed by a conservation architect.

Archaeological remains are sparse throughout the study area and three sites (KP 1, 2 & 3) were recorded centred around pans. These sites consist of a scatter of Stone tools, possible rock art and a small shelter. Fortunately, these sites are within environmental buffer zones around the pans and will not be directly impacted on. An independent paleontological study (Millsteed 2019) found that it is evident that the proposed mining operations pose a risk of negatively impacting upon scientifically highly significant fossil assemblages and damage mitigation protocols are required. Detailed recommended control mitigation measures are included in Section 10 of this report.

In terms of Section 36 of the Act six cemeteries (KP 4, KP 5, KP 7, KP 14, KP 16, KP 18) were recorded. Four of the cemeteries are located in the pit and wash plant area and will be directly impacted on (KP 4, 5, 7 and 18). Two of the cemeteries could be indirectly impacted on. It is recommended that these cemeteries should be retained *in situ*, with a 50 m buffer zone and demarcated with an access gate where possible. If this is not possible these cemeteries can be relocated adhering to legislation. More graves/ cemeteries can be expected in the mining right area and if any additional graves are identified they should ideally be preserved *in-situ* or alternatively relocated according to existing legislation.

No public monuments are located within or close to the study area. The study area is rural in character with an emphasis on agriculture with several mining operations next to the current study area and although it is not a significant cultural landscape the proposed mining can have a negative impact on the sense of place. During the public participation process conducted for the project no heritage concerns were raised.

Table 2. Recorded sites.

Label	Longitude	Latitude	Description	Heritage Significance	Impact Area
KP 1	30° 01' 24.7261" E	26° 09' 31.9931" S	Small Shelter	Low Significance	No direct impact
KP 2	30° 01' 20.9747" E	26° 09' 34.8084" S	Possible Rock Art	Low to Medium Significance	No Direct Impact
KP 3	30° 01' 16.4856" E	26° 09' 34.0812" S	Miscellaneous Stone Tools	Low significance	No Direct impact
KP 4	30° 00' 52.1028" E	26° 09' 42.6708" S	Graves	High Social Significance	Preferred Plant Area
KP 5	30° 00' 44.4671" E	26° 09' 54.2413" S	Graves	High Social Significance	Preferred Plant Area
KP 6	30° 00' 39.9780" E	26° 09' 53.9927" S	Ruin	Low	Preferred Plant Area
KP 7	30° 00' 38.7179" E	26° 09' 54.1547" S	Graves	High Social Significance	Preferred Plant Area
KP 8	30° 00' 51.0877" E	26° 09' 52.3693" S	Stone Cairn	Low significance unless confirmed as a grave – then High Social significance	Preferred Plant Area
KP 9	30° 00' 27.8640" E	26° 09' 36.8425" S	Ruin	Low significance	Opencast Area
KP 10	30° 00' 26.1325" E	26° 09' 08.5608" S	Stone Cairn	Low significance unless confirmed as a grave – then High Social significance	No Direct Impact
KP 11	30° 00' 34.3440" E	26° 09' 18.2376" S	Ruin	Low significance	No Direct Impact
KP 12	29° 59' 52.1701" E	26° 10' 03.1800" S	Ruin	Low to medium significance	Opencast Area
KP 13	29° 59' 56.0041" E	26° 10' 02.3303" S	Ruin	Low significance	Opencast Area
KP 14	30° 01' 59.4588" E	26° 09' 54.4284" S	Graves	High Social Significance	No direct impact
KP 15	30° 01' 19.2252" E	26° 11' 32.7984" S	Ruin	Low significance	No Direct impact
KP 16	30° 01' 14.2213" E	26° 11' 39.7897" S	Graves	High Social Significance	No direct impact
KP 17	30° 01' 57.6712" E	26° 09' 59.8100" S	Ruin	Low to medium significance	No direct impact
KP 18	29° 59' 43.0999" E	26° 10' 06.3001" S	Grave	High Social Significance	Opencast Area

KP 19	30° 00' 54.0144" E	26° 08' 50.5465" S	Stone Cairn	Low significance unless confirmed as a grave – then High Social significance	Topsoil and Overburden Facility
KP 20	29° 59' 02.0219" E	26° 10' 22.3393" S	Stone Cairn	Low significance unless confirmed as a grave – then High Social significance	Opencast area
KP 21	29° 59' 47.2199" E	26° 10' 08.3028" S	Ruin	Low to medium significance	Opencast Area
KP 22	29° 59' 50.3557" E	26° 10' 08.1408" S	Ruin	Low to medium significance	Opencast Area

The impact of the proposed project on heritage resources is considered low to medium and impacts can be mitigated to an acceptable level. The greatest risk to the project is the location of known and unknown graves. It is therefore recommended that the proposed project can commence (from a heritage perspective) on the condition that the following recommendations are implemented as part of the EMPr together with site specific recommendations and based on approval from SAHRA:

- The historic structures (KP 9, 12, 17, 21 and 22) should be assessed by a conservation architect if they are to be impacted on by the development who will make suitable recommendations for mitigation, after which a destruction permit can be applied for from the relevant heritage authority.
- The cemeteries located in the pit and wash plant area (KP 4,5,7 and 18) will be directly impacted on. It is recommended that these cemeteries are preserved *in situ*, fenced with an access gate for family members, with a 50-meter buffer zone. If this is not possible the cemeteries can be relocated adhering to all legal requirements.
- The cemeteries KP 14 and 16 could be indirectly impacted by the development and it is therefore recommended that the cemeteries are preserved *in situ*, fenced with an access gate for family members, with a feasible buffer zone.
- The total number of graves should be confirmed prior to development.
- It is recommended that during the social consultation process to be undertaken by the mine Community Liaison Officer it should be confirmed whether the identified stone cairns represent graves (KP 8 and 20 are located within the impact area).
- Through the social consultation process, to be undertaken by the mine Community Liaison Officer, the existence of unknown and unmarked graves associated must be confirmed in order to mitigate any graves not identified in this study. The implementation of a chance find procedure is recommended.
- Implementation of a heritage site development plan to ensure the protection of heritage resources within the mining area;
- Implementation of a chance find procedure

In terms of the palaeontological heritage the following recommendations apply:

During the construction phase of the mine:

- When the surface infrastructure elements of the mine are being constructed these locations must be regularly inspected to observe if the excavations have encountered bedrock of the Vryheid Formation.
- These regular inspections should be made by a suitable mine employee (such as the environmental officer) who has been trained to identify the types of fossils that may reasonably be expected to occur within the Vryheid Formation.
- Should fossil materials be identified, the excavations must be halted in that area and SAHRA informed of the discovery. An experienced Karoo palaeontologist should be contacted by the mine to assess the significance of the fossils.
- If fossil materials prove to be scientifically significant the palaeontologist should make recommendations that they should be either be protected completely *in situ* or could have damage mitigation procedures emplaced (i.e., excavation by a suitability by a suitably experienced palaeontologist) to minimise negative impacts.

Once excavation of the opencast pit voids begins:

- On-site checks for the occurrence of any fossils of the excavated pits and stockpiled material should be conducted biannually (i.e., every six months).
- The frequency of these checks should be reassessed after twelve (12) months based on the findings.
- The Karoo palaeobotanist should submit a monitoring report to SAHRA on this work.

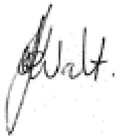
In addition,

- Should any fossil materials be identified, the palaeontologist should ascertain their scientific and cultural importance. Should the fossil prove scientifically or culturally significant the particular excavations involved should be halted and SAHRA informed of the discovery

- Should scientifically or culturally significant fossil material exist within the project areas any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

When the underground mining component of the mining program commences no damage mitigation protocols are recommended. The coals comprising Seam E are the product of a complex series of jellification and other coalification processes that transformed the original vegetation (peat) into coal. Recognisable plant macrofossil materials are not expected to be present within the coals. Such plant macrofossil materials may be present within any siliciclastic partings within the seam. However, the automatic mining machinery will destroy any such fossils before they can be recognised as being present. Similarly, modern industrial health and safety rules would make it extremely difficult for a palaeontologist to be able to access and work at a working mine face. Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

Declaration of Independence

Specialist Name	Jaco van der Walt
Declaration of Independence	I declare, as a specialist appointed in terms of the National Environmental Management Act (Act No 108 of 1998) and the associated 2014 Environmental Impact Assessment (EIA) Regulations, that I: • I act as the independent specialist in this application; • I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant; • I declare that there are no circumstances that may compromise my objectivity in performing such work; • I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity; • I will comply with the Act, Regulations and all other applicable legislation; • I have no, and will not engage in, conflicting interests in the undertaking of the activity; • I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; • All the particulars furnished by me in this form are true and correct; and • I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.
Signature	
Date	1/ 02/ 2019

a) Expertise of the specialist

Jaco van der Walt has been practising as a CRM archaeologist for 15 years. He obtained an MA degree in Archaeology from the University of the Witwatersrand focussing on the Iron Age in 2012 and is a PhD candidate at the University of Johannesburg focussing on Stone Age Archaeology with specific interest in the Middle Stone Age (MSA) and Later Stone Age (LSA). Jaco is an accredited member of ASAPA (#159) and have conducted more than 500 impact assessments in Limpopo, Mpumalanga, North West, Free State, Gauteng, KZN as well as he Northern and Eastern Cape Provinces in South Africa.

Jaco has worked on various international projects in Zimbabwe, Botswana, Mozambique, Lesotho, DRC Zambia and Tanzania. Through this he has a sound understanding of the IFC Performance Standard requirements, with specific reference to Performance Standard 8 – Cultural Heritage.

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

ABBREVIATIONS

AIA: Archaeological Impact Assessment
ASAPA: Association of South African Professional Archaeologists
BGG Burial Ground and Graves
BIA: Basic Impact Assessment
CFPs: Chance Find Procedures
CMP: Conservation Management Plan
CRR: Comments and Response Report
CRM: Cultural Resource Management
DEA: Department of Environmental Affairs
EA: Environmental Authorisation
EAP: Environmental Assessment Practitioner
ECO: Environmental Control Officer
EIA: Environmental Impact Assessment*
EIA: Early Iron Age*
EIA Practitioner: Environmental Impact Assessment Practitioner
EMP: Environmental Management Programme
EMPR: Environmental Management Programme Report
ESA: Early Stone Age
ESIA: Environmental and Social Impact Assessment
GIS Geographical Information System
GPS: Global Positioning System
GRP Grave Relocation Plan
HIA: Heritage Impact Assessment
LIA: Late Iron Age
LSA: Late Stone Age
MEC: Member of the Executive Council
MIA: Middle Iron Age
MPRDA: Mineral and Petroleum Resources Development Act
MSA: Middle Stone Age
NEMA National Environmental Management Act, 1998 (Act No. 107 of 1998)
NHRA National Heritage Resources Act, 1999 (Act No. 25 of 1999)
NID Notification of Intent to Develop
NoK Next-of-Kin
PRHA: Provincial Heritage Resource Agency
SADC: Southern African Development Community
SAHRA: South African Heritage Resources Agency

**Although EIA refers to both Environmental Impact Assessment and the Early Iron Age both are internationally accepted abbreviations and must be read and interpreted in the context it is used.*

GLOSSARY

Archaeological site (remains of human activity over 100 years old)
Early Stone Age (~ 2.6 million to 250 000 years ago)
Middle Stone Age (~ 250 000 to 40-25 000 years ago)
Later Stone Age (~ 40-25 000, to recently, 100 years ago)
The Iron Age (~ AD 400 to 1840)
Historic (~ AD 1840 to 1950)
Historic building (over 60 years old)

1 Introduction and Terms of Reference:

Heritage Contracts and Archaeological Consulting CC (HCAC) has been contracted by ABS Africa (Pty) Ltd to conduct a heritage impact assessment of the proposed Kranspan Project. The mining right area is located on nine portions of the Farm Kranspan 49IT, Mpumalanga Province, approximately 13 km south-west of the town of Carolina (Figure 1 -3). The report forms part of the Environmental Impact Assessment (EIA) Report and Environmental Management Programme Report (EMPR) for the proposed project.

The aim of the study is to survey the proposed development footprint to identify cultural heritage sites, document, and assess their importance within local, provincial and national context. It serves to assess the impact of the proposed project on non-renewable heritage resources, and to submit appropriate recommendations with regard to the responsible cultural resources management measures that might be required to assist the developer in managing the discovered heritage resources in a responsible manner. It is also conducted to protect, preserve and develop such resources within the framework provided by the National Heritage Resources Act of 1999 (Act No 25 of 1999). The report outlines the approach and methodology utilized before and during the survey, which includes: Phase 1, review of relevant literature; Phase 2, the physical surveying of the area on foot and by vehicle; Phase 3, reporting the outcome of the study.

During the survey, historical structures, archaeological features as well as cemeteries were recorded. General site conditions and features on sites were recorded by means of photographs, GPS locations, and site descriptions. Possible impacts were identified, and mitigation measures are proposed in the report. SAHRA as a commenting authority under section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) require all environmental documents, compiled in support of an Environmental Authorisation application as defined by NEMA EIA Regulations section 40 (1) and (2), to be submitted to SAHRA. As such the Environmental Impact Report and its appendices must be submitted to the case officer as well as the EMPr, once it’s completed by the Environmental Assessment Practitioner (EAP).

1.1 Terms of Reference

Field study
Conduct a field study to: (a) locate, identify, record, photograph and describe sites of archaeological, historical or cultural interest; b) record GPS points of sites/areas identified as significant areas; c) determine the levels of significance of the various types of heritage resources affected by the proposed development.

Reporting
Report on the identification of anticipated and cumulative impacts the operational units of the proposed project activity may have on the identified heritage resources for all 3 phases of the project; i.e., construction, operation and decommissioning phases. Consider alternatives, should any significant sites be impacted adversely by the proposed project. Ensure that all studies and results comply with the relevant legislation, SAHRA minimum standards and the code of ethics and guidelines of ASAPA.
To assist the developer in managing the discovered heritage resources in a responsible manner, and to protect, preserve, and develop them within the framework provided by the National Heritage Resources Act of 1999 (Act No 25 of 1999).

Project description

The planned operations entail both surface and underground mining as well as the establishment of various mine support infrastructure within the proposed mining right area and Illima indicated the following:

1. There will be both opencast (roll over) and underground (bord & pillar) mining operations on the project area. The attached plan defines the areas.
2. At this stage, only the E-Seam will be mined. There are some localised areas where the B Seam and CU and CL are present, however they appear to be uneconomic.
3. Mining will commence with opencast areas and underground operations will be started later.
4. The MWP makes provision for a beneficiation plant.

The mine infrastructure will be situated in the south-eastern portion of the farm Kranspan 49IT and will consist of the following:

- Opencast mining areas with contractor's camp.
- Haulroads to access the mining areas.
- Adits from opencast highwalls to provide access to the underground mining.
- ROM stockpile areas.
- Upcast ventilation shaft with the main fan situated on this shaft.
- Offices, stores, workshop, change house, and lamp room, all prefabricated structures that allows for easy removal and rehabilitation of the site.
- Parking area.
- Diesel Tanks
- Crushing and Screening Plant (Raw)
- Dense Medium beneficiation plant
- Product stockpiles and loading area.
- Discard/Tailings
- Onsite laboratory
- Weighbridges
- An access road to the shaft that will be constructed along the overland conveyor route and in the same servitude.

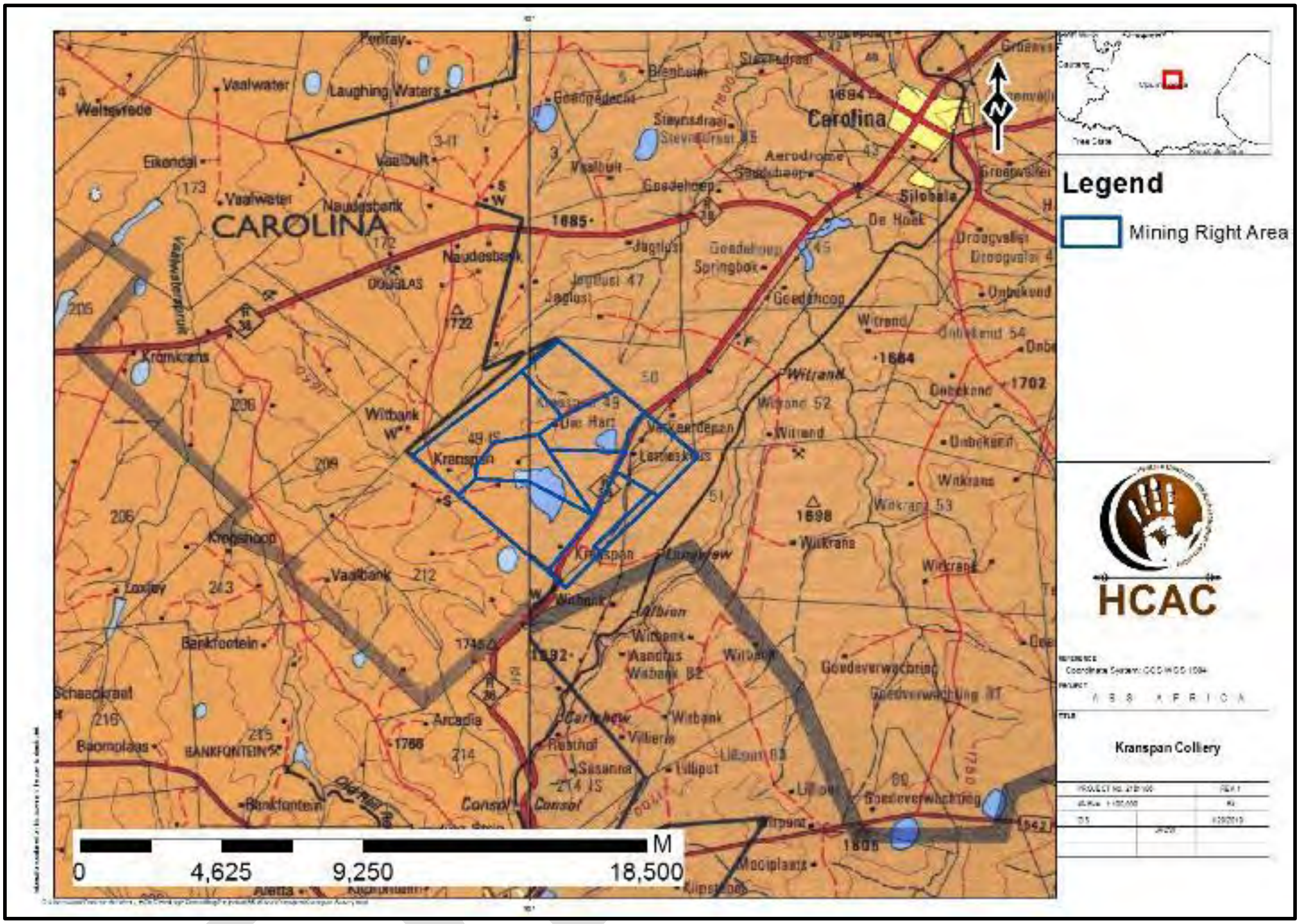


Figure 1. Provincial locality map (1: 250 000 topographical map).

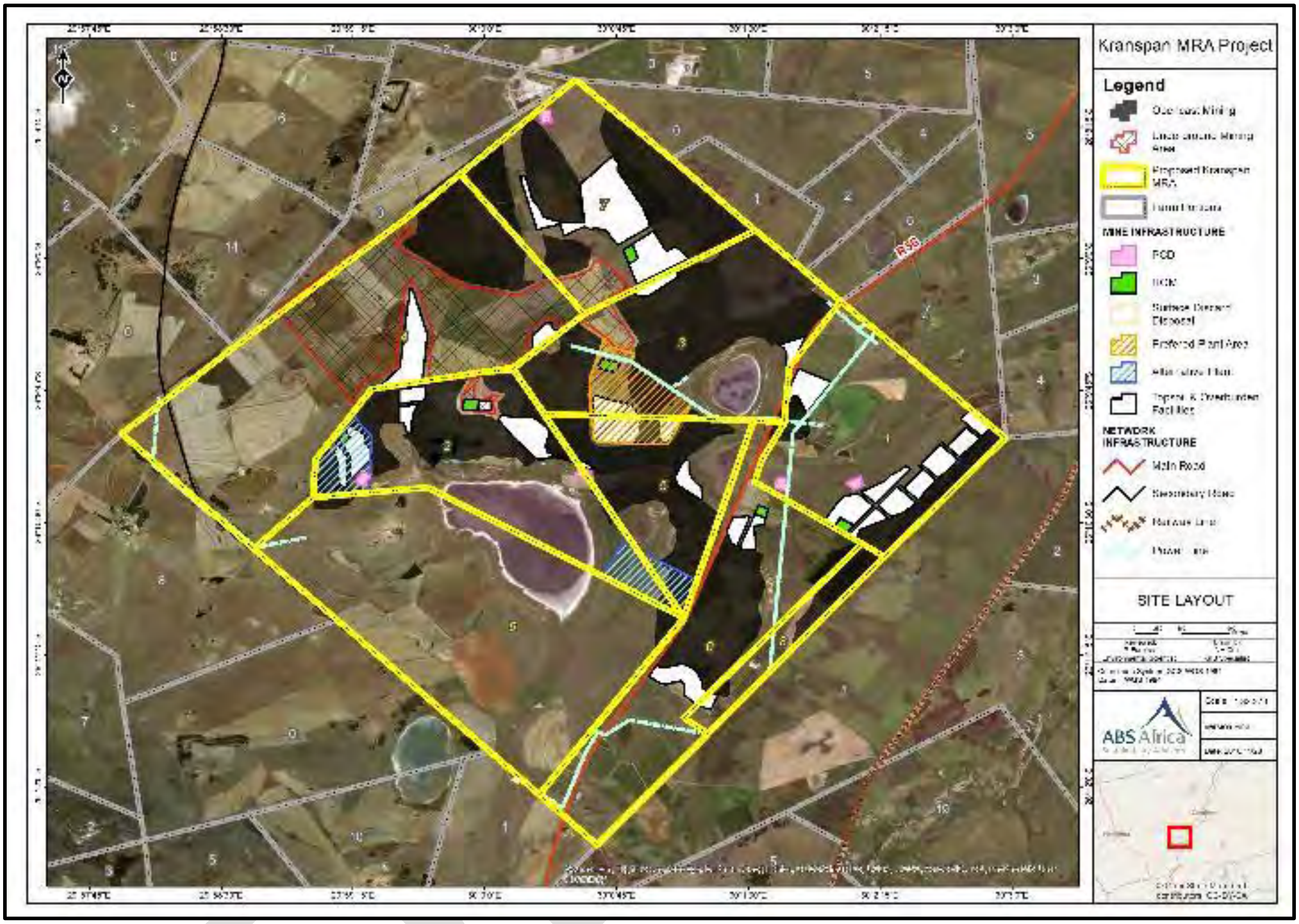


Figure 2. Site layout as provided by ABS Africa (Pty) Ltd.

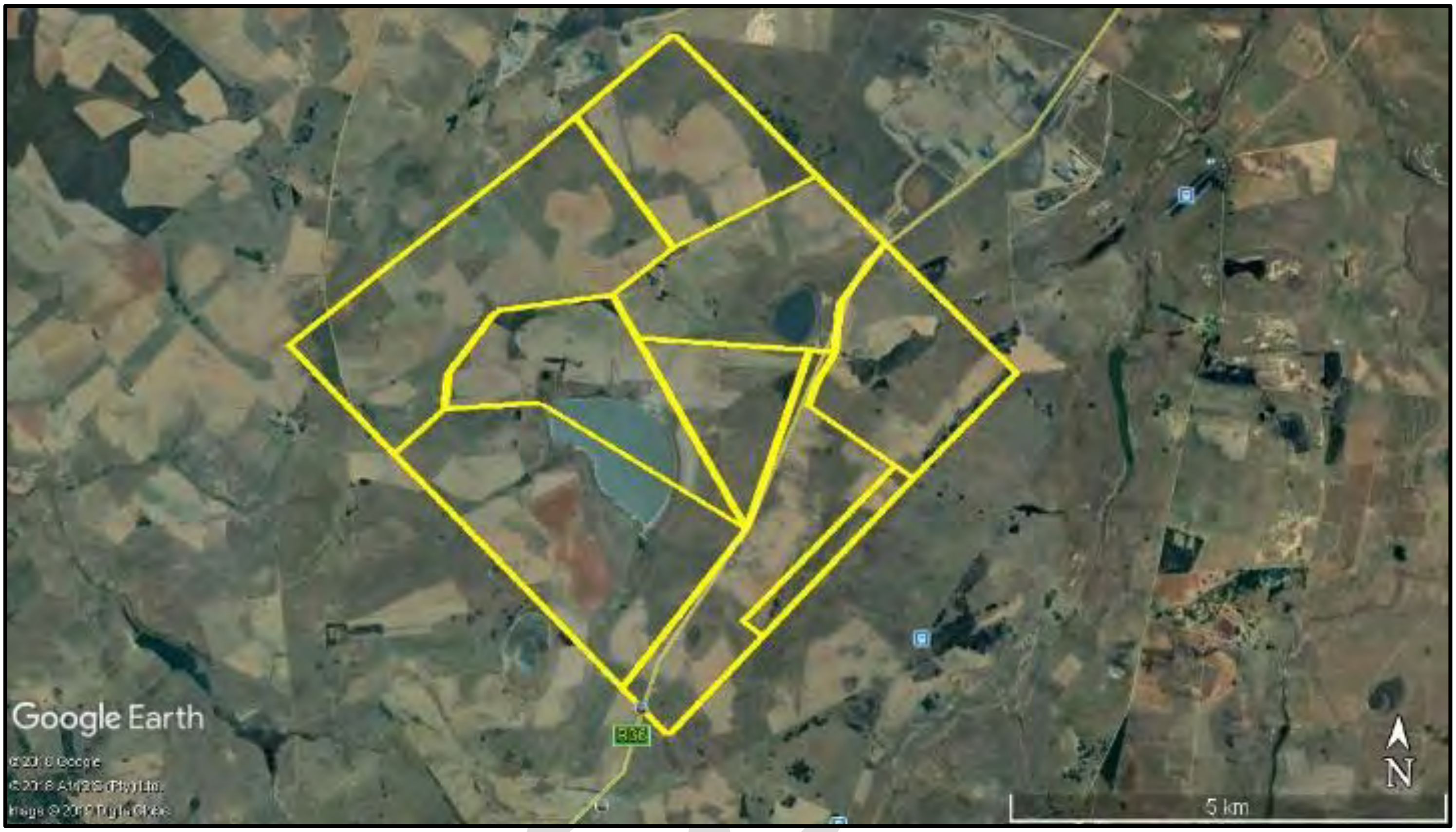


Figure 3. Google image of the mining right area.

2 Legislative Requirements

The HIA, as a specialist sub-section of the EIA, is required under the following legislation:

- National Heritage Resources Act (NHRA), Act No. 25 of 1999)
- National Environmental Management Act (NEMA), Act No. 107 of 1998 - Section 23(2)(b)
- Mineral and Petroleum Resources Development Act (MPRDA), Act No. 28 of 2002 - Section 39(3)(b)(iii)

A Phase 1 HIA is a pre-requisite for development in South Africa as prescribed by SAHRA and stipulated by legislation. The overall purpose of heritage specialist input is to:

- Identify any heritage resources, which may be affected;
- Assess the nature and degree of significance of such resources;
- Establish heritage informants/constraints to guide the development process through establishing thresholds of impact significance;
- Assess the negative and positive impact of the development on these resources; and
- Make recommendations for the appropriate heritage management of these impacts.

The HIA should be submitted, as part of the impact assessment report or EMPr, to the PHRA if established in the province or to SAHRA. SAHRA will ultimately be responsible for the professional evaluation of Phase 1 reports upon which review comments will be issued. 'Best practice' requires Phase 1 reports and additional development information, as per the impact assessment report and/or EMPr, to be submitted in duplicate to SAHRA after completion of the study. SAHRA accepts

Phase 1 AIA reports authored by professional archaeologists, accredited with ASAPA or with a proven ability to do archaeological work.

Minimum accreditation requirements include an Honours degree in archaeology or related discipline and 3 years post-university CRM experience (field supervisor level). Minimum standards for reports, site documentation and descriptions are set by ASAPA in collaboration with SAHRA. ASAPA is based in South Africa, representing professional archaeology in the SADC region. ASAPA is primarily involved in the overseeing of ethical practice and standards regarding the archaeological profession. Membership is based on proposal and secondment by other professional members.

Phase 1 AIA's are primarily concerned with the location and identification of heritage sites situated within a proposed development area. Identified sites should be assessed according to their significance. Relevant conservation or Phase 2 mitigation recommendations should be made. Recommendations are subject to evaluation by SAHRA.

Conservation or Phase 2 mitigation recommendations, as approved by SAHRA, are to be used as guidelines in the developer's decision-making process.

Phase 2 archaeological projects are primarily based on salvage/mitigation excavations preceding development destruction or impact on a site. Phase 2 excavations can only be conducted with a permit, issued by SAHRA to the appointed archaeologist. Permit conditions are prescribed by SAHRA and includes (as minimum requirements) reporting back strategies to SAHRA and deposition of excavated material at an accredited repository.

In the event of a site conservation option being preferred by the developer, a site management plan, prepared by a professional archaeologist and approved by SAHRA, will suffice as minimum requirement.

After mitigation of a site, a destruction permit must be applied for with SAHRA by the applicant before development may proceed.

Human remains older than 60 years are protected by the National Heritage Resources Act, with reference to Section 36. Graves older than 60 years, but younger than 100 years fall under Section 36 of Act 25 of 1999 (National Heritage Resources Act), as well as the Human Tissues Act (Act 65 of 1983) and are the jurisdiction of SAHRA. The procedure for Consultation Regarding Burial Grounds and Graves (Section 36[5]) of Act 25 of 1999) is applicable to graves older than 60 years that are situated outside a formal cemetery administrated by a local authority. Graves in this age category, located inside a formal cemetery administrated by a local authority, require the same authorisation as set out for graves younger than 60 years, in addition to SAHRA authorisation. If the grave is not situated inside a formal cemetery, but is to be relocated to one, permission from the local authority is required and all regulations, laws and by-laws, set by the cemetery authority, must be adhered to.

Human remains that are less than 60 years old are protected under Section 2(1) of the Removal of Graves and Dead Bodies Ordinance (Ordinance No. 7 of 1925), as well as the Human Tissues Act (Act 65 of 1983) and are the jurisdiction of the National Department of Health and the relevant Provincial Department of Health and must be submitted for final approval to the office of the relevant Provincial Premier. This function is usually delegated to the Provincial MEC for Local Government and Planning; or in some cases, the MEC for Housing and Welfare. Authorisation for exhumation and reinternment must also be obtained from the relevant local or regional council where the grave is situated, as well as the relevant local or regional council to where the grave is being relocated. All local and regional provisions, laws and by-laws must also be adhered to. To handle and transport human remains, the institution conducting the relocation should be authorised under Section 24 of Act 65 of 1983 (Human Tissues Act).

3 METHODOLOGY

3.1 Literature Review

A brief survey of available literature was conducted to extract data and information on the area in question to provide general heritage context into which the development would be set. This literature search included published material, unpublished commercial reports and online material, including reports sourced from the South African Heritage Resources Information System (SAHRIS).

3.2 Genealogical Society and Google Earth Monuments

Google Earth and 1:50 000 maps of the area were utilised to identify possible places where sites of heritage significance might be located; these locations were marked and visited during the field work phase. The database of the Genealogical Society was consulted to collect data on any known graves in the area.

3.3 Public Consultation and Stakeholder Engagement:

Stakeholder engagement is a key component of any EIA process, it involves stakeholders interested in, or affected by the proposed development. Stakeholders are provided with an opportunity to raise issues of concern (for the purposes of this report only heritage related issues will be included). The aim of the public consultation process was to capture and address any issues raised by community members and other stakeholders during key stakeholder and public meetings. The process involved:

- Placement of advertisements and site notices;
- Stakeholder notification (through the dissemination of information and meeting invitations);
- Stakeholder meetings undertaken with I&APs;
- Authority Consultation;
- The compilation of an Environmental Impact Assessment Report and opportunity for I&APs to comment on the draft reports.
- The compilation of a Comments and Response Report (CRR).

3.4 Site Investigation

Conduct a field study to: a) systematically survey the proposed project area to locate, identify, record, photograph and describe sites of archaeological, historical or cultural interest; b) record GPS points of sites/areas identified as significant areas; c) determine the levels of significance of the various types of heritage resources recorded in the project area.

Table 3: Site Investigation Details

	Site Investigation
Date	21 – 25 January 2019
Season	Summer - The area has been extensively cultivated and the maize was approximately 2 m high at the time of the field visit. The impact area was sufficiently covered (Figure 4) to adequately record the range of heritage resources in the study area.

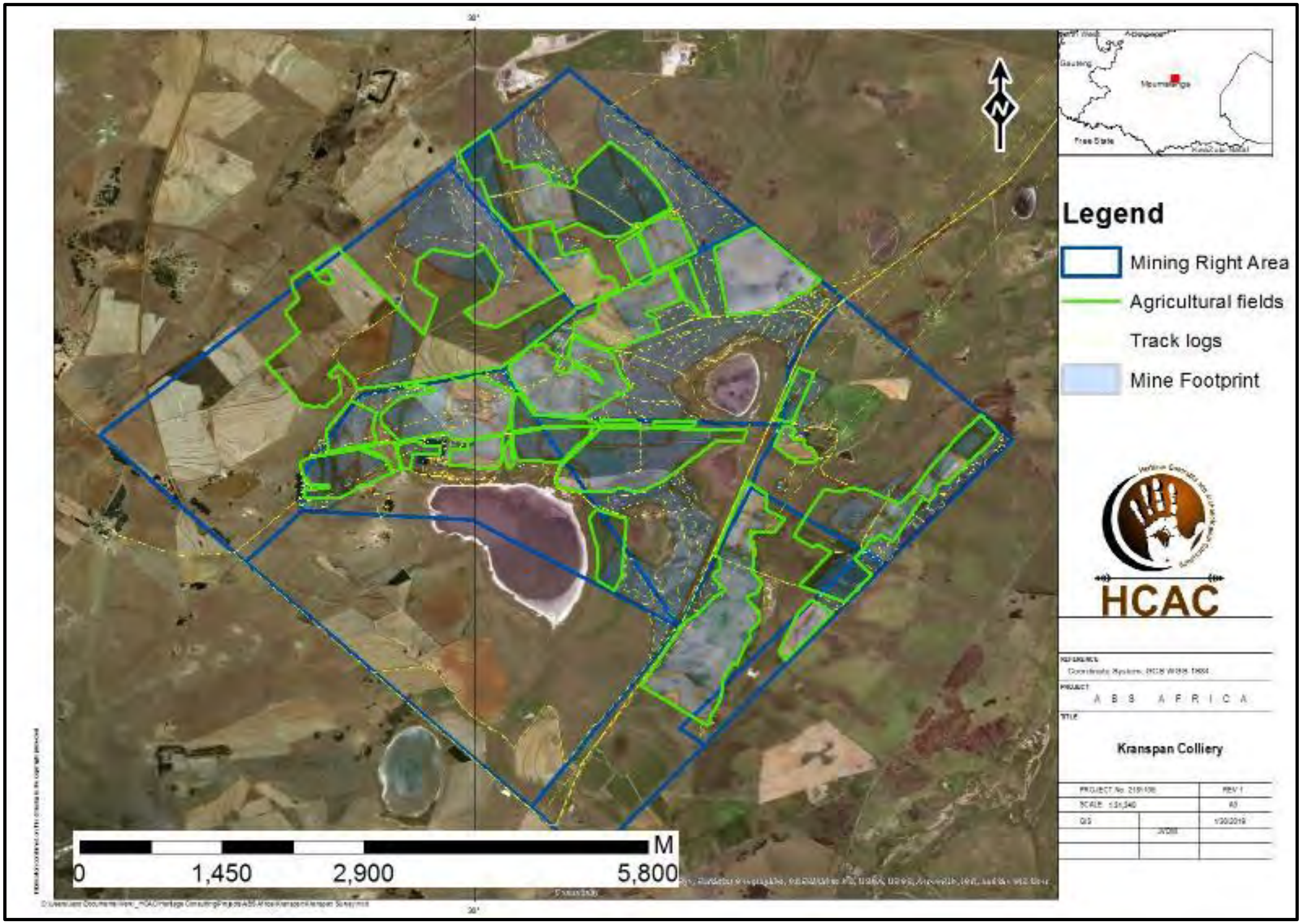


Figure 4: Track logs of the survey in green.

3.5 Site Significance and Field Rating

Section 3 of the NHRA distinguishes nine criteria for places and objects to qualify as 'part of the national estate' if they have cultural significance or other special value. These criteria are:

- Its importance in/to the community, or pattern of South Africa's history;
- Its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
- Its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
- Its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
- Its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
- Its importance in demonstrating a high degree of creative or technical achievement at a particular period;
- Its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
- Its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa;
- Sites of significance relating to the history of slavery in South Africa.

The presence and distribution of heritage resources define a 'heritage landscape'. In this landscape, every site is relevant. In addition, because heritage resources are non-renewable, heritage surveys need to investigate an entire project area, or a representative sample, depending on the nature of the project. In the case of the proposed project the local extent of its impact necessitates a representative sample and only the footprint of the areas demarcated for development were surveyed. In all initial investigations, however, the specialists are responsible only for the identification of resources visible on the surface. This section describes the evaluation criteria used for determining the significance of archaeological and heritage sites. The following criteria were used to establish site significance with cognisance of Section 3 of the NHRA:

- The unique nature of a site;
- The integrity of the archaeological/cultural heritage deposits;
- The wider historic, archaeological and geographic context of the site;
- The location of the site in relation to other similar sites or features;
- The depth of the archaeological deposit (when it can be determined/is known);
- The preservation condition of the sites; and
- Potential to answer present research questions.

In addition to this criteria field ratings prescribed by SAHRA (2006), and acknowledged by ASAPA for the SADC region, were used for the purpose of this report. The recommendations for each site should be read in conjunction with section 10 of this report.

FIELD RATING	***GRADE***	***SIGNIFICANCE***	***RECOMMENDED MITIGATION***
National Significance (NS)	Grade 1	-	Conservation; national site nomination
Provincial Significance (PS)	Grade 2	-	Conservation; provincial site nomination
Local Significance (LS)	Grade 3A	High significance	Conservation; mitigation not advised
Local Significance (LS)	Grade 3B	High significance	Mitigation (part of site should be retained)
Generally Protected A (GP. A)	-	High/medium significance	Mitigation before destruction
Generally Protected B (GP. B)	-	Medium significance	Recording before destruction
Generally Protected C (GP.C)	-	Low significance	Destruction

3.6 Impact Assessment Methodology

The criteria below are used to establish the impact rating on sites:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
- The **duration**, wherein it will be indicated whether:
  - the lifetime of the impact will be of a very short duration (0-1 years), assigned a score of 1;
  - the lifetime of the impact will be of a short duration (2-5 years), assigned a score of 2;
  - medium-term (5-15 years), assigned a score of 3;
  - long term (> 15 years), assigned a score of 4; or
  - permanent, assigned a score of 5;
  - The **magnitude**, quantified on a scale from 0-10 where; 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
  - The **probability of occurrence**, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5 where; 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
  - The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
  - the **status**, which will be described as either positive, negative or neutral.
  - the degree to which the impact can be reversed.
  - the degree to which the impact may cause irreplaceable loss of resources.
  - the *degree* to which the impact can be mitigated.

The **significance** is calculated by combining the criteria in the following formula:
S=(E+D+M) P
S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

ABS Africa (Pty) Ltd requested that for consistency their standard impact assessment methodology should be included for this project. It is included as Appendix B.

The **significance weightings** for each potential impact are as follows:

- < 30 points: Low (i.e., where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e., where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- 60 points: High (i.e., where the impact must have an influence on the decision process to develop in the area).

3.7 Limitations and Constraints of the study

The authors acknowledge that the brief literature review is not exhaustive on the literature of the area. Due to the subsurface nature of archaeological artefacts, the possibility exists that some features or artefacts may not have been discovered/recorded during the survey and the possible occurrence of unmarked graves and other cultural material cannot be excluded. Similarly, the depth of the deposit of heritage sites cannot be accurately determined due its subsurface nature. This report only deals with the footprint area of the proposed development and consisted of non-intrusive surface surveys. This study did not assess the impact on medicinal plants and intangible heritage as it is assumed that these components would have been highlighted through the public consultation process if relevant. It is possible that new information could come to light in future, which might change the results of this Impact Assessment.

4 Description of Socio-Economic Environment

Stats SÁ provides the following information: The total population of the Albert Luthuli Local Municipality is 186,010. Of those aged 20 years and older, 4,4% have completed primary school, 28,8% have some secondary education, 27% have completed matric and 6,3% have some form of higher education. 35,4% of the 45 116 economically active individuals (i.e. those who are employed or unemployed but looking for work) are unemployed.

5 Description of the Physical Environment:

The Kranspan Prospecting Right area is located in the Mpumalanga Province of South Africa, some 13 km southwest of Carolina (Figure 1). The Project can be accessed via the R36 paved provincial road if travelling from the north or the south. The nearest sizeable towns are Carolina, 13 km to the northeast. There are numerous farm homesteads (structures not older than 60 years that is currently occupied) situated within the Project Area. The land is currently mainly used for maize, cattle and sheep farming although mining operations is located adjacent to the study area (Figure 5 – 8). The surface topography is undulating, with gradual rises and falls over the area with the highest elevations towards the central portion of the Project area. The vegetation of the general area and the proposed site consists of Eastern Highveld Grassland (Mucina & Rutherford 2006). Two large pans occur in the area that would have been focal points in antiquity.

Figure 5. General site conditions.

Figure 6. Mining operations adjacent to the study area.

Figure 7. Existing cultivation in the study area.

Figure 8. Existing cultivation in the study area.

6 Results of Public Consultation and Stakeholder Engagement:

Adjacent landowners and the public at large were informed of the proposed activity as part of the EIA process. Site notices and advertisements notifying interested and affected parties were placed at strategic points and in local newspapers as part of the process.

7 Literature / Background Study:

7.1 Literature Review

The following CRM reports were conducted in the vicinity and were consulted for this report:

Author	Year	Project	Findings
Van Schalkwyk, J.	2003	Archaeological Survey of a Section of The Secunda-Mozambique Gas Pipeline, Carolina District, Mpumalanga	Cemeteries
Pistorius, JCC.	2007	A Phase I Heritage Impact Assessment (HIA) Study for The Upgrading of Eskom's Nooitgedacht Substation on The Farm Wintershoek 451 Near Carolina In the Mpumalanga Province of South Africa	No sites were recorded.
Van Schalkwyk, J. A.	2007	Heritage Impact Assessment for The Planned Development on The Farms Hebron 421JT And Twyfelaar 11 IT, Carolina Municipal District, Mpumalanga Province	Iron Age, Historical Sites and Cemeteries were recorded.
Van Schalkwyk, J.A.	2007	Heritage Impact Scoping Report for The Planned Hendrina-Marathon Powerline, Mpumalanga Province	Settlements to initiation sites, industrial and farming related sites as well as cemeteries were noted in the area.
Pelser, A and Van der Walt, J.	2008	A Report on A Heritage Impact Assessment for Proposed Opencast Coal Mining Operations for The Klippan Colliery on The Farm Klippan 452 JS (Emachibini), Wonderfontein, Mpumalanga	Graves were recorded.
Pelser, A.	2012	A Report on a Heritage Impact Assessment (HIA) For the Proposed Motshaotshele Colliery Project, Close to Hendrina, Mpumalanga Province	Cemeteries

7.1.1 Genealogical Society and Google Earth Monuments

No known grave sites are on record close to the impact areas.

7.2 General History of the area

7.2.1 Stone Age

South Africa has a long and complex Stone Age sequence of more than 2 million years. The broad sequence includes the Later Stone Age, the Middle Stone Age and the Earlier Stone Age. Each of these phases contains sub-phases or industrial complexes, and within these, we can expect regional variation regarding characteristics and time ranges. For Cultural Resources Management (CRM) purposes it is often only expected/ possible to identify the presence of the three main phases. Yet sometimes the recognition of cultural groups, affinities or trends in technology and/or subsistence practices, as represented by the sub-phases or industrial complexes, is achievable (Lombard et al. 2012). The three main phases can be divided as follows;

- Later Stone Age; associated with Khoi and San societies and their immediate predecessors. Recently to ~30 thousand years ago
- Middle Stone Age; associated with Homo sapiens and archaic modern humans. 30-300 thousand years ago.
- Earlier Stone Age; associated with early Homo groups such as Homo habilis and Homo erectus. 400 000-> 2 million years ago.

Early Stone Age:

The Early Stone Age in southern Africa is defined by the Oldowan complex, primarily found at the sites Sterkfontein, Swartkrans and Kromdraai, situated within the Cradle of Humankind, just outside Johannesburg (Kuman, 1998). Within this complex, tools are more casual and expediently made, and tools consist of rough cobble cores and simple flakes. The flakes were used for such activities as skinning and cutting meat from scavenged animals. This industry is unlikely to occur in the study area.
The second complex is that of the more common Acheulean, defined by large hand axes and cleavers produced by hominids at about 1.4 million years ago (Deacon & Deacon, 1999). Among other things, these Acheulian tools were probably used to butcher large animals such as elephants, rhinoceros and hippopotamus that had died from natural causes. Acheulian artefacts are usually found near the raw material from where they were quarried, at butchering sites, or as isolated finds. No Acheulian sites are on record near the project area, but isolated finds are possible. However, isolated finds have little value.

Middle Stone Age:

During the Middle Stone Age, significant changes start to occur in the evolution of the human species. These changes manifest themselves in the complexity of the stone tools created, as seen in the diversity of tools, the standardisation of these tools over a widespread area, the introduction of blade technology, and the development of ornaments and art. What these concepts ultimately attest to is an increase or development of abstract thinking. By the beginning of the Middle Stone Age (MSA), toolkits included prepared cores, parallel-sided blades and triangular points hafted to make spears (Volman, 1984). MSA people had become accomplished hunters by this time, especially of large grazing animals such as wildebeest, hartebeest and eland.
These hunters are classified as early humans, but by 100,000 years ago, they were anatomically fully modern. The oldest evidence for this change has been found in South Africa, and it is an important point in debates about the origins of modern humanity. In particular, the degree to which behaviour was fully modern is still a matter of debate. The repeated use of caves indicates that MSA people had developed the concept of a home base and that they could make fire. These were two important steps in cultural evolution (Deacon & Deacon, 1999). Accordingly, if there are caves in the study area, they may be sites of archaeological significance. MSA artefacts are common throughout southern Africa, but unless they occur in undisturbed deposits, they have little significance.

Later Stone Age:

The Later phases of the Stone Age began at around 20 000 years BP (Before Present). This period was marked by numerous technological innovations and social transformations within these early hunter-gatherer societies. Hunting tools now included the bow and arrow. More particularly, the link-shaft arrow which comprises a poisoned bone tip loosely linked to a shaft which fell away when an animal was shot and left the arrow tip embedded in the prey animal. Other innovations included bored stones used as digging –stick weights to help with the uprooting of tubers and roots, small stone tools, normally less than 25mm long, which was used for cutting meat and scraping hides. There were also polished bone needles, twine made from plant fibres, tortoiseshell bowls, fishing equipment including bone hooks and stone sinkers, ostrich eggshell beads and other decorative artwork (Delius, 2007).

These people may be regarded as the first modern inhabitants of Mpumalanga, known as the San or Bushmen. They were a nomadic people who lived together in small family groups and relied on hunting and gathering of food for survival. Evidence of their existence is to be found in numerous rock shelters throughout the Eastern Mpumalanga where some of their rock paintings are still visible. A number of these shelters have been documented throughout the Province (Bornman, 1995; Schoonraad in Barnard, 1975; Delius, 2007). These include areas such as Witbank, Ermelo, Barberton, Nelspruit, White River, Lydenburg and Ohrigstad.

At Honingklip near Badplaas in the Carolina District, two LSA rock shelters with four panels of rock art was discovered and archaeologically investigated. The site was used between 4870 BP and as recently as 200 BP. Stone walls at both sites date to the last 250 years of hunter-gatherer occupation and they may have served as protection against intruders and predators. Pieces of clay ceramic and iron beads found at the site indicate that there was an early social interaction between the hunter-gatherer (San) communities and the first farmers who moved into this area at around 500 AD.

Three late Stone Age sites are on record in the greater area. The sites are Welgelegen Skuiling close to Ermelo, Chrissiesmeer (also known for rock art) and lastly Groenvlei close to Carolina; this area is also known for rock art (Bergh 1999).

7.2.2 Iron Age

The Iron Age as a whole represents the spread of Bantu speaking people and includes both the pre-Historic and Historic periods. It can be divided into three distinct periods:

- The Early Iron Age: Most of the first millennium AD.
- The Middle Iron Age: 10th to 13th centuries AD
- The Late Iron Age: 14th century to the colonial period.

The Iron Age is characterised by the ability of these early people to manipulate and work Iron ore into implements that assisted them in creating a favourable environment to make a better living.

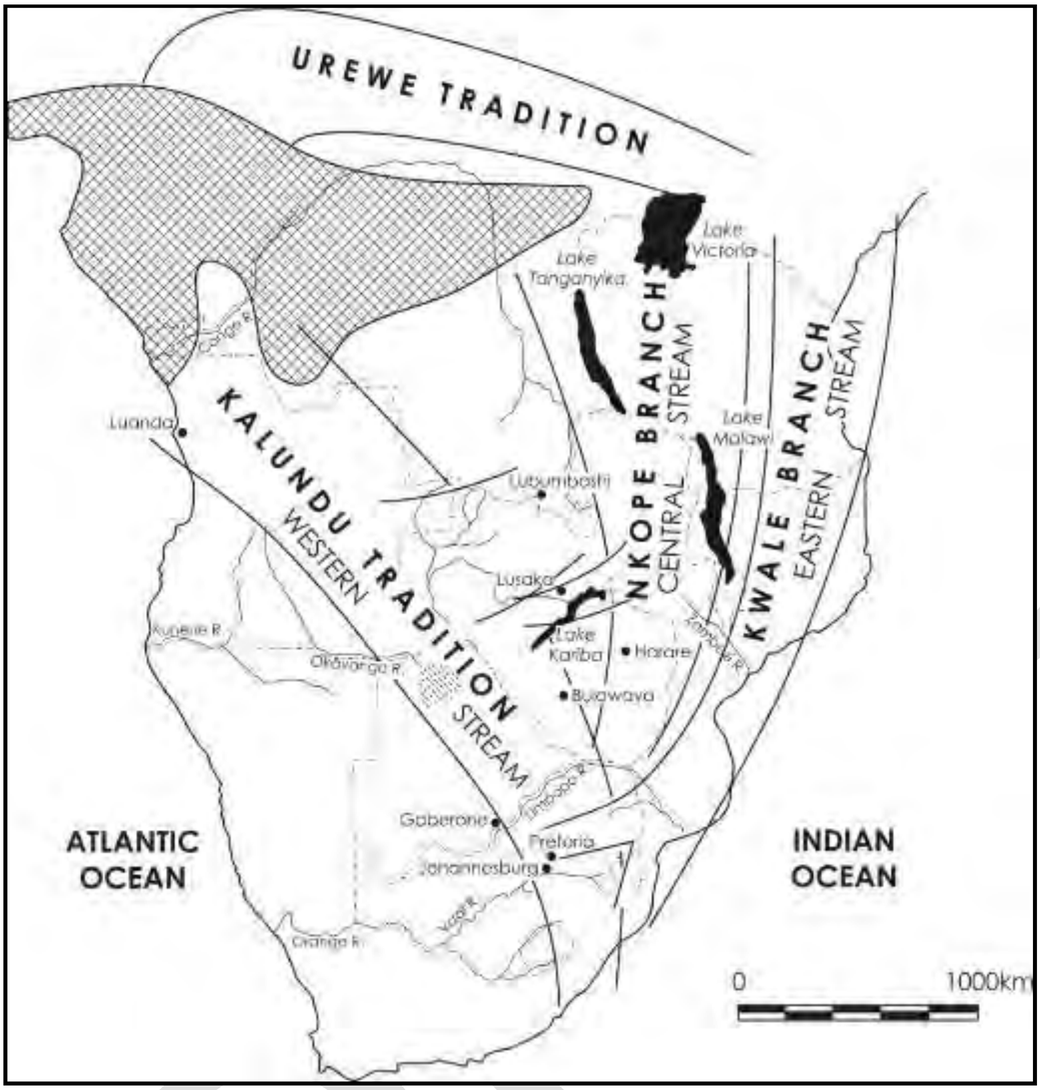


Figure 9. Movement of Bantu speaking farmers (Huffman 2007).

Early and Middle Iron Age
No sites dating to this period are on record close to the study area.

Late Iron Age
Stonewalled settlements are well known around the Watervalboven and Machadodorp area to the north of the study area, in fact, these settlements are found all along the Mpumalanga escarpment, from Ohrigstad in the north, all the way to Carolina in the south (Maggs 2007). These settlements consist of roughly circular homesteads linked by walled roads or cattle tracks associated with agricultural terraces. These complexes sometimes extend over several square kilometres, and some researchers claim that these settlements are the most prominent footprint on the landscape of any pre-colonial society in South Africa and compare this complex agricultural system to the internationally renowned terraced settlements of Nyanga in eastern Zimbabwe (Delius et al. 2012).

7.2.3 Anglo-Boer War

Figure 10. The Witkloof Monument (http://www.boerenbrit.com).

The Witkloof Monument (Figure 9) stands testament to an interesting battle that took place in the larger area namely the battle of Leliefontein. According to the map (Figure 10) from J.S. Bergh, (red), Geskiedenisatlas van Suid-Afrika, Die vier noordelike provinsies, p. 54, there were two concentration camps located to the north of the study area close to Belfast. These sites will not be impacted by the development.

Figure 11. Concentration camps represented by red dots and railway stations with grey squares (Bergh 1999).

7.3 Cultural Landscape

The cultural landscape of the study area is characterised by extensive cultivation from prior to 1966 (Van der Walt 2018).

8 Findings of the Survey

The greater area is characterised by agricultural activities and has been extensively cultivated. The area has been used for agricultural purposes from prior to the 1960's (Van der Walt 2018) and evidence of historical occupation of the area was recorded in the form of historical buildings and burial sites. During the survey 22 heritage features (Figure 12) were recorded. These sites were numbered numerically with the pre-fix KP for Kranspan. Several of these sites fall outside of the current mine layout and will not be directly impacted (Table 2). Below is a short description of identified Heritage Resources (NHRA Section 34 - 36) as protected by the NHRA.

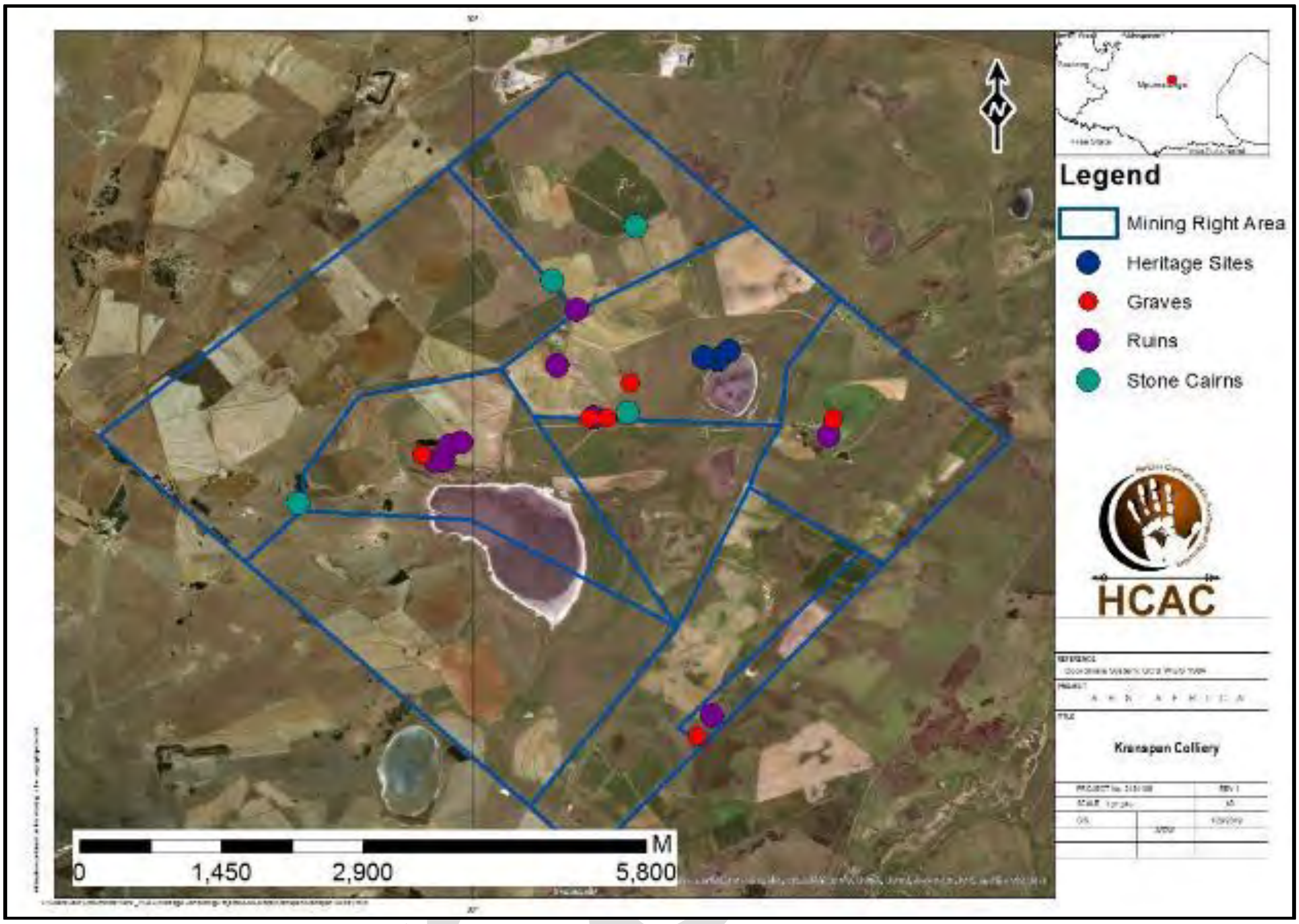


Figure 12: Distribution of recorded sites in the study area.

8.1.1 Built Environment (Section 34 of the NHRA)

Several farm labourer dwellings and farm homesteads occur in the study area (Figure 13 – 16. These structures have not been recorded individually as they are not older than 60 years and of no heritage significance.

Figure 13. Farm labourer dwelling in study area.

Figure 14. Modern farmstead.

Figure 15. Abandoned ruin.

Figure 16. Modern farmstead with manicured lawns.

Nine ruins were recorded (Table 4). The record structures' potential to contribute to aesthetic, historic, scientific and social aspects are low to moderate and it is therefore of low heritage significance. If structures (KP 9, 12, 17, 21 and 22) are older than 60 years, they are protected by the NHRA and a permit application process would have to be followed if the structures are to be impacted on in any way. It should also be noted that the recorded farm labourer dwellings are often associated with unmarked graves.

Table 4. Recorded ruins

LABEL	LONGITUDE	LATITUDE	DESCRIPTION
KP 6	30° 00' 39.9780" E	26° 09' 53.9927" S	Ruin
KP 9	30° 00' 27.8640" E	26° 09' 36.8425" S	Ruin
KP 11	30° 00' 34.3440" E	26° 09' 18.2376" S	Ruin
KP 12	29° 59' 52.1701" E	26° 10' 03.1800" S	Ruin
KP 13	29° 59' 56.0041" E	26° 10' 02.3303" S	Ruin
KP 15	30° 01' 19.2252" E	26° 11' 32.7984" S	Ruin
KP 17	30° 01' 57.6712" E	26° 09' 59.8100" S	Ruin
KP 21	29° 59' 47.2199" E	26° 10' 08.3028" S	Ruin
KP 22	29° 59' 50.3557" E	26° 10' 08.1408" S	Ruin

KP 6

Ruin that was constructed with cement bricks (Figure 17 and 18). The structure has a chimney but no longer has a roof. It was probably used for farm labourer housing. It should be noted that structures like these are often associated with the unmarked graves of still born babies.

Figure 17. Structure at KP6.

Figure 18. Structure at KP 6.

Heritage Significance: Low Heritage Significance ***Field Rating: GP C***

KP 9

The site comprises the ruin of a sandstone feature with a hipped roof that was added onto over time (Figure 19 – 22). Later additions onto the feature has been plastered. Besides the roof the structure has no other remaining fittings. The structure is dilapidated and no longer in use.

Figure 19. Structure with added on plastered sections.

Figure 20. Structure with hipped roof.

Figure 21. All the fittings have been removed.

Figure 22. General site conditions.

Heritage Significance: Low to medium Heritage Significance
Field Rating: GP B

KP 11

Red clay brick structure (Figure 23). The structure was probably used for farm labourer housing. It should be noted that structures like these are often associated with the unmarked graves of still born babies.

Figure 23. Structure at KP 11.

Heritage Significance: Low Heritage Significance ***Field Rating: GP C***

KP 12

The structure consists of a very dilapidated sandstone ruin that is highly overgrown with partial walls still standing. In the north eastern corner, the foundations of a circular hut constructed with ferricrete was recorded. The structure is probably older than 60 years.

Figure 24. Sandstone structure at KP 12.

Figure 25. Ferricrete structure at KP 12.

Figure 26. General site conditions at KP 12.

Heritage Significance: Low to Medium Significance
Field Rating: GP B

KP 13

The site comprises an abandoned cement brick feature (Figure 27) and associated remains (chicken coop). The site is associated with farm labourer dwellings. It should be noted that structures like these are often associated with the unmarked graves of still born babies.

Figure 27. Abandoned dwelling at KP13.

Heritage Significance: Low Significance ***Field Rating: GP C***

KP 15

KP 15 comprises the ruin of a farm labourer dwelling (Figure 29 and 29) that has been altered over the years. The structure has been added onto with red sundried bricks, mud bricks and ferricrete that was plastered. The remains of a sheep kraal also occur on site. It should be noted that structures like these are often associated with the unmarked graves of still born babies.

Figure 28. Dilapidated structure at KP 15.

Figure 29. General site conditions at KP 15.

Heritage Significance: Low Significance ***Field Rating: GP C***

KP 17

A large sandstone farm complex, the outlying buildings are currently being used as sheds (Figure 30). The main dwelling is very dilapidated with only a few walls standing with no roof / roof trusses (Figure 31). KP 17 is associated with the cemetery at KP 14.

Figure 30. Outlying buildings still in use.

Figure 31. Ruins of main dwelling.

Heritage Significance: Low to medium significance
Field Rating: GP B

KP 21

Large ruin containing multiple structures and features. The large house has sections that seem older and built from sandstone blocks (Figure 33). The later sections were built from brick and cement (Figure 34 and 35). The house is roughly 30m x 15m in size with the older section situated in the western part of the structure. Other structures include a garage or warehouse and a cold room constructed by layers of cement bricks that were filled up with rubble. Multiple large trees are present around the house with a packed stone feature under a large tree directly NW of the house (possible platform). The structures have no roof.

Figure 32. Structures at KP 21.

Figure 33. Structures at KP 21.

Figure 34. Structures at KP 21.

Figure 35. Structures at KP 21.

Heritage Significance: Low to Medium significance
Field Rating: GP B

KP 22

Partially collapsed structure built from large sandstone blocks. The structure is approx. 15m x 8m in size. The area is surrounded by very thick overgrowth of grass (Figure 36 to 39).

Figure 36. Structure at KP 22.

Figure 37. Wall at KP 22.

Figure 38. Structure at KP 22.

Figure 39. Structure at KP 22.

Heritage Significance: Low to medium significance ***Field Rating: GP B***

8.1.2 Archaeological and paleontological resources (Section 35 of the NHRA)

Archaeological remains are sparse in the study area. As expected, the only remains were recorded next to the pan that would have been a focal point for humans in antiquity. Because the pan and its margins are located within an environmental buffer zone no impact is foreseen on these features, therefore the areas around the pans was not surveyed in detail and more features can be expected in the buffer zone. The following archaeological features were recorded during the survey for the proposed project.

Table 5. Recorded archaeological features in the study area

LABEL	LONGITUDE	LATITUDE	DESCRIPTION
KP 1	30° 01' 24.7261" E	26° 09' 31.9931" S	Small Shelter
KP 2	30° 01' 20.9747" E	26° 09' 34.8084" S	Possible Rock Art
KP 3	30° 01' 16.4856" E	26° 09' 34.0812" S	Miscellaneous Stone Tools

KP 1

The shelter was formed by two large rocks that form a cavity and has been closed up with dry stone walling (Figure 40 and 41). There is no anthropogenic deposit, cultural material or artefacts.

Figure 40. Shelter.

Figure 41. Dry stone wall.

Heritage Significance: Low Significance
Field Rating: GP C

KP 2

Possible monochrome drawing in yellow approximately 10 cm wide (Figure 42). The drawing is very faded.

Figure 42. Possible Rock Art.

Heritage Significance: Low to Medium Significance ***Field Rating: GP B***

KP 3

Stone tool scatter consisting of two miscellaneous flakes located on a rock outcrop (Figure 43 and 44).

Figure 43. Scattered stone tools.

Figure 44. Area where stone tools was found.

Heritage Significance: Low Significance ***Field Rating: GP C***

In terms of the palaeontological component an independent study was conducted by Prof Barry Millsteed and found that:" *The aerial extent of the Mining Right application area is underlain by an assemblage of stratigraphic units consisting of coal-bearing sediments of the Vryheid Formation and intrusive dolerite of the Karoo Dolerite Suite. These bedrock units are overlain in part by a Cainozoic ferricrete layer that appears to be present upon the topographically higher areas within the project area. Lying upon the ferricrete and, in the topographically lower areas upon the Vryheid Formation strata is by a pervasive layer of unconsolidated Cainozoic regolith.*
Due to the methodologies employed in the opencast mining process and also the extreme costs of mining no negative impact upon the geological sequence will be expected to occur below the base of Seam E in the opencast voids as the mining will not extend deeper than that. Within the underground mining operations, the negative impacts upon the geology will be predominantly constrained to occurring within Seam E. Coal seams occur at depths between 5–75 m. The coal seams are relatively flat lying, but the depth of burial tends to increase towards the centre of the application area due to increasing topographic height of the land surface. Any negative impacts will be constrained to the Vryheid Formation and the overlaying geological units." (Millsteed 2019)

Recommended mitigation protocols for the paleontological component are included in Section 10 of the report.

8.1.3 Burial Grounds and Graves (Section 36 of the NHRA)

In terms of Section 36 of the Act 6 cemeteries were recorded (Table 6).

Table 6. Recorded cemeteries in the study area

LABEL	LONGITUDE	LATITUDE	DESCRIPTION
KP 4	30° 00' 52.1028" E	26° 09' 42.6708" S	Graves
KP 5	30° 00' 44.4671" E	26° 09' 54.2413" S	Graves
KP 7	30° 00' 38.7179" E	26° 09' 54.1547" S	Graves
KP 14	30° 01' 59.4588" E	26° 09' 54.4284" S	Graves
KP 16	30° 01' 14.2213" E	26° 11' 39.7897" S	Graves
KP 18	29° 59' 43.0999" E	26° 10' 06.3001" S	Grave

KP 4

Approximately 26 graves in an overgrown area located under wattle trees (Figure 45). Due to the dense vegetation it is difficult to discern the total number of graves. Graves have stone packed dressings with some that are covered by cement slabs (Figure 46). The oldest visible date is 1963.

Figure 45. General site conditions.

Figure 46. Grave covered by a cement slab at KP 4.

Heritage Significance: High Social Significance
Field Rating: GP A

KP 5

Approximately 24 graves under wattle trees. Most of the graves have stone grave dressings (Figure 47) and are overgrown by the wattle trees (Figure 48). Two graves are marked by cement slabs (Figure 49) with the oldest visible date being 1974. The cemetery is overgrown and the final number of graves is unconfirmed.

Figure 47. Grave at KP 5.

Figure 48. Overgrown grave.

Figure 49. Grave with cement slab.

Figure 50. Stone packed grave.

Heritage Significance: High Social Significance
Field Rating: GP A

KP 7

Approximately 5 graves in the open veld associated with the ruin at KP 6 (Figure 51 -52). The graves have stone packed dressings (Figure 53) and no headstones.

Figure 51. General site conditions at KP 7.

Figure 52. General site conditions at KP7.

Figure 53. Stone packed grave at KP 7.

Heritage Significance: High Social Significance
Field Rating: GP A

KP 14

The cemetery is surrounded by stone walls (Figure 55) and comprises 14 graves mostly relating to the Pretorius family. The graves have granite headstones, is aligned east to west and well looked after (Figure 54).

Figure 54. Graves at KP 14.

Figure 55. General site conditions at KP 14.

Heritage Significance: High Social Significance ***Field Rating: GP A***

KP 16

Partially fenced cemetery with approximately 8 stone packed graves (Figure 56 and 57). The cemetery is highly overgrown and grave dressings consist of ferricrete. It is difficult to discern the total number of graves due to the vegetation cover.

Figure 56. General site conditions at KP16.

Figure 57. General site conditions at KP 16.

Heritage Significance: High Social Significance ***Field Rating: GP A***

KP 18

A single grave with a granite headstone was identified at KP 18 by Lucas Wells and brought to the attention of the author after the survey of the study area. No photographs of the site are available.

Heritage Significance: High Social Significance
Field Rating: GP A

8.1.3.1 Stone Cairns

Four stone cairns (Table 7) was identified that although unlikely could mark graves.

Table 7. Stone Cairns in the study area

LABEL	LONGITUDE	LATITUDE	DESCRIPTION
KP 8	30° 00' 51.0877" E	26° 09' 52.3693" S	Stone Cairn
KP 10	30° 00' 26.1325" E	26° 09' 08.5608" S	Stone Cairn
KP 19	30° 00' 54.0144" E	26° 08' 50.5465" S	Stone Cairn
KP 20	29° 59' 02.0219" E	26° 10' 22.3393" S	Stone Cairn

KP 8

Stone cairn located under a wattle tree (Figure 58 and 59) and could be a possible grave, or the remains of a demolished stone dwelling.

Figure 58. General site conditions at KP8.

Figure 59. Stone Cairn at KP8.

Heritage Significance: Low significance unless the site is confirmed to be a grave in which case it is of High Social Significance
Field Rating: GP C - if confirmed to be a grave, GP A

KP 10

Stone cairn marked by ferricrete (Figure 60) located under wattle trees. The cairn is roughly orientated east to west and could possibly represent a grave. The site is most likely the result of clearing agricultural fields.

Figure 60. Stone packed feature at KP10.

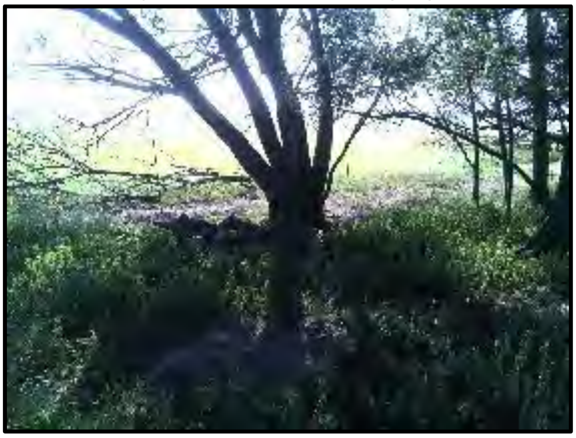


Figure 61. General site conditions at KP 10.

Heritage Significance: Low significance unless the site is confirmed to be a grave in which case it is of High Social Significance
Field Rating: GP C if confirmed to be a grave GP A

KP 19

Small thicket of large trees (Figure 62) with scattered stone features, glass and fence posts (Figure 63 – 65) underneath the trees. Could be possible graves or relating to clearing of agricultural fields.

Figure 62. Thicket of trees.

Figure 63. Stone cairn.

Figure 64.Artefacts on site.

Figure 65. Stone Cairn.

Heritage Significance: Low significance unless the site is confirmed to be a grave in which case it is of High Social Significance
Field Rating: GP C if confirmed to be a grave GP A

KP 20

Scattered stone feature (Figure 66 and 67) disturbed by farming. Purpose of the feature is unknown but could relate to clearing of agricultural fields.

Figure 66.Scattered stone feature.

Figure 67. Scattered stone feature.

Heritage Significance: Low significance unless the site is confirmed to be a grave in which case it is of High Social Significance   ***Field Rating: GP C if confirmed to be a grave GP A***

8.2 Cultural Landscapes, Intangible and Living Heritage.

The study area is rural in character surrounded by agricultural and mining developments and although it is not a significant cultural landscape the proposed mining can have a negative impact on the sense of place. From a heritage point of view the area has been extensively disturbed and this would have impacted on heritage resources. Visual impacts to scenic routes and sense of place are also considered to be low due to the existing developments in the area.

8.3 Battlefields and Concentration Camps

There are no battlefields or related concentration camp sites located in the study area.

9 Potential Impact

During the heritage assessment 22 sites were identified. Of these sites the proposed development will directly impact on 13 sites (Table 8)

Table 8. Sites that will be directly impacted by the development

SITE	DESCRIPTION	LONGITUDE	LATITUDE	IMPACT
KP 4	Graves	30° 00' 52.1028" E	26° 09' 42.6708" S	Preferred Plant Area
KP 5	Graves	30° 00' 44.4671" E	26° 09' 54.2413" S	Preferred Plant Area
KP 6	Ruin	30° 00' 39.9780" E	26° 09' 53.9927" S	Preferred Plant Area
KP 7	Graves	30° 00' 38.7179" E	26° 09' 54.1547" S	Preferred Plant Area
KP 8	Stone Cairn	30° 00' 51.0877" E	26° 09' 52.3693" S	Preferred Plant Area
KP 9	Ruin	30° 00' 27.8640" E	26° 09' 36.8425" S	Opencast Area
KP 12	Ruin	29° 59' 52.1701" E	26° 10' 03.1800" S	Opencast Area
KP 13	Ruin	29° 59' 56.0041" E	26° 10' 02.3303" S	Opencast Area
KP 18	Grave	29° 59' 43.0999" E	26° 10' 06.3001" S	Opencast Area
KP 19	Stone Cairn	30° 00' 54.0144" E	26° 08' 50.5465" S	Topsoil and Overburden Facility
KP 20	Stone Cairn	29° 59' 02.0219" E	26° 10' 22.3393" S	Opencast area
KP 21	Ruin	29° 59' 47.2199" E	26° 10' 08.3028" S	Opencast Area
KP 22	Ruin	29° 59' 50.3557" E	26° 10' 08.1408" S	Opencast Area

The chances of impacting unknown archaeological sites in the study area is considered to be negligible. If the correct mitigation measures are implemented, impacts on the identified heritage features and graves can be avoided or mitigated to an acceptable level. Structures older than 60 years are protected by the NHRA and should be mitigated prior to development. Any direct impacts that did occur would be during the construction phase only with secondary impacts on sites that will be retained and preserved. Cumulative impacts occur from the combination of effects of various impacts on heritage resources. The importance of identifying and assessing cumulative impacts is that the whole is greater than the sum of its parts. In the case of the development, it will, with the recommended mitigation measures and management actions, not impact any significant heritage resources directly. However, this and other projects in the area could have an indirect impact on the heritage landscape.

9.1.1 Pre-Construction phase

It is assumed that the pre-construction phase involves the removal of topsoil and vegetation as well as the establishment of infrastructure needed for the construction phase. These activities can have a negative and irreversible impact on heritage sites. Impacts include destruction or partial destruction of non-renewable heritage resources.

9.1.2 Construction Phase

During this phase, the impacts and effects are similar in nature but more extensive than the pre-construction phase. These activities can have a negative and irreversible impact on heritage sites. Impacts include destruction or partial destruction of non-renewable heritage resources.

9.1.3 Operation Phase

No impact is envisaged for the recorded heritage resources during this phase.

9.1.3.1 Impact on Archaeological Features

Three archaeological features were identified that will not be impacted on by the development (Figure 68).

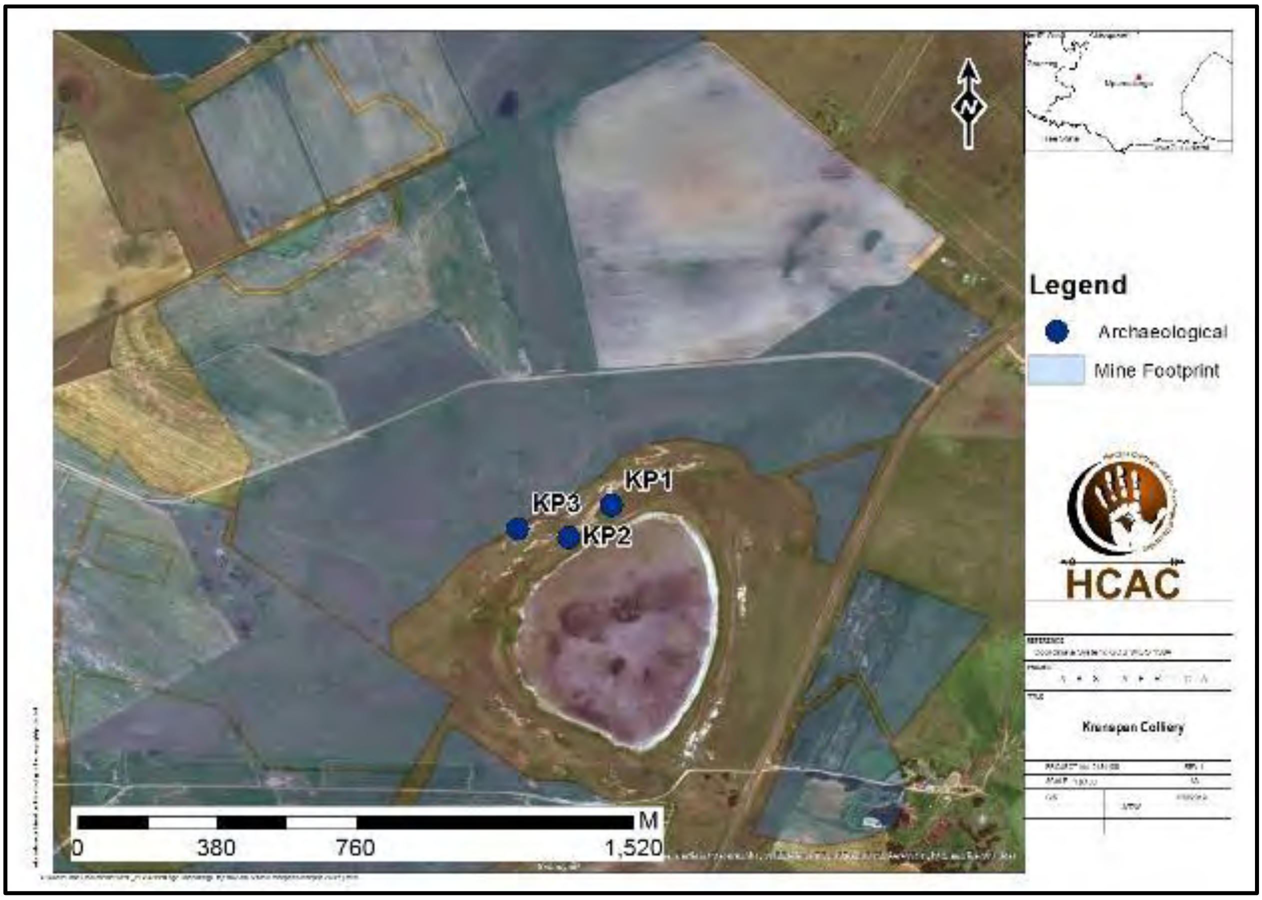


Figure 68. Location of recorded archaeological features.

Table 9. Impact Assessment on known archaeological heritage resources

Nature: During the earth moving activities resulting in disturbance of surfaces and/or sub-surfaces may destroy, damage, alter, or remove from its original position archaeological material or objects.		
	Without mitigation	**With mitigation (Preservation/ excavation of site)**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (2)	Low (2)
Probability	Not Probable (2)	Not probable (2)
Significance	**16 (Low)**	**16 (Low)**
Status (positive or negative)	Negative	Negative
Reversibility	Not reversible	Not reversible
Irreplaceable loss of resources?	No resources were recorded	No resources were recorded.
Can impacts be mitigated?	Yes, a chance find procedure should be implemented.	Yes
Mitigation: Due to the lack of apparent significant archaeological resources in the impact area no further mitigation is required prior to construction. A Chance Find Procedure should be implemented for the project should any sites be identified during the construction process. The known sites should be mapped to protect them from accidental damage.		
Cumulative impacts: Since the surrounding area is characterised by agricultural developments and due to the lack of heritage resources that will be impacted on in the study area cumulative impacts are considered to be low.		
Residual Impacts: If sites are destroyed this results in the depletion of archaeological record of the area. However, if sites are recorded and preserved or mitigated this adds to the record of the area.		

9.1.3.2 Impact on recorded structures

Nine ruins were identified in the study area of which 6 will be directly impacted on by the proposed development (Figure 69).

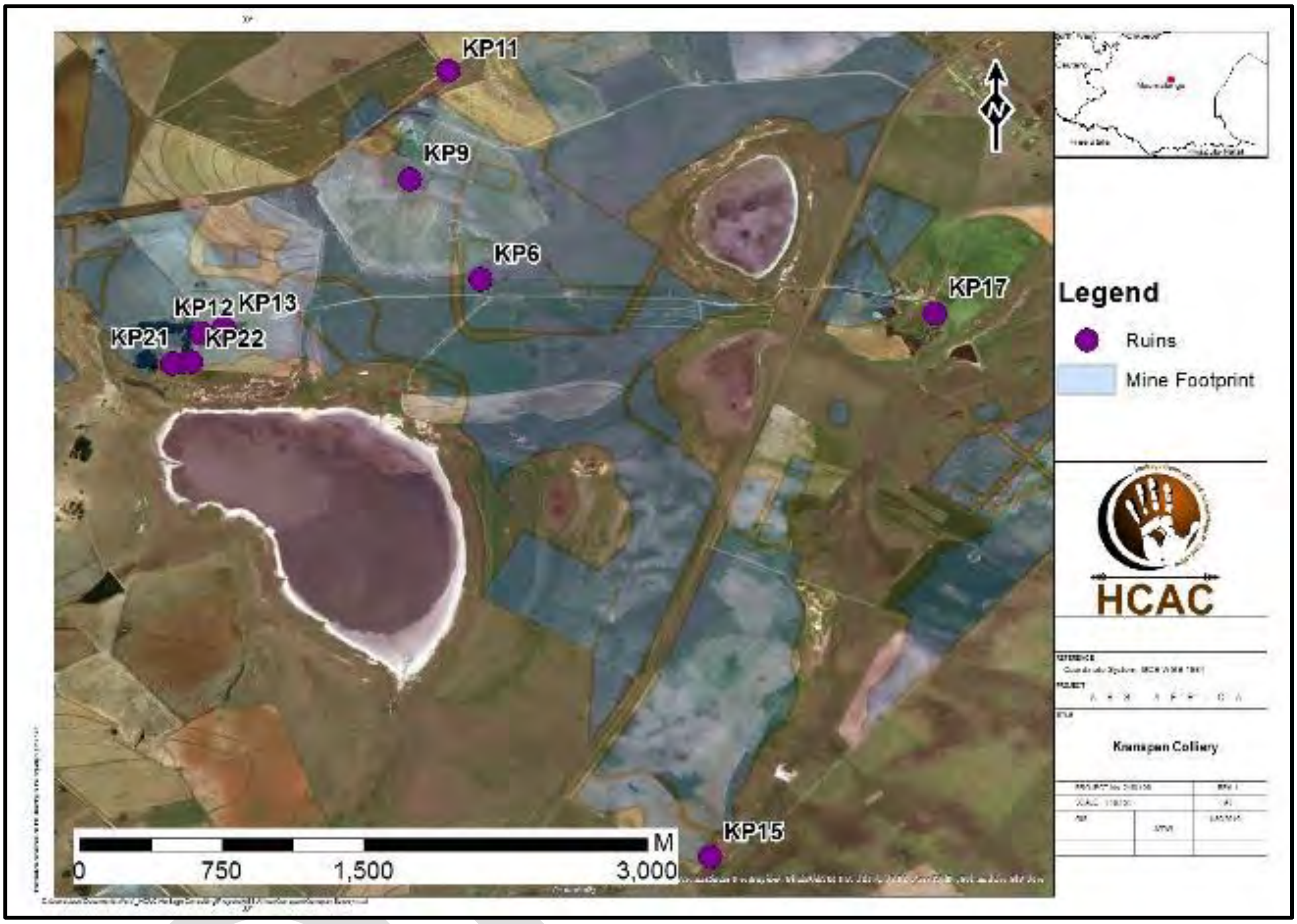


Figure 69. Location of the recorded structures.

Table 10. Impact assessment on structures older than 60 years.

Nature: During earth moving activities resulting in disturbance of surfaces and/or sub-surfaces may destroy, damage, alter, or remove from its original position heritage material or objects.		
	Without mitigation	**With mitigation (Preservation/ excavation of site)**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (2)	Low (2)
Probability	Definite (5)	Probable (3)
Significance	**40 (Medium)**	**24 (Low)**
Status (positive or negative)	Negative	Negative
Reversibility	Not reversible	Not reversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Mitigation: The structures are of low to moderate significance, but are protected by the heritage act due to their age. It is recommended that if impacted on the sites should be assessed by a conservation architect after which a destruction permit can be applied for adhering to all legal requirements. A chance find procedure should be implemented for the project.		
Cumulative impacts: Since the surrounding area is characterised by agricultural developments and due to the lack of significant heritage resources that will be impacted on in the study area cumulative impacts are considered to be low.		
Residual Impacts: If sites are destroyed this results in the depletion of heritage record of the area. However, if sites are recorded and preserved or mitigated this adds to the record of the area.		

9.1.3.3 Impact on recorded cemeteries

During the survey 6 cemeteries were identified and the proposed development will have a direct impact on 4 of the cemeteries (Figure 70).

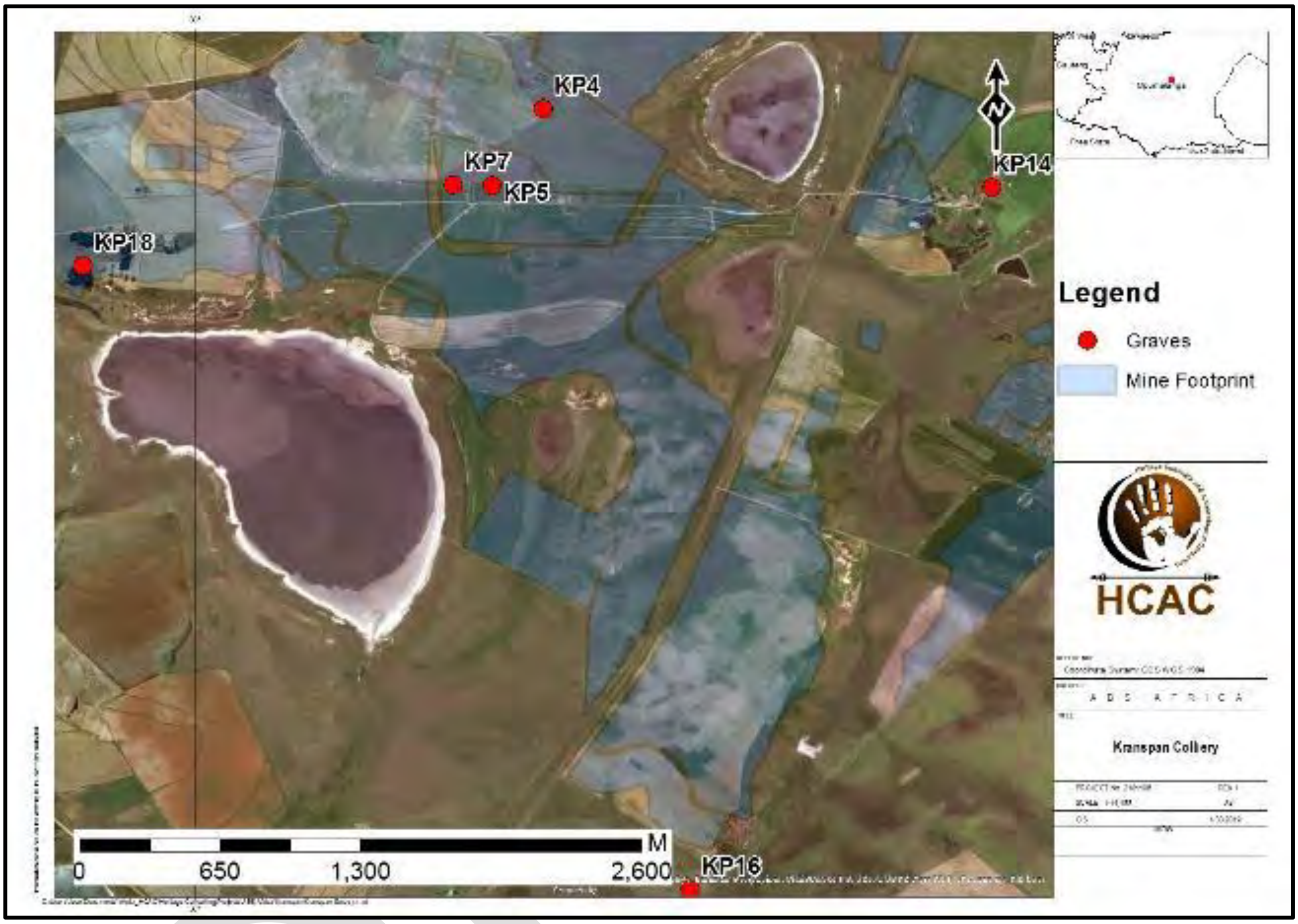


Figure 70. Location of recorded cemeteries.

Table 11 Impact Assessment on recorded graves

Nature: During earth moving activities resulting in disturbance of surfaces and/or sub-surfaces may destroy, damage, alter, or remove from its original position graves and burial sites.		
	Without mitigation	**With mitigation (Preservation/ excavation of site)**
Extent	Local (3)	Local (3)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (4)	Low (2)
Probability	Definite (5)	Not probable (2)
Significance	**60 (Medium - High)**	**20 (Low)**
Status (positive or negative)	Negative	Negative
Reversibility	Not reversible	Not reversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Mitigation: Graves and cemeteries are of high social significance, it is recommended that the cemeteries should be demarcated and preserved *in situ.* If this is not possible the graves can be relocated adhering to all legal requirements. A chance find procedure should be implemented for the project.		

9.1.3.4 Impact on Stone Cairns

Three of the four identified stone cairns will be impacted on by the development (Figure 71).

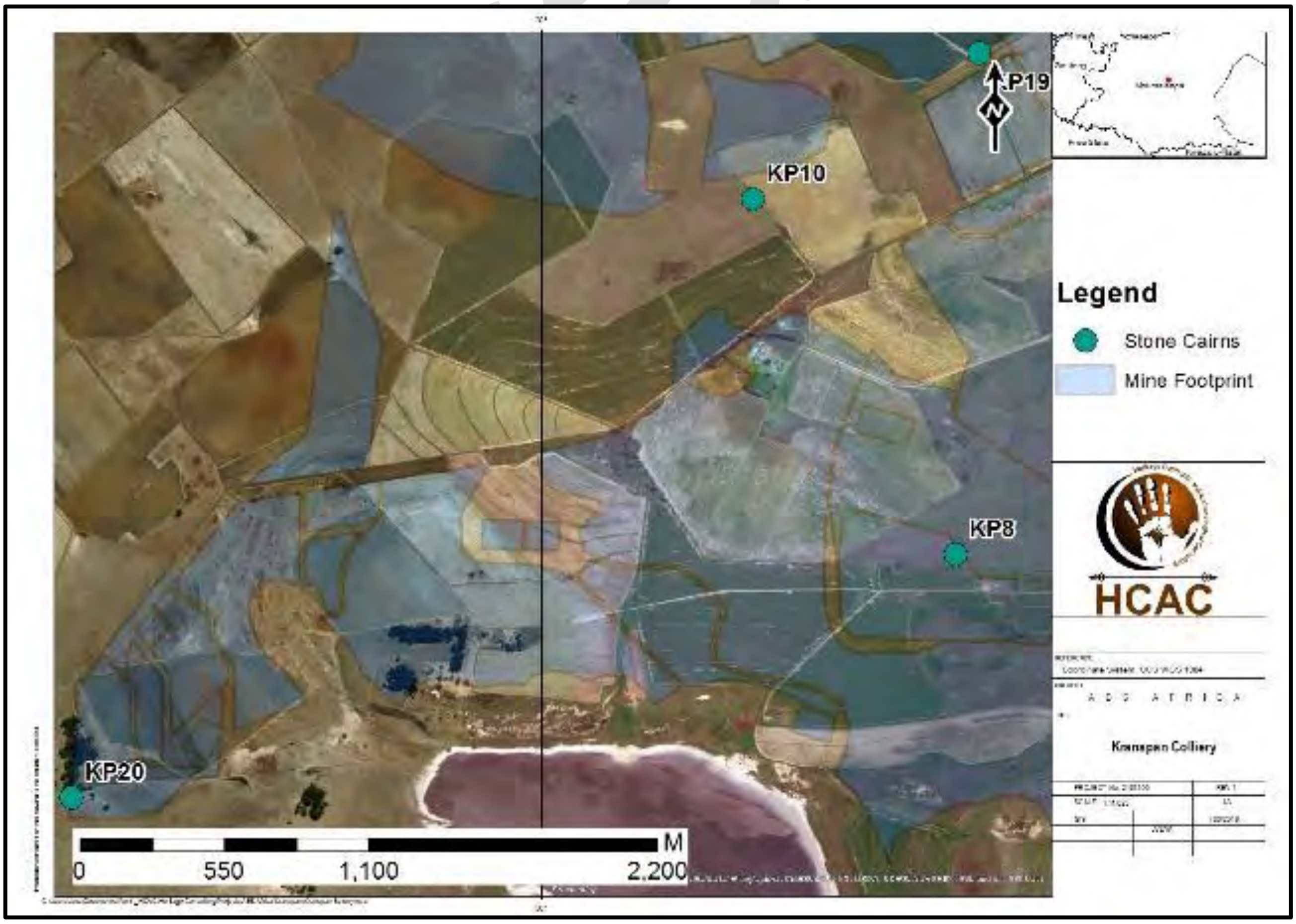


Figure 71. Identified Stone Cairns in the study area.

Table 12. Impact assessment for Stone Cairns in the study area

Nature: During earth moving activities resulting in disturbance of surfaces and/or sub-surfaces may destroy, damage, alter, or remove from its original position graves and burial sites.

	Without mitigation	**With mitigation (Preservation/ excavation of site)**
Extent	Local (3)	Local (3)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (4)	Low (2)
Probability	Definite (5)	Not probable (2)
Significance	**60 (Medium – High)**	**20 (Low)**
Status (positive or negative)	Negative	Negative
Reversibility	Not reversible	Not reversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:
If the cairns are related to clearing activities the features are of low significance and no further mitigation is required. It is recommended that the presence of graves should be confirmed by the social team. Graves and cemeteries are of high social significance, it is recommended that if confirmed to be graves the cairns should be demarcated and preserved *in situ.* If this is not possible the graves can be relocated adhering to all legal requirements. A chance find procedure should be implemented for the project.

9.1.4 Impact on Wash Plant Alternatives

Three wash plant alternatives were considered (Figure 72). The impact of the three alternatives on heritage resources is summarised in Table 13 and the impact on identified sites is indicated in Figure 73.

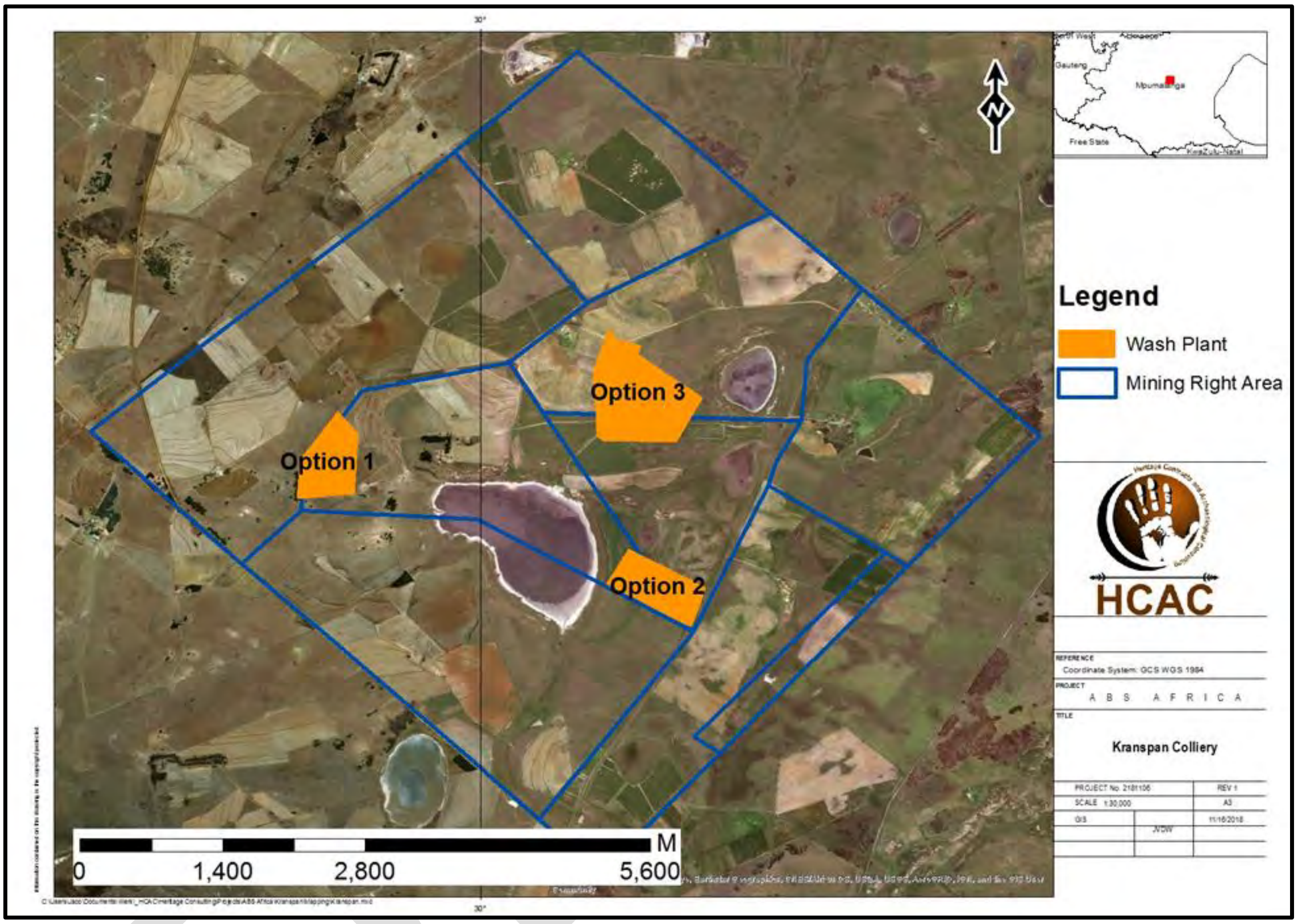


Figure 72. Wash plant Alternatives

Table 13. Impacts on heritage resources by the three wash plant alternatives

Option	Option 1	Option 2	Option 3
Impact	Indirect impact on a Stone Cairn	No direct or indirect impact on known heritage sites.	Direct impact on KP 4, 5,6,7 and 8 (Figure 73).
Acceptable/ Not acceptable	**Acceptable** it the correct mitigation measures are implemented.	**Preferred option**	From a heritage point of view this option is the **least preferred alternative.**

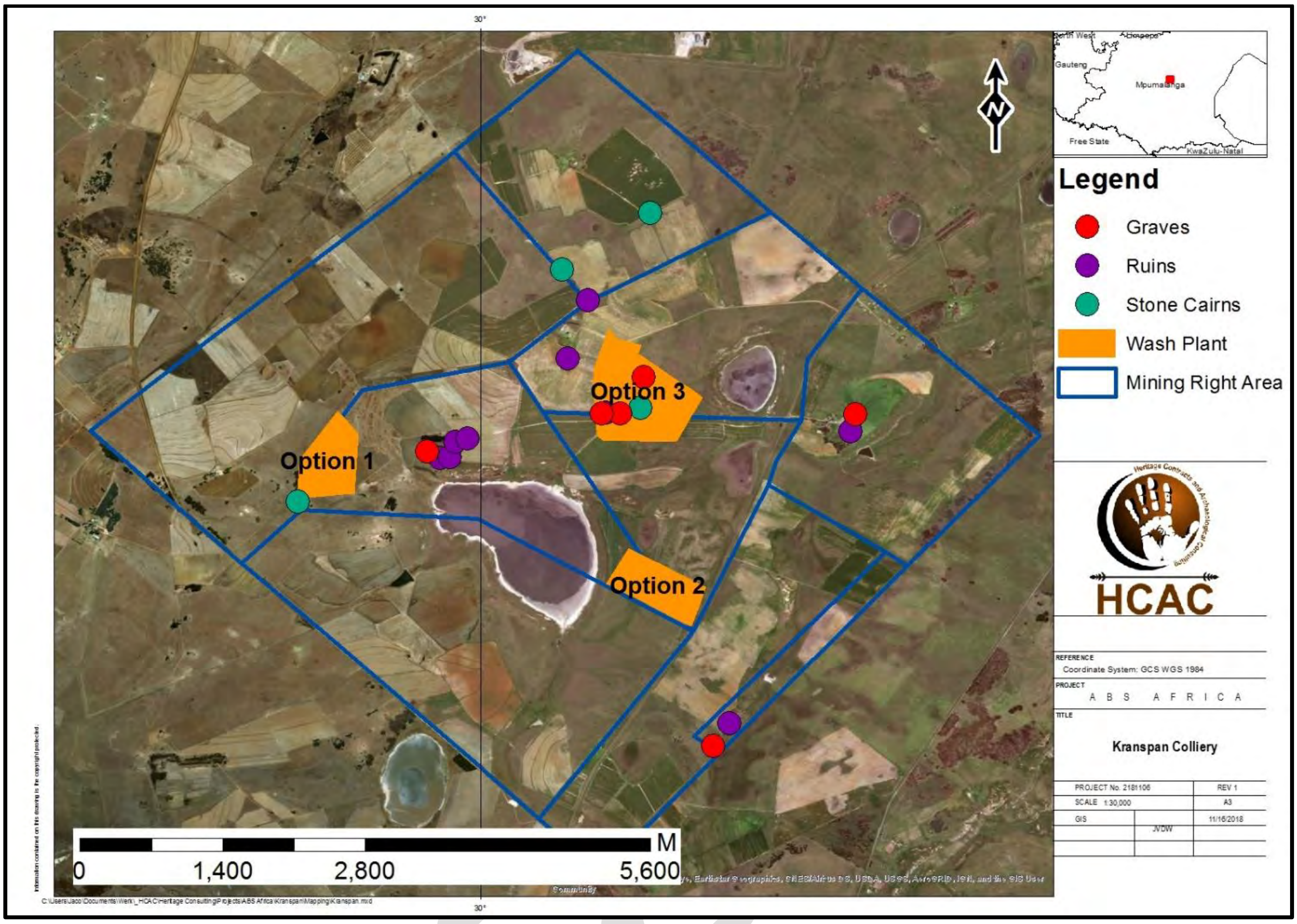


Figure 73. Sites as indicated in relation to wash plant alternatives.

Table 14. EMPR management measures

OBJECTIVE: To preserve and mitigate non-renewable heritage resources in the study area.	
Project component/s	Heritage resources can be impacted on during earth moving activities by the project.
Potential Impact	Irreplaceable loss of heritage resources and accidental damage to burial sites in the study area as well as depletion of the archaeological database of the area.
Activity/risk source	Activities such as vegetation clearing and earth moving activities could destroy recorded resources.
Mitigation: Target/Objective	A heritage site development plan incorporated into the environmental management plan that considers heritage resources in the event of any future extensions of infrastructure or identification of heritage resources in current operations. *In situ* preservation of known graves.

Mitigation: Action/control	**Responsibility**	**Timeframe**
• A Consultation process to determine if any graves or still born burials exist in and around the structures must be conducted	Social team/ Community Liaison officer	Prior to earth works
• Implement a Chance Finds Procedure to ensure that if any heritage resources are uncovered that these are reported and correctly mitigated.	ECO	Daily
• The historic structures should be assessed by a conservation architect if they are to be impacted on by the development who will make suitable recommendations for mitigation, after which a destruction permit can be applied for from the relevant heritage authority.	Kranspan Colliery	Prior to development
• Implementation of a heritage site development plan to ensure the protection of heritage resources within the mining area;	Kranspan Colliery	Prior to development
• Implementation of a chance find procedure	Kranspan Colliery	Life of Mine
• Implementation of paleontological protocols (Millsteed 2019)	Kranspan Colliery and ECO	Life of Mine

Performance Indicator	• Graves should be retained *in situ/* relocated adhering to legal requirements. • Heritage impacts should be considered in any future development in the area.

	• Ongoing preservation of retained sites. • Implementation of a chance find procedure i.e. immediate reporting to relevant heritage authorities of any heritage feature discovered during any phase of development or operation of the facility.
Monitoring	The ECO should monitor the known heritage resources during construction and the possible occurrence of subsurface heritage resources regularly.

10 Recommendations and conclusion

HCAC was appointed to conduct a Heritage Impact Assessment for the Kranspan Colliery to determine the presence of cultural heritage sites and the impact of the proposed project on these non-renewable resources. The study area was assessed both on desktop level and by a field survey. The field survey was conducted as a non-intrusive pedestrian survey to cover the extent of the footprint of the proposed mine. The mining right area is located on nine portions of the Farm Kranspan 49IT, Mpumalanga Province, approximately 13 km south-west of the town of Carolina. The planned operations entail both surface and underground mining as well as the establishment of various mine support infrastructure within the proposed mining right area.

The study area is characterised by extensive maize fields that have been cultivated from prior to 1966. These agricultural activities would have impacted on surface indicators of heritage sites. However, several sites were still intact and recorded during the survey (Table 2).

In terms of the built environment (Section 34 of the NHRA) nine ruins were recorded (KP 6, KP 9, KP 11, KP 12, KP 13, KP 15, KP 17, KP 21, KP 22). Apart from KP 11, 15 and 17 that will not be directly impacted on the other ruins are all located in the preferred plant and opencast area. Although these ruins' potential to contribute to aesthetic, historic, scientific and social aspects is low, if confirmed to be older than 60 years these features are protected by legislation and must be assessed by a conservation architect.

Archaeological remains are sparse throughout the study area and three sites (KP 1, 2 & 3) were recorded centred around pans. These sites consist of a scatter of Stone tools, possible rock art and a small shelter. Fortunately, these sites are within environmental buffer zones around the pans and will not be directly impacted on. An independent paleontological study (Millsteed 2019) found that it is evident that the proposed mining operations pose a risk of negatively impacting upon scientifically highly significant fossil assemblages and damage mitigation protocols are required. Detailed recommended control mitigation measures are included in Section 10 of this report.

In terms of Section 36 of the Act six cemeteries (KP 4, KP 5, KP 7, KP 14, KP 16, KP 18) were recorded. Four of the cemeteries are located in the pit and wash plant area and will be directly impacted on (KP 4, 5, 7 and 18). Two of the cemeteries could be indirectly impacted on. It is recommended that these cemeteries should be retained *in situ*, with a 50 m buffer zone and demarcated with an access gate where possible. If this is not possible these cemeteries can be relocated adhering to legislation. More graves/ cemeteries can be expected in the mining right area and if any additional graves are identified they should ideally be preserved *in-situ* or alternatively relocated according to existing legislation.

No public monuments are located within or close to the study area. The study area is rural in character with an emphasis on agriculture with several mining operations next to the current study area and although it is not a significant cultural landscape the proposed mining can have a negative impact on the sense of place. During the public participation process conducted for the project no heritage concerns were raised.

The impact of the proposed project on heritage resources is considered low to medium and impacts can be mitigated to an acceptable level. The greatest risk to the project is the location of known and unknown graves. It is therefore recommended that the proposed project can commence (from a heritage perspective) on the condition that the following recommendations are implemented as part of the EMPr together with site specific recommendations and based on approval from SAHRA:

- The historic structures (KP 9, 12, 17, 21 and 22) should be assessed by a conservation architect if they are to be impacted on by the development who will make suitable recommendations for mitigation, after which a destruction permit can be applied for from the relevant heritage authority.
- The cemeteries located in the pit and wash plant area (KP 4,5,7 and 18) will be directly impacted on. It is recommended that these cemeteries are preserved *in situ*, fenced with an access gate for family members, with a 50-meter buffer zone. If this is not possible the cemeteries can be relocated adhering to all legal requirements.
- The cemeteries KP 14 and 16 could be indirectly impacted by the development and it is therefore recommended that the cemeteries are preserved *in situ*, fenced with an access gate for family members, with a feasible buffer zone.
- The total number of graves should be confirmed prior to development.
- It is recommended that during the social consultation process to be undertaken by the mine Community Liaison Officer it should be confirmed whether the identified stone cairns represent graves (KP 8 and 20 are located within the impact area).
- Through the social consultation process, to be undertaken by the mine Community Liaison Officer, the existence of unknown and unmarked graves associated must be confirmed in order to mitigate any graves not identified in this study. The implementation of a chance find procedure is recommended.
- Implementation of a heritage site development plan to ensure the protection of heritage resources within the mining area;
- Implementation of a chance find procedure

In terms of the palaeontological heritage the following recommendations apply:

During the construction phase of the mine:

- When the surface infrastructure elements of the mine are being constructed these locations must be regularly inspected to observe if the excavations have encountered bedrock of the Vryheid Formation.
- These regular inspections should be made by a suitable mine employee (such as the environmental officer) who has been trained to identify the types of fossils that may reasonably be expected to occur within the Vryheid Formation.
- Should fossil materials be identified, the excavations must be halted in that area and SAHRA informed of the discovery. An experienced Karoo palaeontologist should be contacted by the mine to assess the significance of the fossils.
- If fossil materials prove to be scientifically significant the palaeontologist should make recommendations that they should be either be protected completely *in situ* or could have damage mitigation procedures emplaced (i.e., excavation by a suitability by a suitably experienced palaeontologist) to minimise negative impacts.

Once excavation of the opencast pit voids begins:

- On-site checks for the occurrence of any fossils of the excavated pits and stockpiled material should be conducted biannually (i.e., every six months).
- The frequency of these checks should be reassessed after twelve (12) months based on the findings.
- The Karoo palaeobotanist should submit a monitoring report to SAHRA on this work.

In addition,

- Should any fossil materials be identified, the palaeontologist should ascertain their scientific and cultural importance. Should the fossil prove scientifically or culturally significant the particular excavations involved should be halted and SAHRA informed of the discovery

- Should scientifically or culturally significant fossil material exist within the project areas any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

When the underground mining component of the mining program commences no damage mitigation protocols are recommended. The coals comprising Seam E are the product of a complex series of jellification and other coalification processes that transformed the original vegetation (peat) into coal. Recognisable plant macrofossil materials are not expected to be present within the coals. Such plant macrofossil materials may be present within any siliciclastic partings within the seam. However, the automatic mining machinery will destroy any such fossils before they can be recognised as being present. Similarly, modern industrial health and safety rules would make it extremely difficult for a palaeontologist to be able to access and work at a working mine face. Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

10.1 Chance Find Procedures

The possibility of the occurrence of subsurface finds cannot be excluded. Therefore, if during construction any possible finds such as stone tool scatters, artefacts or bone and fossil remains are made, the operations must be stopped and a qualified archaeologist must be contacted for an assessment of the find and therefor chance find procedures should be put in place as part of the EMP. A short summary of chance find procedures is discussed below.

This procedure applies to the developer's permanent employees, its subsidiaries, contractors and subcontractors, and service providers. The aim of this procedure is to establish monitoring and reporting procedures to ensure compliance with this policy and its associated procedures. Construction crews must be properly inducted to ensure they are fully aware of the procedures regarding chance finds as discussed below.

- If during the pre-construction phase, construction, operations or closure phases of this project, any person employed by the developer, one of its subsidiaries, contractors and subcontractors, or service provider, finds any artefact of cultural significance or heritage site, this person must cease work at the site of the find and report this find to their immediate supervisor, and through their supervisor to the senior on-site manager.
- It is the responsibility of the senior on-site Manager to make an initial assessment of the extent of the find and confirm the extent of the work stoppage in that area.
- The senior on-site Manager will inform the ECO of the chance find and its immediate impact on operations. The ECO will then contact a professional archaeologist for an assessment of the finds who will notify the SAHRA.

10.2 Reasoned Opinion

From a heritage perspective, the proposed project is acceptable. If the above recommendations are adhered to and based on approval from SAHRA, HCAC is of the opinion that the development can continue as the development will not impact negatively on the heritage record of the area.

11 References

Archaeological database, University of the Witwatersrand.

Barnard, C. 1975. Die Transvaalse Laeveld. Komee van 'n Kontrei.

Bulpin, T.V. 2001. *Discovering Southern Africa*. 6th Ed. Discovering Southern Africa Productions.

Deacon, H.J. & Deacon, J. 1999. Human Beginnings in South Africa: Uncovering the Secrets of the Stone Age. Cape Town: David Phillips Publishers.

Delius, P. 2007. Mpumalanga History and Heritage. University of KwaZulu-Natal Press.

Delius, P, Maggs, T & Schoeman, M. 2012. Bokoni: Old Structures, New Paradigms? Rethinking Pre-colonial Society from the Perspective of the Stone-Walled Sites in Mpumalanga, Journal of Southern African Studies, 38:2, 399-414.

Geskiedenisatlas van Suid-Afrika. Die vier noordelike provinsies. Edited by J. S.. Pretoria: J. L. van Schaik Uitgewers.

Universiteit van Pretoria.

Kuman, K., 1998. The earliest South African Industries. In: *Lower Palaeolithic Settlement of the Old World*. Eds by M.D. Petraglia and R. Korisetter, pp 151-186. Routledge Press, London.

Lombard, M., Wadley, L., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., Swart, J. & Mitchell, P. (2012). South African and Lesotho Stone Age sequence updated (I). *South African Archaeological Bulletin*, *67*(195), 123–144.

Lombard, W. A. 1952. *Memorial album of the Van Riebeeck Festival Commission*. Hogeveld Pers

Maggs, T.M. 1972. Bilobial dwellings: a persistent feature of southern Tswana settlements.

(South African Archaeological Society Goodwin Series **1**), pp. 54-65

Maggs, T. 2007. Iron Age Settlements Of The Mpumalanga Escarpment: Some Answers But Many Questions. The Digging Stick. Volume 24, No 2

Mason, R.J. 1962. *The Prehistory of the Transvaal*. Johannesburg: Witwatersrand University Press.

Mucina, L. & Rutherford,M.C. 2006. The vegetation map of South Africa, Lesotho and Swaziland. SANBI, Pretoria.

Myburgh, A.C. 1956. *Die Stamme van die Distrik Carolin*a. Staatsdrukker. Pretoria.

National Heritage Resources Act NHRA of 1999 (Act 25 of 1999)

Pelser, A and Van der Walt, J. 2008 A Report On A Heritage Impact Assessment For Proposed Opencast Coal Mining Operations For The Klippan Colliery On The Farm Klippan 452 JS (Emachibini), Wonderfontein, Mpumalanga

Pistorius, JCC. 2007. A Phase I Heritage Impact Assessment (Hia) Study For The Upgrading Of Eskom's Nooitgedacht Substation On The Farm Wintershoek 451 Near Carolina In The Mpumalanga Province Of South Africa

Ross, R. 1999. A *concise history of South Africa*. Cambridge University Press. Cambridge.

SAHRA Report Mapping Project Version 1.0, 2009

Van Schalkwyk, J.A. 2007. Heritage Impact Scoping Report For The Planned Hendrina-Marathon Powerline, Mpumalanga Province

Van Schalkwyk, J. A. 2007. Heritage Impact Assessment For The Planned Development On The Farms Hebron 421JT And Twyfelaar 11IT , Carolina Municipal District, Mpumalanga Province

Volman, T.P. 1984. Early prehistory of southern Africa. In: Klein, R.G. (ed.) *Southern African Prehistoryand Palaeoenvironments*: 169-220. Rotterdam: Balkema

Appendix A
Curriculum Vitae of Specialist

Jaco van der Walt
Archaeologist

jaco.heritage@gmail.com
+27 82 373 8491
+27 86 691 6461

Education:

Particulars of degrees/diplomas and/or other qualifications:

Name of University or Institution:		University of Pretoria
Degree obtained	**:**	BA Heritage Tourism & Archaeology
Year of graduation	**:**	2001
Name of University or Institution:		University of the Witwatersrand
Degree obtained	**:**	BA Hons Archaeology
Year of graduation	**:**	2002
Name of University or Institution	**:**	University of the Witwatersrand
Degree Obtained	**:**	MA (Archaeology)
Year of Graduation	:	2012
Name of University or Institution	**:**	University of Johannesburg
Degree	**:**	PhD
Year	:	Currently Enrolled

EMPLOYMENT HISTORY:

2011 – Present:	**Owner – HCAC (Heritage Contracts and Archaeological Consulting CC)**.
2007 – 2010 :	**CRM Archaeologist,** Managed the Heritage Contracts Unit at the University of the Witwatersrand.
2005 - 2007:	**CRM Archaeologist**, Director of Matakoma Heritage Consultants
2004:	**Technical Assistant**, Department of Anatomy University of Pretoria
2003:	**Archaeologist**, Mapungubwe World Heritage Site
2001 - 2002:	**CRM Archaeologists,** For R & R Cultural Resource Consultants, Polokwane
2000:	**Museum Assistant**, Fort Klapperkop.

Countries of work experience include:

Republic of South Africa, Botswana, Zimbabwe, Mozambique, Tanzania, The Democratic Republic of the Congo, Lesotho and Zambia.

SELECTED PROJECTS INCLUDE:

Archaeological Impact Assessments (Phase 1)

Heritage Impact Assessment Proposed Discharge Of Treated Mine Water Via The Wonderfontein Spruit Receiving Water Body Specialist as part of team conducting an Archaeological Assessment for the Mmamabula mining project and power supply, Botswana

Archaeological Impact Assessment Mmamethlake Landfill

Archaeological Impact Assessment Libangeni Landfill

Linear Developments

Archaeological Impact Assessment Link Northern Waterline Project At The Suikerbosrand Nature Reserve

Archaeological Impact Assessment Medupi – Spitskop Power Line,

Archaeological Impact Assessment Nelspruit Road Development

Renewable Energy developments

Archaeological Impact Assessment Karoshoek Solar Project

Grave Relocation Projects

Relocation of graves and site monitoring at Chloorkop as well as permit application and liaison with local authorities and social processes with local stakeholders, Gauteng Province.

Relocation of the grave of Rifle Man Maritz as well as permit application and liaison with local authorities and social processes with local stakeholders, Ndumo, Kwa Zulu Natal.

Relocation of the Magolwane graves for the office of the premier, Kwa Zulu Natal

Relocation of the OSuthu Royal Graves office of the premier, Kwa Zulu Natal

Phase 2 Mitigation Projects

Field Director for the Archaeological Mitigation For Booysendal Platinum Mine, Steelpoort, Limpopo Province. Principle investigator Prof. T. Huffman

Monitoring of heritage sites affected by the ARUP Transnet Multipurpose Pipeline under directorship of Gavin Anderson.

Field Director for the Phase 2 mapping of a late Iron Age site located on the farm Kameelbult, Zeerust, North West Province. Under directorship of Prof T. Huffman.

Field Director for the Phase 2 surface sampling of Stone Age sites effected by the Medupi – Spitskop Power Line, Limpopo Province

Heritage management projects

Platreef Mitigation project – mitigation of heritage sites and compilation of conservation management plan.

MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS:

- Association of Southern African Professional Archaeologists. Member number 159

  Accreditation:

  - Field Director Iron Age Archaeology
  - Field Supervisor Colonial Period Archaeology, Stone Age Archaeology and Grave Relocation
- Accredited CRM Archaeologist with SAHRA
- Accredited CRM Archaeologist with AMAFA
- Co-opted council member for the CRM Section of the Association of Southern African Association Professional Archaeologists (2011 – 2012)

PUBLICATIONS AND PRESENTATIONS

- A Culture Historical Interpretation, Aimed at Site Visitors, of the Exposed Eastern Profile of K8 on the Southern terrace at Mapungubwe.
  - J van der Walt, A Meyer, WC Nienaber
  - Poster presented at Faculty day, Faculty of Medicine University of Pretoria 2003
- 'n Reddingsondersoek na Anglo-Boereoorlog-ammunisie, gevind by Ifafi, Noordwes-Provinsie. South-African Journal for Cultural History 16(1) June 2002, with A. van Vollenhoven as co-writer.
- Fieldwork Report: Mapungubwe Stabilization Project.
  - WC Nienaber, M Hutten, S Gaigher, J van der Walt
  - Paper read at the Southern African Association of Archaeologists Biennial Conference 2004
- A War Uncovered: Human Remains from Thabantšho Hill (South Africa), 10 May 1864.
  - M. Steyn, WS Boshoff, WC Nienaber, J van der Walt
  - Paper read at the 12th Congress of the Pan-African Archaeological Association for Prehistory and Related Studies 2005
- Field Report on the mitigation measures conducted on the farm Bokfontein, Brits, North West Province .
  - J van der Walt, P Birkholtz, W. Fourie
  - Paper read at the Southern African Association of Archaeologists Biennial Conference 2007
- Field report on the mitigation measures employed at Early Farmer sites threatened by development in the Greater Sekhukhune area, Limpopo Province. J van der Walt
  - Paper read at the Southern African Association of Archaeologists Biennial Conference 2008
- Ceramic analysis of an Early Iron Age Site with vitrified dung, Limpopo Province South Africa.
  - J van der Walt. Poster presented at SAFA, Frankfurt Germany 2008

- Bantu Speaker Rock Engravings in the Schoemanskloof Valley, Lydenburg District, Mpumalanga (*In Prep)*
    - J van der Walt and J.P Celliers
- Sterkspruit: Micro-layout of late Iron Age stone walling, Lydenburg, Mpumalanga. W. Fourie and J van der Walt. A Poster presented at the Southern African Association of Archaeologists Biennial Conference 2011
- Detailed mapping of LIA stone-walled settlements' in Lydenburg, Mpumalanga. J van der Walt and J.P Celliers
    - Paper read at the Southern African Association of Archaeologists Biennial Conference 2011
- Bantu-Speaker Rock engravings in the Schoemanskloof Valley, Lydenburg District, Mpumalanga. J.P Celliers and J van der Walt
    - Paper read at the Southern African Association of Archaeologists Biennial Conference 2011
- Pleistocene hominin land use on the western trans-Vaal Highveld ecoregion, South Africa, Jaco van der Walt.
    - J van der Walt. Poster presented at SAFA, Toulouse, France. Biennial Conference 2016

REFERENCES:

1. Prof Marlize Lombard — Senior Lecturer, University of Johannesburg, South Africa
   E-mail: mlombard@uj.ac.za
2. Prof TN Huffman — Department of Archaeology Tel: (011) 717 6040
   University of the Witwatersrand
3. Alex Schoeman — University of the Witwatersrand
   E-mail:Alex.Schoeman@wits.ac.za

Proposed Kranspan Project: Noise Impact Assessment

Project done for ABS Africa

Report Compiled By:
Andre Bruwer

Project Leader:
Hanlie Liebenberg-Enslin

Report No: 18 ABS07N | Date: March 2019

Address: 480 Smuts Drive, Halfway Gardens | Postal: P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | Fax: +27 (0)11 805 7010
www.airshed.co.za

Report Details

Report Title	Proposed Kranspan Project: Noise Impact Assessment
Client	ABS Africa
Report Number	18ABS07N
Report Version	Draft
Date	March 2019
Prepared by	Andre Bruwer, MEng (Environmental) (University of Pretoria)
Reviewed by	Hanlie Liebenberg-Enslin PhD. (Uni. of Johannesburg)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Version	Date	Comments

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 1.3
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.3 and Appendix B
A declaration that the person is independent in a form as may be specified by the competent authority	Report details (Executive Summary) and Section 1.3
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report	Section 3.3
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 3.3 and Section 4.2
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.3
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 1.6
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternative	Section 4
An identification of any areas to be avoided, including buffers	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 3.1 and Section 4.2
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.7
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 4.2
Any mitigation measures for inclusion in the EMPr	Section 5
Any conditions for inclusion in the environmental authorisation	Section 5 and Section 7
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 5
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	Section 7
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 5
A description of any consultation process that was undertaken during the course of preparing the specialist report	Not applicable.
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	Not applicable.
Any other information requested by the competent authority.	Not applicable.

Glossary and Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure that has been A-weighted to simulate human hearing.
C_i	Correction for impulsiveness
Ct	Correction for tonality
EAP	Environmental Assessment Practitioner
EC	European Commission
EHS	Environmental, Health, and Safety (IFC)
FMAC	Francois Malherbe Acoustic Consulting cc
Hz	Frequency in Hertz
HV	Heavy vehicle
IEC	International Electro Technical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
Kn	Noise propagation correction factor
K1	Noise propagation correction for geometrical divergence
K2	Noise propagation correction for atmospheric absorption
K3	Noise propagation correction for the effect of ground surface;
K4	Noise propagation correction for reflection from surfaces
K5	Noise propagation correction for screening by obstacles
kW	Power in kilowatt
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{AIeq} (T)	The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
$L_{Req,d}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
$L_{Req,n}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
$L_{R,dn}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.
L_{A90}	The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period

L_{me}	Sound power level 25 m from a road, 4 above ground (in dBA)
L_P	Sound pressure level (in dB)
L_{PA}	A-weighted sound pressure level (in dBA)
L_{PZ}	Un-weighted sound pressure level (in dB)
Ltd	Limited
L_W	Sound Power Level (in dB)
NEMAQA	National Environment Management Air Quality Act
masl	Meters above sea level
m^2	Area in square meters
m/s	Speed in meters per second
NLG	Noise level guideline
NSR	Noise sensitive receptor
p	Pressure in Pa
Pa	Pressure in Pascal
µPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 µPa
Pty	Proprietary
rpm	Rotational speed in revolutions per minute
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
STRM	Shuttle Radar Topography Mission
USGS	United States Geological Survey
WG-AEN	Working Group – Assessment of Environmental Noise (EC)
WHO	World Health Organisation
%	Percentage

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by ABS Africa to undertake a specialist environmental noise impact study for the proposed Kranspan Project (hereafter referred to as the project).

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the development of the proposed project and recommend suitable management and mitigation measures. To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from surveys conducted in 29 and 30 January 2019.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

In the assessment of simulated noise levels, reference was made to the International Finance Corporation (IFC) noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) which is also in line with the South African National Standards (SANS) 10103 rating for urban districts.

The baseline acoustic environment was described in terms of the location of NSRs, the ability of the environment to attenuate noise over long distances, as well as existing background and baseline noise levels. The following was found:

- The closest NSRs include individual farmsteads and informal settlements.
- Cattle, residential, vehicles and mining activities are the main contributors to the baseline acoustic environment of the area.
- The lowest baseline noise levels (as measured during the survey) was 34.4 dBA during the day and 36.8 dBA during the night.

Noise emissions from the proposed mine layout were estimated using L_W predictions for industrial machinery (Bruce & Moritz, 1998), where L_W estimates are a function of the power rating of the equipment engine.

The source inventory, local meteorological conditions and information on local land use were used to populate the noise propagation model[1] (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 12 km east-west by 12 km north-south. The area was divided into a grid matrix with a 50-m resolution and NSRs were included as discrete receptors.

The main findings of the impact assessment are:

- A management and mitigation plan are recommended to minimise noise impacts from the project on the surrounding area.
- The processing and beneficiation plant be located at the preferred area, as the alternate plant areas are too close to existing sensitive receptors in the area.
- The noise levels from the project operations exceed the selected noise criteria at the KN2 and KN3 for day- and night-time conditions with change in noise from baseline conditions expected to be more than 15 dBA. According to SANS 10103 (2008); 'very strong' reaction may be expected from the community for increased noise levels of more than 15 dBA.
- The noise levels from the project operations exceed the selected noise criteria at KN1 and KN5 only during night-time conditions. According to SANS 10103 (2008); 'little' to 'medium' reaction may be expected at KN5 during- day and night-time conditions as the increase is more than 5 dBA, but less than 10 dBA
- Construction and closure phase impacts are expected to be similar to simulated noise impacts of the operational phase.

The following key recommendations should be included in the project environmental management programme:

- A monitoring programme as per the requirements of the IFC and SANS 10103:
    - Annually during the operational phase at KN1, KN2 and KN3 if the homesteads are going to be used for residential purposes by Ilima; and at KN5.
    - In response to complaints received.

Based on the findings of the assessment and provided the measures planned and recommended are in place, it is the specialist opinion that the project may be authorised.

[1] 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 and the informal community will be relocated by the Msobo mine prior to construction at Kranspan, the change in position of the plant is not expected to result in higher noise impacts than what was simulated in the impact assessment and the conclusions and recommendations are still valid.

Table of Contents

List of Tables

List of Figures

1 Introduction

Ilima Coal Company (Ilima) plans on developing a new coal mineon various portions of the farm Kranspan 49 IT, approximately 13 km south-west of Carolina in Mpumalanga.

Open cast mining will take place concurrently with an underground mining section. A conventional strip mining method will be employed for each of the opencast pits, while a conventional bord and pillar operation will be employed for the underground mining section. ROM from the underground mine will be transported to the surface via a conveyor to a surface stockpile. From there an overland conveyor will transport the underground ROM to the screening and crushing plant. After that 70% of the coal will be beneficiated for export.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by ABS Africa to undertake a specialist environmental noise impact study for the proposed Kranspan Project and associated infrastructure (hereafter referred to as the project).

1.1 Study Objective

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the operations at the project and recommend suitable management and mitigation measures. The layout of the project site is provided in Figure 1.

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
   a. The identification of NSRs from available maps and field observations;
   b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
   c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from surveys conducted in 29 and 30 January 2019.
4. An impact assessment, including:
   a. The establishment of a source inventory for proposed activities.
   b. Noise propagation simulations to determine environmental noise levels as a result of the project.
   c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.