SECTION 2

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2.1.1 Regional Geology

The iron ore in the Sishen / Postmasburg area is preserved in chemical and clastic sediments of the Proterozoic Transvaal Supergroup, deposited between about 2 500 and 1 800 million years ago. The stratigraphy has been deformed by thrusting from the west and has also undergone extensive karstification. The thrusting has produced a series of open, north to south plunging, anticlines, synclines and grabens. Karstification has been responsible for the development of deep sinkholes

Bruce, King and Mokaning are situated in the northern part of the Maramane Dome. Carbonate rocks of the Campbellrand Subgroup and iron formations of the Asbesheuwels Subgroup of the Transvaal sequence define the dome. The eastern part of Maramane Dome is exposed. The red beds of the Gamagara Formation of the Olifantshoek Group overlie the Transvaal sequence along an angular unconformity to the west.

Preceding the deposition of the Gamagara Formation, erosion, sinkhole development and supergene enrichment took place. These sinkholes were aligned to the chert-rich dolomite units of the Campbellrand Subgroup. The Manganore Iron Formation slumped into graben like sinkholes. A siliceous chert breccia (Wolhaarkop Breccia) developed at the base of the Manganore Iron Formation during the process of slumping. Simultaneous ferruginisation took place. The presence of hematite clasts in the basal conglomerate of the Gamagara Formation indicates the secondary enrichment of the Manganore Iron-Formation preceded the deposition of the Gamagara Formation. Sinkhole development and supergene enrichment of the iron-formation appear to be controlled by the stratigraphy of the underlying Campbellrand carbonates.

Further west, Ongeluk lava is thrust over the Gamagara Formation. This thrust, dipping about 10 degrees west strikes from the Rooinekke Mine in the south to the Black Rock Mine in the north.

Younger sediments of the Karoo Supergroup (Dwyka tillite) and Kalahari Formations cover large parts of the area (Grinaker-LTA Process Engineering, 2003).

2.1.2 Local Geology

The south-eastern and central parts of Bruce and the western parts of King and Mokaning area are characterised by higher topography, which is defined by the Manganore Iron-formation. This includes chert breccia, banded ironstone shale and laminated iron ore.

The ore deposits occur within the Wolhaarkop Breccia, which overlies the dolomites of the Cambellrand Formation and is overlain by the Sishen shale.

Dolomites of the Campbell Supergroup occur as irregular outcrops in the east and isolated outcrops in the south-western area.

The Doornfontein Conglomerate member of the Gamagara Formation unconformably overlies the Manganore Iron Formation. This member consists of conglomerate, gritstones and interbedded shales. The shale units associated with the iron-rich conglomerates and gritstones may be iron rich and form part of the ore body. Above the Doornfontein Conglomerate Member is a zone of interbedded white, red and black shales. These shales form the Sishen Shale Member. This shale is impersistent along strike and thins and pinches over paleo-hills along the Gamagara unconformity. On Bruce outcrops of this shale member can be found on either side of the iron ore outcrops.

Purple and white coloured, cross-bedded quartzite of the Marthaspoort Member outcrop is found in the south-western part of the farm. Younger sediments consisting of clay, calcrete and sand of the Kalahari Formation cover the northern part of Bruce. Iron ore rubble covers large areas around the iron ore outcrops.

Lenticular and irregular low tonnage laminated iron ore in the banded ironstone of the Manganore Iron Formation is known as Thabazimbi ("Thaba")-type ore. Due to the impurities and nature of this ore, none was included in the ore reserve. The laminated Manganore-type constitutes the bulk of the ore reserve in Bruce. It varies from a massive to thickly laminated ore. The boundaries of these ore bodies crosscut primary bedding. Manganore-type ore can be brecciated to form breccia ore. The massive Manganore-type and Thaba-type ores can be difficult to distinguish except for their different stratigraphical relationships.

Two types of iron ores are found in the Gamagara Formation. Both are found in the Doornfontein Conglomerate Member. The conglomeratic-type ore consists of rounded hematite clasts in a hematite matrix. The conglomerate ore can grade into gritty hematite ore containing hematite granules in a fine-grained platy hematite matrix. The difference between the conglomerate ores of the Gamagara Formation and the breccia ores of the Manganore Iron Formation can be found in the roundness and type of clasts and the degree of sorting. Clasts in the former are better rounded;

polymictic as far as types of hematite ore concerned and some degree of sorting can be seen. The massive ore is usually fine to very fine grained and sand to silt sized hematite grains in a platy hematite matrix. The ore is often faintly laminated. The Gamagara (conglomeratic) ore types are not abundantly found at Bruce.

The Sishen iron deposit is trough shaped striking north, north-west to south, south-east. The ore is best developed along the axis. Thick units of both Manganore (laminated) and Gamagara (conglomeratic) ores are developed in the basins. Lithologies of the Gamagara Formation often pinch out on paleo-highs. The Manganore Iron-Formation is more deformed than the Gamagara strata. This together with the geometry of the Gamagara Formation implies that the predominant basin and dome structures developed prior to the deposition of the Gamagara strata.

The basins represent paleo-sinkhole structures. Dissolution of the carbonates below the Kuruman (Manganore) Iron-Formation resulted in slumping of the interbedded cherts and overlying iron-formations. This dissolution may have been joint controlled explained by lineaments shown on structural contour maps compiled by Sishen.

Deformation of the strata increases to the east. A younger erosion cycle of probably the Karoo and / or pre-Kalahari in age could cause this deformation. The local slumping of Kalahari sediments into sinkhole structures could be related to deformation in recent times. Smaller scale open folding in the outcrops at Bruce could be related to the low angle thrusting further west.

Refer to **Error! Reference source not found.** (page 2-4) illustrating the local geology of the BKM Mine area.

2.1.3 Geological Structures

The iron ore outcrops are discontinuous and irregular in shape. Although striking north-south is recognised on the western part of Bruce, it is poorly developed and discontinuous. Basin-and domelike structures are developed. The regional dip of the strata is 5 to 10 degrees to the west. A north south trending thrust, which has thrust the Ongeluk Lava over the above sequence, is located to the west. A number of north-south trending dykes are present.

Laminated iron ore of the Manganore Formation is well developed in these basins. Thinner lenses of the clastic Gamagara-type iron ore occur higher up in the basins and the Doornfontein Member is thicker. Basins with no iron ore filled with Gamagara and Kalahari sediments are developed further east. The latter basinal development was also found at Sishen.

Refer to Figure 2-2 (page 2-5) illustrating the various dykes present in the BKM Mine area.

- Existing Eskom Power lines (132 kV) from the Sishen traction station are present to the north of the farm Parson and transect the farm Bruce. Another line traverses the farms Mokaning and King parallel to the Port Elizabeth railway line.
- The Vaal Gamagara pipeline runs in a north-south position along the R 325 road. The pipeline is divided into a northern and southern section. The northern section supplies water to Kathu, Kuruman etc. Sishen Mine is pumping excess water into this section of the pipeline. The southern section of the pipeline, from where the proposed BKM Mine will receive its water, supplies water to the Postmasburg area.
- Sishen Mine borders the farm Bruce to the west.
- Various gravel farm- and prospecting roads are present on the BKM Mine property.
- An existing Sishen waste dump is situated to the north of the farm Bruce.
- Houses Croucamp and House Markram are situated on the Farm Parson.

1.6.4 Presence of Servitudes

Table 1-2 (page 1-15) provides the various servitudes present on the BKM Mine property, as derived from the Register of Deeds, Vryburg Deeds Office (Northern Cape).

Table 1-2: Servitudes

Servitude	Farm Name and Number	Portion	Use	Deed of Servitude Number	Owner	Title Deed Number
Pipeline	Bruce No. 544	RE	Water Supply	K 125/1976 S	Iscor	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 14/1970 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 18/1970 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 20/1966 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 32 /1978 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 36/1965 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 39/1976 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 41/1966 S	Eskom	T 349/54
Electrical Power line	Bruce No. 544	RE	Power Supply	K 72/1976 S	Eskom	T 349/54
Electrical Power line	Mokaning No. 560	1 (Pro Rata)	Power Supply	K 572/1954 S	Eskom	T 572/1968
Electrical Power line	Mokaning No. 560	2 (Mokaning B)	Power Supply	K 70/1979 S	Eskom	T 572/1968
Electrical Power line	Mokaning No. 560	3 (Mokaning C)	Power Supply	K 70/1979 S	Eskom	T 572/1968

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1.6.5 Land Tenure and Use of Immediately Adjacent Land

Table 1-3 provides the land tenure and use associated with the BKM Mine property

Table 1-3: Land tenure and use

Farm Name and Number	Portion	Use	Representative	Contact Details
Bruce No. 544	RE	Grazing / Wilderness	Assmang Ltd	053 311 6666
	2	Grazing / Wilderness	Transnet Ltd	011 773 8886
	3	Grazing / Wilderness	Transnet Ltd	011 773 8886
	4	Grazing / Wilderness	Transnet Ltd	011 773 8886
King No. 561	RE	Grazing / Wilderness	Assmang Ltd	053 311 6666
	1	Grazing / Wilderness	Transnet Ltd	011 773 8886
	2	Grazing / Wilderness	Transnet Ltd	011 773 8886
	3	Grazing / Wilderness	Transnet Ltd	011 773 8886
Mokaning No. 560	RE	Grazing / Wilderness	N J Steyn	053 331 0973
	1 (Pro Rata)	Grazing / Wilderness	Assmang Ltd	053 311 6666
	2 (Mokaning B)	Grazing / Wilderness	Assmang Ltd	053 311 6666
	3 (Mokaning C)	Grazing / Wilderness	Assmang Ltd	053 311 6666
	4 (Portion of Mokaning B)	Grazing / Wilderness	A F Steyn N J Steyn	053 331 0973
Parsons No. 564	RE	Grazing / Wilderness	Assmang Ltd	053 311 6666
	2 (Remainder)	Grazing / Wilderness	Assmang Ltd	053 311 6666

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1.7 Description of the Proposed Project

1.7.1 Background

Assmang Limited has mining operations in the Northern Cape Province, which includes Beeshoek Iron Ore Mine ("Beeshoek Mine"). Mining at the Beeshoek Mine was established in 1964 with a basic hand sorting operation. In 1975 a full washing and screening plant was installed. Due to increased production, Beeshoek South, a southern extension of the Beeshoek Mine, was commissioned during 1999 on the farms of Beeshoek and Olynfontein.

Assmang is the holder of old order rights in respect of high-grade hematite iron ore deposits north of Beeshoek Mine on the farms Bruce, King and Mokaning, adjacent to the current Sishen Mine. Assmang plans to replace and increase its iron ore sales by undertaking a new mining development (hereafter referred to as the BKM Mine, named after the farms Bruce, King and Mokaning) in order to utilize the available iron ore deposits. Beeshoek Mine will be decreasing its iron ore production significantly during the next 6 years as it reaches the end of its production capacity.

An application for mining rights on the Bruce, King and Mokaning farms have been submitted to the Department of Minerals and Energy, Norhtern Cape Province. The proposed BKM Mine is therefore intended to phase in iron ore production, replacing Beeshoek Mine production whilst Beeshoek Mine scales down. Increased production will take advantage of additional capacity allocation to be made available by Spoornet on the Sishen Saldanha iron ore export channel over the period 2010 to 2015.

1.7.2 Mineral Deposit

The BKM Mine will mine high-grade hematite iron ore. Iron ore in the Sishen / Postmasburg area is preserved within a sequence of Proterozoic sediments of the Transvaal Supergroup and Olifantshoek Group. The ore deposits occur within the Wolhaarkop Breccia, which overlies the dolomites of the Cambellrand Formation and is overlain by the Sishen shale.

1.7.3 Estimated Reserve

Iron ore (Hematite) in the Sishen / Postmasburg area is preserved within a sequence of Proterozoic sediments of the Transvaal Supergroup and Olifantshoek Group.

Beeshoek Mine currently exports approximately 5.3 million tonnes per annum to Japan, China, and Europe.

A study conducted by Snowden (2005) estimated the mineral resources within the northern deposits of Assmang (BKM Mine area) at approximately 673.5 million tonnes (Refer to Table 1-4).

Table 1-4: BKM Mine resource estimates

Category	Tonnes (Mt)	Fe (%)	Mn (%)	Al_2O_3 (%)	SiO_2 (%)	K_2O (%)	P (%)
Bruce A (at 65.1 percent)							
Measured	23.5	64.92	0.05	1.61	3.93	0.10	0.07
Indicated	99.0	64.53	0.03	1.83	3.77	0.15	0.03
Inferred	0.8	63.40	0.11	2.70	4.64	0.49	0.04
Total	123.3	64.60	0.03	1.79	3.80	0.14	0.06
Bruce B (at 64.43 percent)							
Measured	21.1	65.71	0.01	1.14	2.68	0.13	0.04
Indicated	77.0	64.06	0.03	1.87	4.18	0.20	0.05
Inferred	8.7	64.64	0.02	1.44	4.21	0.12	0.02
Total	106.8	64.43	0.03	1.69	3.89	0.18	0.04
Bruce C (at 64.49 percent)							
Measured	37.5	65.45	0.04	1.40	3.41	0.13	0.04
Indicated	6.9	65.97	0.03	1.27	2.75	0.13	0.03
Inferred	1.6	64.80	0.04	1.87	4.02	0.15	0.04
Total	46.0	65.51	0.04	1.40	3.33	0.13	0.04
King / Mokaning (at 64.6 percent)							
Measured	255.8	64.53	0.25	1.97	3.96	0.34	0.04
Indicated	123.9	64.48	0.44	1.84	3.28	0.38	0.05
Inferred	17.0	63.98	0.35	2.10	3.46	0.37	0.05
Total	397.4	64.49	0.31	1.94	3.73	0.35	0.04

Figure 2-1: Bruce, King and Mokaning deposit

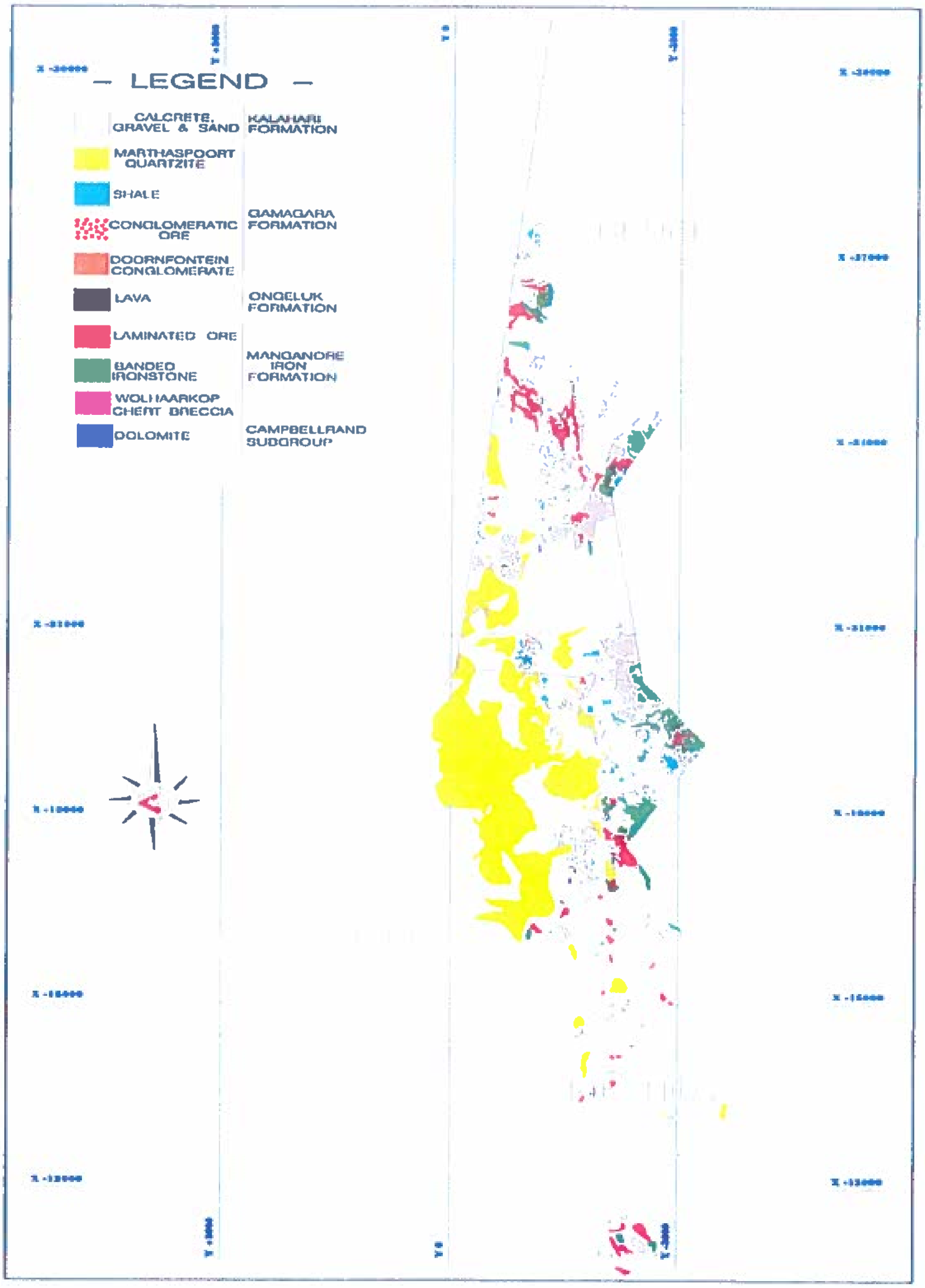
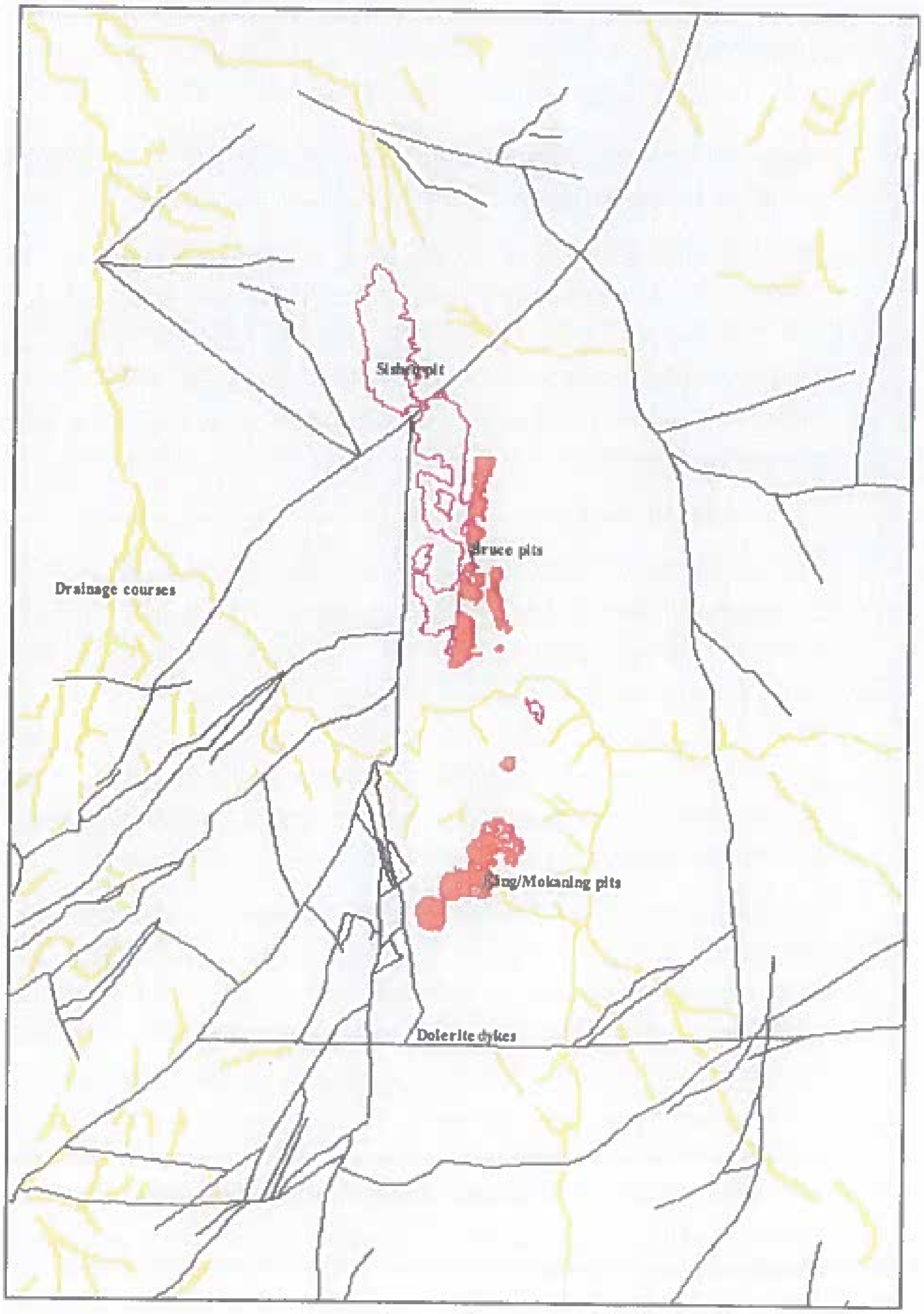


Figure 2-2: Geological structures associated with the BKM Mine area (grey lines indicate dolerite dykes)



2.1.4 Ore types

Grinaker-LTA Process Engineering identified the following ore types in the Assmang 10 Million Ton Study Report:

- Laminated Ore

The older laminated ore types occur in the upper portion of the Manganore Iron Formation as enriched high-grade hematite bodies

The boundaries of high-grade hematite ore bodies in the Manganore Iron Formation crosscut primary sedimentary bedding, indicating that secondary hematitisation of iron formation took place. In general three ore types are present within the Manganore Iron Formation, namely, laminated, massive and breccia ore. In all of these, some of the stratigraphic and sedimentological features of the original iron formation are preserved.

- Conglomeratic Ore

The conglomeratic ore found in the Doornfontein conglomerate member of the Gamagara Formation is Lenticular and not persistently developed along strike. It consists of stacked, upward fining conglomerate-gritstone-shale sedimentary cycles. The lowermost conglomerates and gritstones tend to be rich in sub-rounded to rounded hematite ore pebbles and granules and forms the main ore bodies. The amount of iron ore pebbles decreases upwards in the sequence so that upper conglomerates normally consist of poorly sorted angular to rounded chert and banded iron formation pebbles.

Two types of ore are found in the Gamagara Formation, namely, conglomeratic and massive ore. Both types form part of the Doornfontein conglomerate member. The conglomerate ore includes all grain sizes from poorly sorted conglomerates to gritstones. Pebbles in the conglomerates are angular to sub-rounded and consist of laminated and massive hematite ore and partly hematised iron formation. Conglomeratic ore often grades upwards into gritty hematite ore containing a variety of rounder hematite ore granule in a matrix of fine grained platy hematite with quartz and muscovite filling. The massive ore of the Doornfontein member of the Gamagara Formation is fine to very fine grained and consists of sand to silt-sized hematite grains in a matrix of platy hematite.

Refer to Appendix 1 for the Borehole logs taken from the geotechnical holes on the farm Bruce, King, Mokaning and Parson.

2.2 Climate

2.2.1 Regional Climate

The BKM Mine is located in a low rainfall area. Most of the rainfall in this semi-arid region occurs in summer and early autumn during the months of November to April. High summer temperatures cause atmospheric instability and turbulence, which leads to the development of thunderstorms. The temperature in the area varies between -9 °C and 42 °C, with an average of 19.2°C.

2.2.2 Rainfall

Records from the South African Weather Bureaux for the Postmasburg and Kuruman Weather Stations (years 2000 and 2003) and from the Sishen Weather Station for the years 1961 to 2001 (Sishen Iron Ore Mine EMPR, 2002) show that the mean annual rainfall for the area is approximately 386 mm.

The month of July experiences on average, the lowest rainfall with an average monthly rainfall for the Postmasburg, Kuruman and Sishen Weather Stations respectively of 0.85 mm, 0.55 mm and 2.00 mm.

The month of February experiences on average the highest rainfall with an average monthly rainfall for the Postmasburg, Kuruman and Sishen Weather Stations respectively of 65.65 mm, 57.60 mm and 56.00 mm.

The above given information is reflected in Table 2-1 (page 2-8).

Table 2-1: Average Monthly Rainfall Data

Months	Average Monthly Rainfall Data for the years 2000 to 2003 (mm)		Average Rainfall for the years 1961 to 2001
	Postmasburg (Station 0321110 7)	Kuruman (Station 0393806 4)	Sishen (Station 0356857AX)
January	38.9	34.3	70.0
February	77.15	58.05	56.0
March	62.25	37.2	62.0
April	65.65	57.6	33.0
May	10.45	11	12.0
June	13.3	5.65	6.0
July	0.85	0.55	2.0
August	12.2	15.05	3.0
September	25.75	18	8.0
October	5.05	42.1	23.0
November	43	54.7	31.0
December	45.35	64.1	55.0
Total	399.9	398.3	361

2.2.3 Rainfall Intensities

Table 2-2 illustrates the highest recorded precipitation in 60 minutes and 24 hours. The table further details the expected maximum precipitation event over 24 hours for the return periods of 25, 50 and 100 years (Sishen Iron Ore EMPR, 2002).

Table 2-2: Storm events of the different recurrence intervals

	Maximum recorded		Expected maximum in 24 hours for		
Recurrence Interval	60 min	24 hrs	25 yr	50 yr	100 yr
Maximum Rainfall Intensity (mm)	35,9	101,0	92,1	108,5	124,7

2.2.4 Mean Monthly Maximum and Minimum Temperatures

Summers in the Northern Cape Province are hot with maximum temperatures usually between 30°C and 35°C. Mean daily and monthly ambient temperatures for the Postmasburg and Kuruman area show high diurnal and seasonal variation.

From December to February, mean maximum temperatures are greater than 30°C for both the Postmasburg and Kuruman area, whereas between May and September the mean minimum temperatures drop to below 10°C.

The above information in provided within Table 2-3.

Table 2-3: Temperature data for the years 2000 to 2003

Months	Temperature Data for the years 2000 to 2003 (°C)						Temperature Data for the years 1961 to 2001 (°C)		
	Postmasburg (Station 0321110 7)			Kuruman (Station 0393806 4)			Sishen (Station 0356857AX)		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
January	31.48	15.03	23.25	31.10	15.35	23.23	32.90	19.00	25.95
February	31.38	15.05	23.21	30.75	16.03	23.39	31.40	18.30	24.85
March	29.65	14.73	22.19	29.68	13.78	21.73	29.40	16.30	22.85
April	25.68	11.35	18.51	25.80	10.98	18.39	25.70	12.20	18.95
May	21.48	5.03	13.25	22.05	4.60	13.33	22.30	7.30	14.80
June	18.60	1.93	10.26	19.60	1.75	10.68	19.00	3.60	11.30
July	17.93	0.55	9.24	19.20	0.30	9.75	19.60	3.10	11.35
August	20.25	2.53	11.39	21.73	2.95	12.34	22.00	5.30	13.65
September	23.38	6.10	14.74	24.80	6.90	15.85	26.00	9.70	17.85
October	28.98	11.18	20.08	29.30	11.98	20.64	28.5	13.20	20.85
November	21.68	9.78	15.73	21.88	10.68	16.28	30.70	16.00	23.35
December	31.83	14.53	23.18	31.28	15.18	23.23	32.40	17.80	25.1

2.2.5 Mean Annual Evaporation

Evaporation in the region recorded by the Sishen Weather Station is 2026 mm per year. The evaporation is approximately five times higher than the mean annual precipitation. Refer to Table 2-4.

Table 2-4: Mean monthly minimum and maximum evaporation for the region

Months	Minimum	Maximum	Average
January	450	339	272
February	138	337	220
March	93	284	186
April	75	196	135
May	73	148	112
June	44	143	91
July	72	137	107
August	112	193	143
September	143	249	203
October	180	331	249
November	197	387	268
December	211	388	293
Total	1788	3132	2026
Average	149	261	-

2.2.6 Prevailing Wind Direction and speed

The spatial and annual variability in the wind field for Kathu is clearly evident in Figure 2-3 (page 2-11). The predominant wind direction is from the north-northwest to west with frequent winds also occurring from the north and south. Over the six-year period, frequency of occurrence was between 9.8 % and 12 % from the northerly to westerly sector, with southerly winds occurring 8 % of the time. Less frequent winds (~6 % of the time) are from the southwesterly sector. Winds from the northeasterly and southeasterly sectors are relatively infrequent occurring < 5 % of the total period. Calm conditions (wind speeds < 1 m/s) occur for <1 % of the time, with winds between 2-4 m/s occurring for 68 % of the time.

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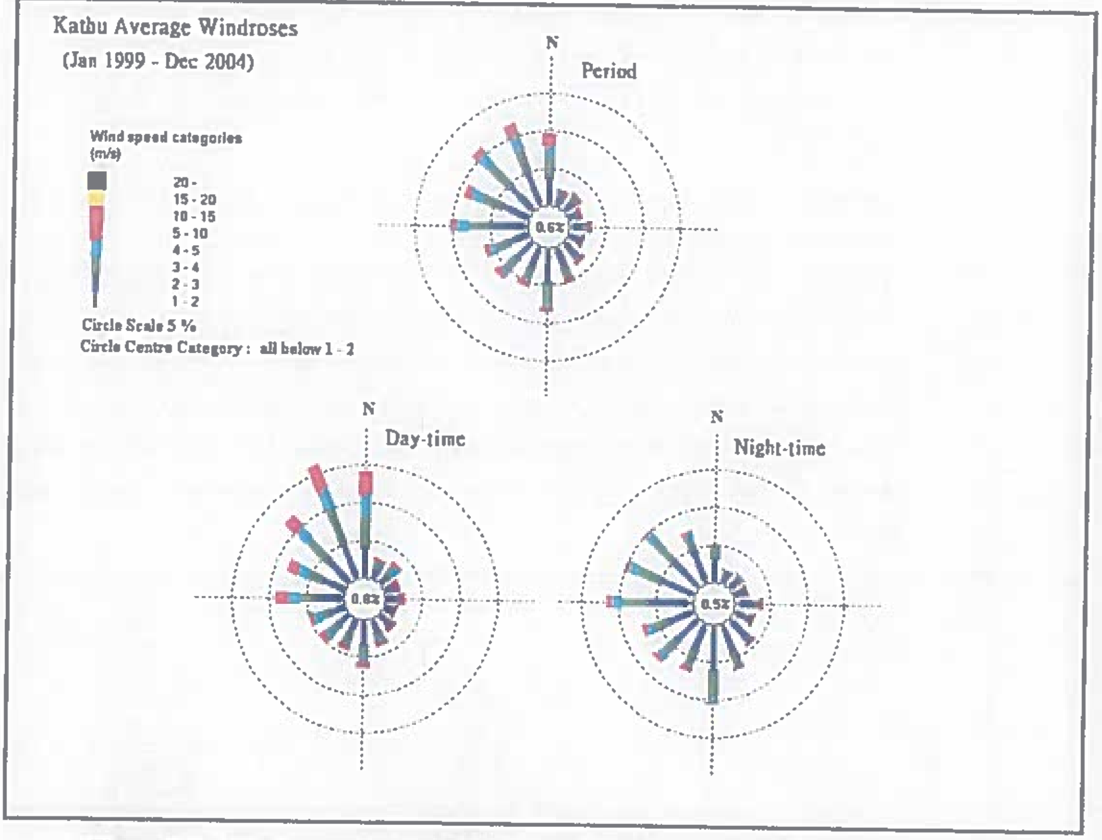


Figure 2-3: Wind roses for the Period 1999 - 2004 recorded at Kathu

During the daytime, there is an increase in winds from north-northwest, north and northwest, with frequencies of >15 %, 14 % and 12 % respectively. Nocturnal wind flow reflects more dominant winds from the west, west-northwest and south. Frequent winds from the west occur for ~12 % of the time, ~11 % from south and with 10 % frequency from the north-west and west-northwest. Nigh-time conditions also reflect a decrease in wind speeds ranging mainly from 1-4 m/s in comparison to daily wind speeds of between 2 m/s and 12 m/s.

Figure 2-4 (page 2-12) shows that the spatial seasonal variability in the wind field from Kathu is clearly evident. During the summer months, the wind flows from the north to north-northwest. However, this changes dramatically during autumn (April to May) when the winds blow more frequently from the west. Winter months and springtime reflect similar patterns with the predominant airflow from the north-northwesterly to westerly sector. There is marked evidence during the spring months of August and September, where the wind speed is increased (see Figure 2-4). Wind speeds are fairly similar throughout the seasons with slightly lower wind speeds during the winter months.

Mean daily wind speeds are generally in the range of 2 m/s to 5 m/s, with maximum daily speeds typically ranging from 3 m/s to 10 m/s. The months of August to October are characterised by increased wind velocities with low wind speeds occurring during the months of April to July. Figure 2-5 (page 2-13) and Figure 2-6 (page 2-13) show the maximum and mean wind speeds, recorded at Kathu during the year 2003 respectively.

The wind regime largely reflects the synoptic scale circulation. The flow field is dominated by northwesterly to north-northeasterly winds, with northerly winds clearly prevailing as may be expected due to the anticyclones that dominate the region throughout much of the year. During winter-months (July - August), the enhanced influence of westerly wave disturbances is evident in the increase frequency of southwesterly winds. An increase in the frequency of northeasterly winds during spring months, and the continued prevalence of northwesterly and northerly airflow, reflects the combined influence of anticyclonic subsidence and easterly wave systems.

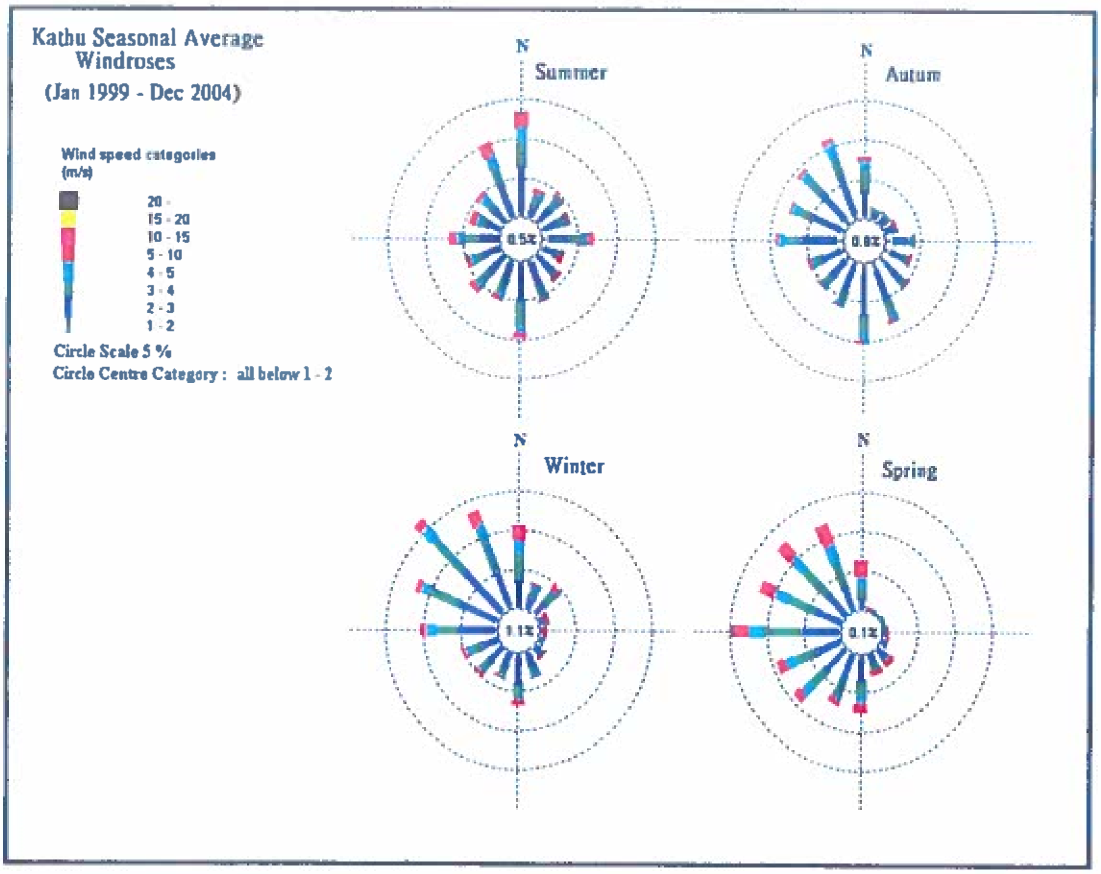


Figure 2-4: Seasonal wind roses for the period 1999 - 2003 recorded at Kathu

Thermo-topographical impacts on the flow regime give rise to distinct diurnal trends in the wind field. Calm periods and low wind speeds are generally more prevalent during the nighttime. Although lower wind speeds were recorded at the JIA station during the nighttime the airflow pattern was very similar to that of the daytime, indicating the absence of strong diurnal shifts in the wind field characteristic of more uneven terrain.

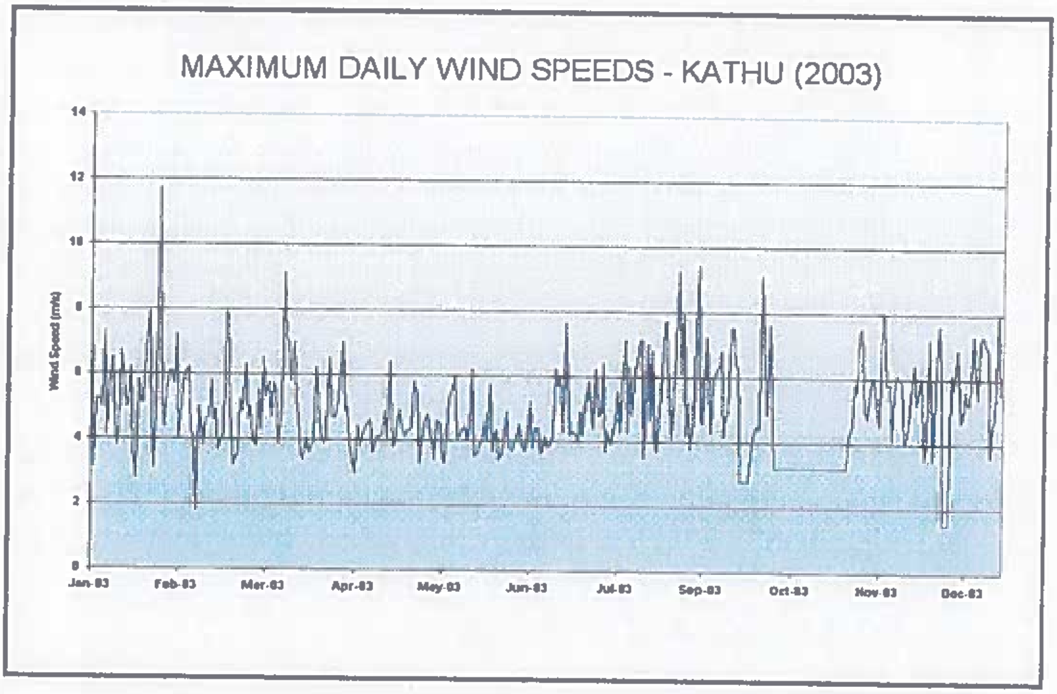


Figure 2-5: Maximum daily wind speeds recorded at Kathy for the year 2003

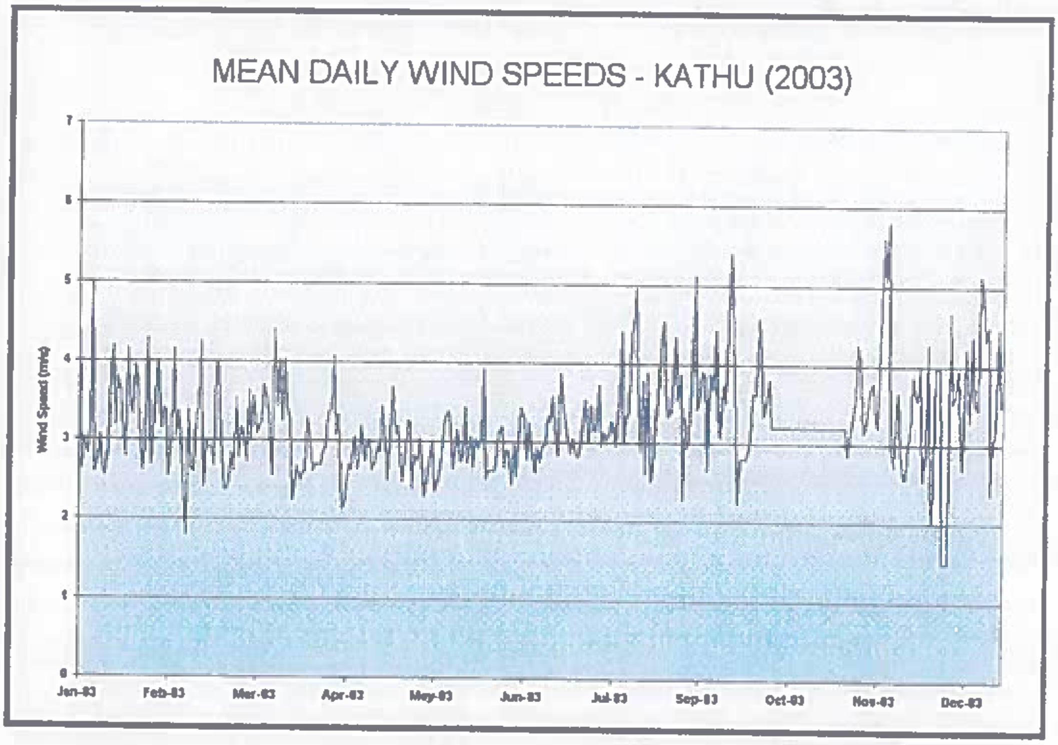


Figure 2-6: Mean daily wind speeds recorded at Kathy for the year 2003

2.2.7 Mixing Depth and Atmospheric Stability

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions and the erosion of the mixing layer. Low wind speeds are normally associated with these conditions and this results in less dilution potential.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 2-5 below. The hourly standard deviation of wind direction, wind speed and predicted solar radiation were used to determine hourly-average stability classes. Refer to Figure 2-7 (page 2-15).

Table 2-5: Atmospheric stability classes

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong nighttime inversions and slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

The mixed layer ranges in depth from a few metres (i.e. stable or neutral layers) during nighttimes to the base of the lowest-level elevated inversion during unstable, daytime conditions. Elevated inversions may occur for a variety of reasons, and on some occasions as many as five may occur in the first 1000 m above the surface. The lowest-level elevated inversion is located at a mean height above ground of 1 550 m during winter months with a 78 % frequency of occurrence. By contrast, the mean summer subsidence inversion occurs at 2 600 m with a 40 % frequency.

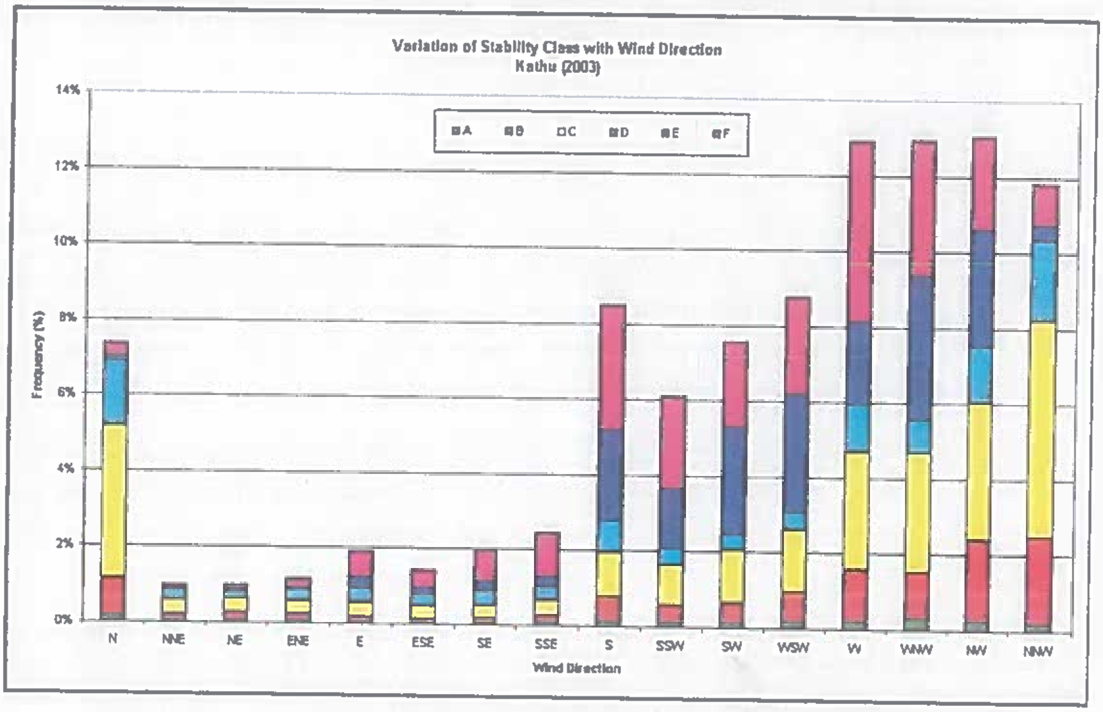


Figure 2-7: Atmospheric stability for each wind direction at Kathu for the period 2003

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. In contrast, the highest concentrations for ground level, or near-ground level releases would occur during weak wind speeds and stable (nighttime) atmospheric conditions.

2.2.8 Incidence of Extreme Weather Conditions

The Postmasburg region is dry with rainfall typical of a semi-arid area. Temperatures can reach extremes of between - 9°C and 40°C, with frost occurring during the winter months, from May to August. Fog and snow are unlikely to occur in this region. Thunderstorms occur irregularly during the summer months from October to March. High winds (in the excess of 8 m / s) are likely to occur once in every 22 days of the year.

2.3 Topography

The area surrounding the proposed BKM mining area consists of a mix of unutilised gradually sloping mountainsides and relatively flat river valleys in the south to flat uncultivated land in the north. The general topography is characterized by generally flat terrain with no steep inclines except for the two mountain ranges to the west (Langberg range) and a smaller range to the east (Kuruman Heuwels).

Altitudes ranges from approximately 1360 metres above mean sea level (mamsl) in the south to 1200 mamsl in the north. Various landform elevations occur on the three farms, with the highest elevations on the southern portion of Mokaning farm (1365 mamsl) and on the border between Mokaning and King farms (347.3 mamsl).

The Gamagara River flows in a northern direction through the eastern portion of the Mokaning and King farms, crossing the southern portion of Bruce farm, flowing in a westerly direction. Refer to Figure 1-4 (page 1-12).

2.4 Soil

Refer to Appendix 2.

2.4.1 Data Collection

2.4.1.1 Field Work

A preliminary soil survey was undertaken on the three farms (Bruce, King and Mokaning) that comprised the study area for the proposed BKM Mine to be developed by Assmang in the Northern Cape. The site was visited during three days in June 2004, when the site was traversed on a reconnaissance basis by motor vehicle. The soils exposed on surface and in road cuttings were observed and classified. A limited number of hand auger borings were put down to identify the subsoils. The area was divided into land types and typical soils for each land type identified. A total of approximately 6000 hectares was mapped.

The farm Parson was then added to the study area to provide a possible site for the processed product stockpiles, plant site and associated infrastructure. The soils of Parson (an area of approximately 2150 hectares) were mapped in the same manner as the first three farms, while the areas to be affected by infrastructure were mapped in more detail using standard classification procedures. The second field investigation was undertaken during October 2004 and comprised the examination of the proposed open cast mining areas and infrastructure areas, observing the surface soils and putting down hand auger borings.

A total of 39 auger holes were excavated across the site. Nine representative soil samples were taken from the site. The samples were analysed for physical and chemical properties, to aid in soil classification and to determine the soil fertility and nutrient status in the area. The remainder of the site was mapped by means of visual inspection of the soils using exposures in road and railway cuttings.

2.4.1.2 Soil Profile Identification And Description Procedure

The identification and classification of soils was carried out in terms of "Soil Classification, A Taxonomic System for South Africa", (MacVicar et al, 1991 edition). This is a relatively simple system that has two levels of classification, an upper, fairly general level comprising Soil Forms and a lower, more specific level comprising Soil Families.

Each of the Soil Forms in the classification is defined by a specific, unique vertical sequence of diagnostic horizons. All forms are further divided into two or more Families that have the same vertical sequence of diagnostic horizons, but are differentiated within the Form on the basis of certain physical and/or chemical properties.

2.4.2 Description

2.4.2.1 Soil Forms Identified

Soil distribution is strongly linked to the topography of the area. In turn, the topography is closely linked to the underlying surface geology.

Hard rock outcrop characterises the topographic highs of the area. The outcrops generally comprise quartzites and the iron ore bearing ironstones. These outcrops form prominent hills or ridges with moderate to steep slopes. In these areas, soils are very shallow to non-existent, occurring as erratic pockets of orange sands within the outcrops. The pockets can be as much as 1m deep. The very shallow soils and rock outcrop are classified as Mispah Form soils, with the pockets comprising Hutton Form soils.

The very gently sloping areas between the hills and ridges are generally underlain by calcrete or dolomite. The calcrete is overlain by orange fine sands, which are classified as Plooysburg Form soils. The calcrete surface is undulating, with isolated boulder outcrop occurring within the soils. The soil depth is highly variable, being between about 0,3 m and greater than 2m. The shallower soils are classified as Augrabies Form soils. They cannot be classified as Mispah or Glenrosa Form soils due to their red colouring.

On the lower slopes between the Plooysburg Form soils and the Mispah Form soils are Hutton Form soils. However, these areas are characterised by abundant to numerous surface boulders derived from the outcrop upslope characteristic of a scree slope that have moved by gravity down slope to be deposited on the ground surface.

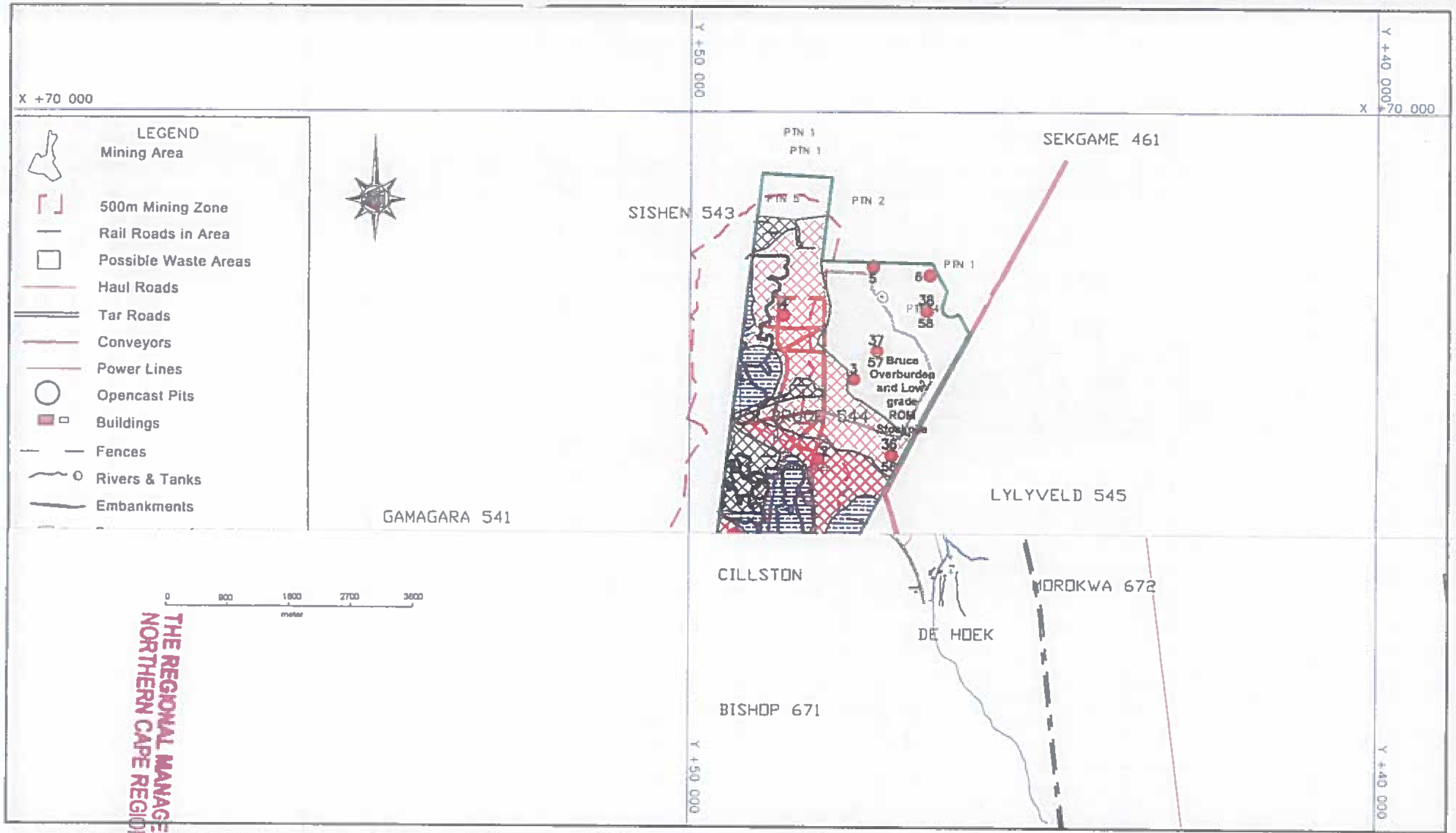
In many of the drainage lines and depressions, the soils show no differentiation from the surrounding soils. However, in the main streams such as sections of the Gamagara and in the larger pans, the soils are more clayey and are classified as Kroonstad Form soils.

A soil distribution map is provided in Figure 2-8 (page 2-19). The positions of all auger holes and sampling positions are indicated on this soil site plan. The Soil Form and Family and diagnostic horizons are summarised in Table 2-6 (page 2-20).

The Mispah Form soils are non bleached and non-calcareous in the A-horizon, characteristic of the Myhill Family. The Hutton Form soils are characteristically dystrophic and non-luvic in the B1-horizon, indicative of Lillieburn Family soils while the Plooysburg Form soils are non-luvic - Brakkies family and the Augrabies Form soils have a non-bleached red A horizon and are non-luvic, characteristic of the Khubus Family.

The Hutton and Plooysburg Form soils examined on site comprise dry, yellowish red to red, apedal, loose, fine sands, with little observed differentiation between the topsoil and the B1-horizon sandy loams. The topsoil of the Mispah Form and Augrabies Form soils is also very similar in structure.

It should be noted that the soil physical and chemical characteristics suggest that they are of wind blown origin rather than in situ weathering of the bedrock.



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Soil Type Distribution

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Figure Number: 2-8

Table 2-6: Soil forms and families

Soil Form	Soil Family	Code	Diagnostic Horizons
Mispah	Myhill	Ms-1100	Orthic A Hard Rock
Hutton	Lilleburn	Hu-1100	Orthic A Red Apedal B
Plooysburg	Brakkies	Py-1000	Orthic A Red Apedal B Hardpan Carbonate Horizon
Augrabies	Khubus	Ag-1210	Orthic A Neocarbonate B
Kroonstad	Morgendal	Kd-1000	Orthic A E Horizon G Horizon

The soils mapped are generally considered to be poor agricultural soils due to the absence of structure, the low to very low clay content resulting in poor available moisture capacity due to very rapid drainage. This is exacerbated by the semi-arid climate of the area. The physical characteristics of these soils can be summarised as follows:

- Available moisture capacity: poor
- Intake rate: good
- Drainage: good
- Erosion hazard: moderate
- Tillage constraints: moderate -presence of scattered boulders and outcrop.

2.4.3 Soil Chemical and Physical Characteristics

Laboratory testing was carried out on representative samples of the soils in the area. A total of nine samples of the lower topsoil horizon (B2/1) were tested to determine the physical and chemical characteristics of the soil.

The laboratory test results are tabulated within Table 2-7 (page 2-21). Samples were taken over a 20 to 50 cm depth range.

Table 2-7: Results of soil laboratory analysis

Sample Number	S1	S2	S3	S4	S5	S6	S7	S8	S9	Std
Auger Hole No	31	32	33	34	35	36	37	38	39	-
Soil Form	Py	Ag	Ag	Hu	Hu	Ag	Py	Py	Hu	-
% Clay	4	10	6	6	8	6	6	6	8	15-25
% Silt	7	10	7	2	13	10	14	5	5	-
% Sand	89	80	87	92	79	84	80	89	87	-
Na (cmol/kg)	0.09	0.19	0.09	0.10	0.13	0.08	0.09	0.10	0.09	<2
K (cmol/kg)	0.25	0.47	0.26	0.19	0.56	0.16	0.20	0.16	0.41	6-10
Ca (cmol/kg)	3.87	1.17	1.73	6.02	20.7	1.13	2.86	3.78	5.51	55-75
Mg (cmol/kg)	0.64	1.01	0.52	0.54	1.43	0.37	0.57	0.64	0.78	20-35
P (mg/kg)	5.5	9.47	9.34	6.18	16.7	4.51	2.85	2.58	34.6	-
CEC (cmol/kg)	7.93	7.39	12.8	4.68	7.84	2.67	4.46	5.49	4.29	5-15
S-Value (cmol/kg)	4.84	2.75	2.59	6.84	22.8	1.74	3.71	4.69	6.79	5-15
SAR	0.17	0.21	0.27	0.16	0.24	0.32	0.18	0.18	0.11	-
PH	5.86	6.47	6.57	7.44	7.86	7.27	7.25	7.73	7.87	3-9
EC (mS/m)	25	42	11	23	31	8	14	13	80	-
ESP	1.14	1.29	0.71	2.05	1.63	3.11	1.97	1.77	2.19	-

2.4.3.1 Soil Chemical Characteristics

2.4.3.1.1 Soil Acidity / Alkalinity

Soil pH has a direct influence on plant growth in a number of ways, through the direct effect of the hydrogen ion concentration on nutrient uptake and indirectly through the effect on major trace nutrient availability and by mobilization of toxic ions such as aluminium and manganese, which restrict plant growth.

A pH range of between 6 and 7 most readily promotes the availability of plant nutrients, whilst pH values below 3 or above 9 will seriously affect nutrient uptake.

The pH of the soils tested is between 5.86 and 7.87, in the neutral to alkaline range, and within acceptable limits.

2.4.3.1.2 Soil Salinity / Sodicity

Highly saline soils will result in the reduction of plant growth caused by the diversion of plant energy from normal physiological processes to those involved in the acquisition of water under highly stressed conditions. Salinity levels of 60mS/m will have no affect on plant growth. From 60 – 120 mS/m salt sensitive plants are affected and above 120 mS/m growth of all plants is severely affected.

The electric conductivity of the soils tested is between 8 and 80 mS/m and generally less than 45 mS/m. The soils are thus non-saline.

In addition, soil salinity may directly influence the affects of particular ions on soil properties. The sodium adsorption ratio (SAR) is an indication of the affect of sodium on soils. At high SAR levels, certain clay minerals, when saturated with sodium, swell markedly. With the swelling and dispersion of a sodic soil, pore spaces become blocked and infiltration rates and permeability are greatly reduced. The critical SAR for poorly drained grey soils is 6, for slowly draining black swelling soils is 10 and for well drained soils and recent sands is 15.

The SAR is less than 0,35 and the exchangeable sodium % is less than 3,2. Therefore, the soils are also non-sodic.

2.4.3.1.3 Soil Fertility

The levels of sodium, potassium, calcium and magnesium are generally very low. The levels of available phosphorus are generally low to medium. These soils are considered to be poor arable soils, suitable for cultivation on a small scale only, provided that adequate levels of the required fertilisers are applied.

2.4.3.1.4 Nutrient Storage and Cation Exchange Capacity (CEC)

The potential of a soil to retain and supply nutrients can be assessed by measuring the cation exchange capacity (CEC). A lack of organic matter and clay minerals, which provide exchange sites that serve as nutrient stores, results in a low ability to store and supply nutrients for plant growth. Low CEC values are an indication of soils lacking organic matter and clay minerals. Typically, a soil low in organic matter and clay may have a CEC of 1 to 5 meq/100g.

The CEC of the soils tested is between 4,461 and 12,75 meq/100g. This indicates that the soils have a low to acceptable ability to store and provide nutrients for plant growth.

2.4.3.1.5 Soil Organic Status

The organic content of the soils was not tested but from visual inspection is very low. This is due to the wind blown nature of the soils combined with the sparse vegetation and semi-arid climate.

2.4.3.2 Soil Physical Characteristics

The soils comprise fine to medium grained sands with a clay content of less than 10 % and a silt content of less than 15 %. The sand content varies between 79 % and 92 %. These sands drain rapidly and have poor moisture holding capacity.

2.4.4 Soil Erosion Hazard

The erosion potential of a soil is expressed by an erodibility factor (K), which is determined from soil texture, permeability, organic matter content and soil structure. The soil Erodibility Nomography of Wischmeier et al (1971) was used to calculate the K value. Erosion problems may be experienced when K is greater than 0,2.

The K value can be used to determine the erodibility of a particular soil form. Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of that soil and the treatment of the soil.

Erodibility ratings are:

- Resistant K factor = <0,15
- Moderate K factor = 0,15 – 0,35
- Erodible K factor = 0,35 – 0,45
- Highly erodible K factor = .0,45

The main erosion force in this area is wind. The Mispah and the Hutton, Plooysburg and Augrabies soils display a moderate erosion hazard, with a K value of 0.2. Due to the gentle topography underlying the Hutton, Plooysburg and Augrabies soils, little erosion has taken place.

However, when disturbed, loosened and stockpiled, the erosion index of the soils will be moderate to high and erosion will take place unless the soils are adequately protected.

2.4.5 Soil Depth

The topsoil depth is generally between 0,30 and 0,50 metres, except in the areas of Mispah Form soils and rock outcrop, where topsoil is less than 0,10 metres thick. The total soil depth is highly variable. In the areas of Mispah and Augrabies soils and outcrop, soil depth is between 0,0 and 1,0 metres, averaging about 0,50 metres. In the areas of Hutton and Plooysburg Form soils, soil depth ranges between 0,3 and greater than 2,0 metres. It is generally in the order of 0,4 to 1,0 metres. In general, soil depth is less than 0,50 metres with frequent scattered cobbles and boulders on surface.

2.4.6 Dry Land Production Potential

In general the available moisture capacity of the soils mapped is poor, while the intake rates and drainage are good. There are moderate tillage constraints to these soils due to the presence of scattered shallow outcrop and surface boulders. The nutrient status is poor, and fertilizer supplements will be required if these soils are to be vegetated. Based on the consistency of the soils and the climate of the area, the dry land cultivation potential of these soils is rated as poor.

2.4.7 Irrigation Potential

The irrigation potential of the area is generally fair to poor. Water intake rates and drainage are very rapid and hence micro-spray or drip irrigation is recommended. No surface water is available for irrigation purposes and groundwater from boreholes would need to be used if the area is to be irrigated.

2.5 PRE-MINING LAND CAPABILITY

Refer to Appendix 2.

2.5.1 Data Collection

The land capability of the study area was classified into four classes – wetland, arable land, grazing land and wilderness – according to the chamber of mines Guidelines (1991). The criteria for this classification are set out in Table 2-8.

Table 2-8: Criteria for pre-mining land capability Chamber of Mines, 1991)

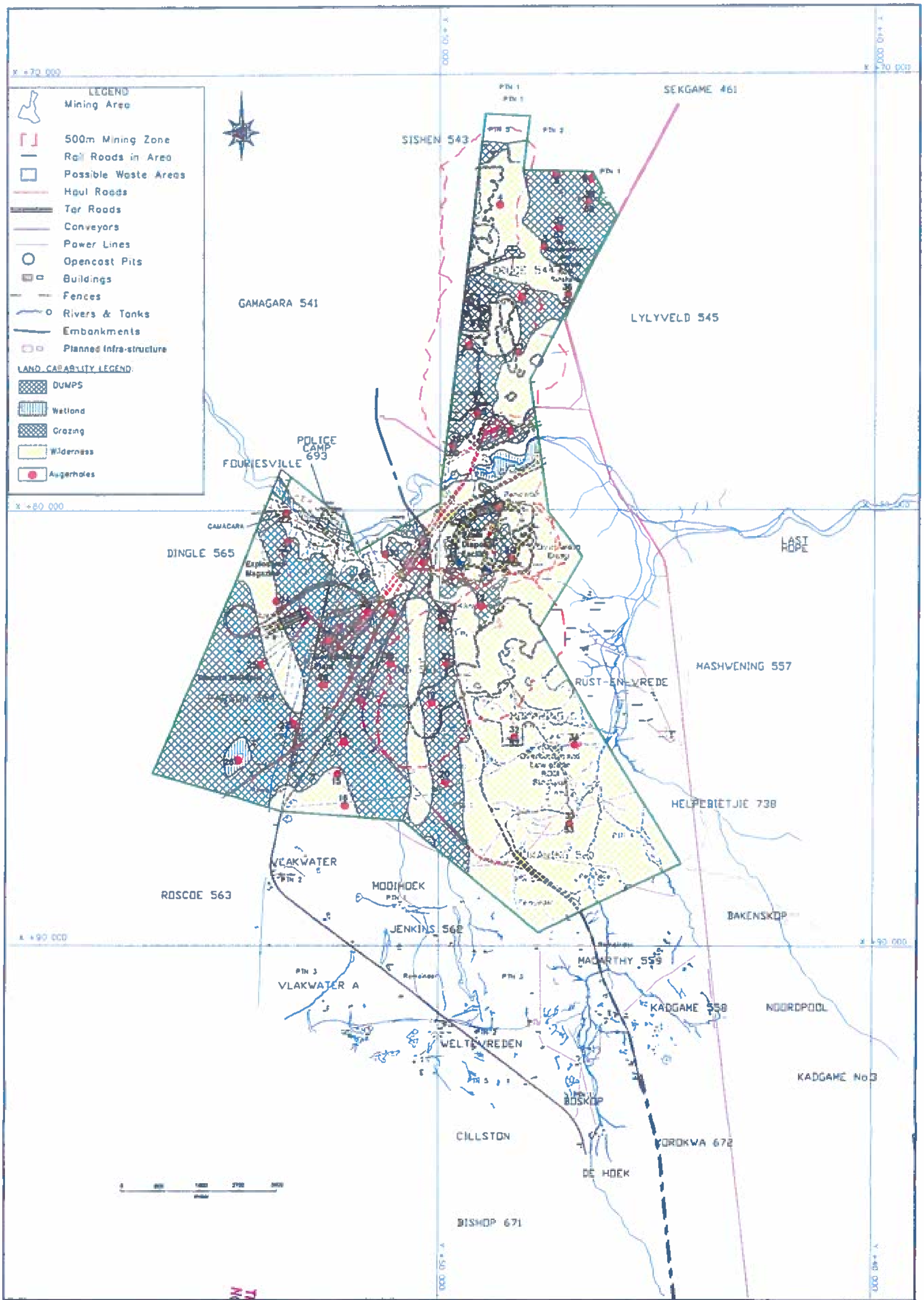
Criteria for Wetland	Land with organic soils for supporting hygrophilous vegetation where soil and vegetation processes are water determined.
Criteria for Arable Land	Land, which does not qualify as a wetland. The soil is readily permeable to a depth of 750mm. The soil has a pH value of between 4,0 and 8,4. The soil has a low salinity and SAR. The soil has less than 10 % (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm. Has a slope (in %) and erodibility factor (K) such that their product is <2,0. Occurs under a climate of crop yields that are at least equal to the current national average for these crops.
Criteria for Grazing Land	Land, which does not qualify as wetland or arable land. Has soil or soil-like material, permeable to roots of native plants that is more than 250mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100mm. Supports or is capable of supporting a stand of native or introduced grass species, or other forage plants utilisable by domestic livestock or game animals on a commercial basis.
Criteria for Wilderness Land	Land, which does not qualify as wetland, arable land or grazing land.

2.5.2 Description

In terms of land capability, the Mispah and Augrabies Form soils can be classified as wilderness land or non-arable land. Although the remainder of the area is underlain by Plooysburg and Hutton Form soils, due to the variability of soil depth and the presence of rock outcrop within the soil profile, as well as abundant to numerous scattered boulders on surface, these soils are classified at best as low yielding grazing land. There are no substantial / extensive areas of arable land. There are a limited number of wetland areas within the site, associated with small pans.

The distribution of the land capability classes is indicated on Figure 2-9 (page 2-26).

Figure 2-9: Land capability of the BKM Mine area



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Land Capability

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Figure Number: 2-9

2.6.1 Pre-mining Land Use

The current land use is predominantly grazing, with a relatively low stocking unit per hectare. There is no surface water on the site, and all stock watering is provided by reservoirs with a groundwater source. The main land use in the surrounding area is mining and agriculture – cattle and small livestock farming with an average carrying capacity of the land being low (12ha per unit of large stock).

The distribution of current land use is illustrated on Figure 2-10 (page 2-28).

2.6.2 Agricultural Potential

This region is not suited to the production of arable agricultural products owing to the low rainfall. Consequently, there is no record of any significant form of agricultural production in this area.

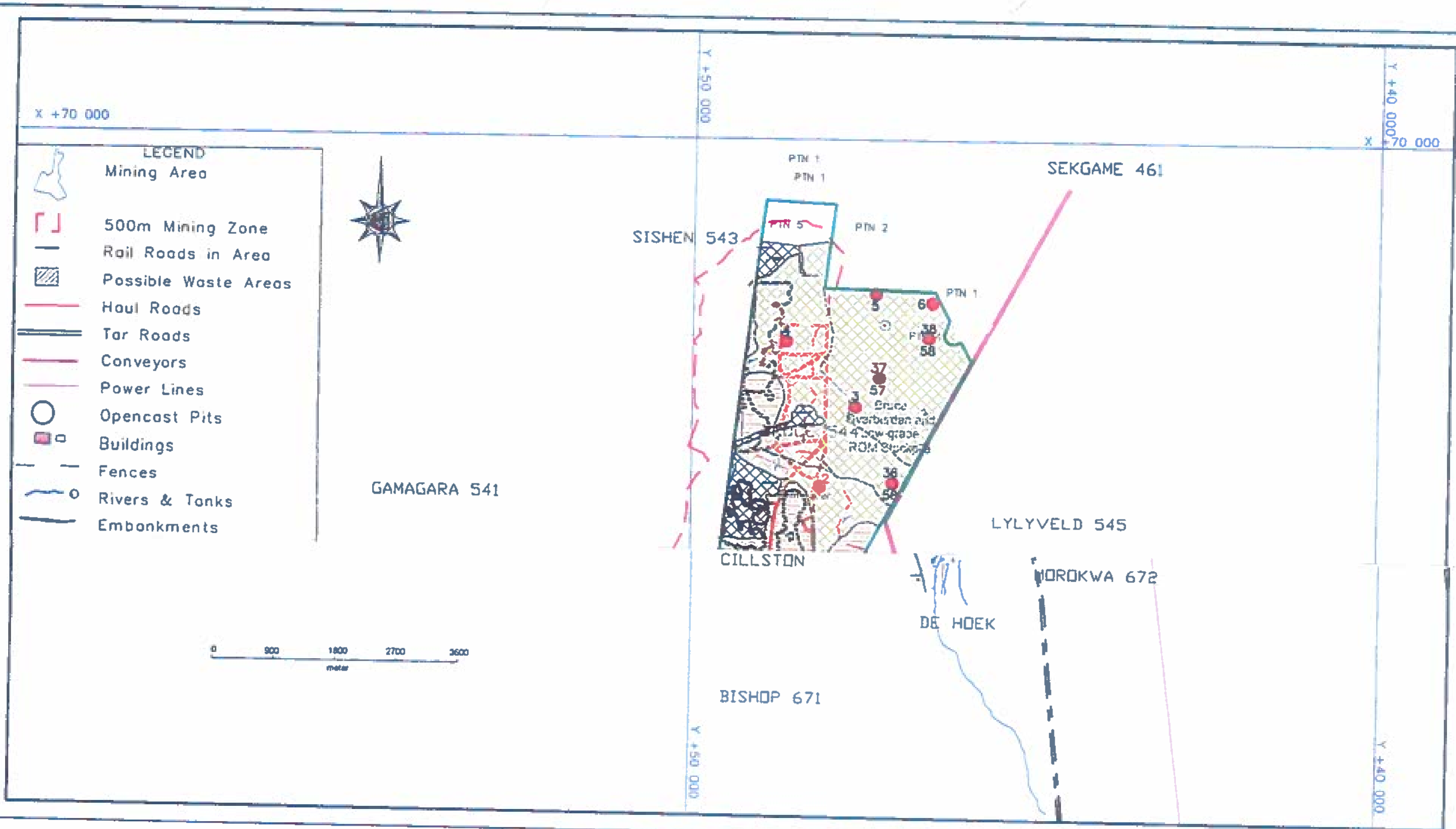
The area is utilized for low density stock farming

2.6.3 Evidence of Misuse

Grazing has disturbed the natural vegetation in the area. Along the western boundary of Bruce, neighbouring Sishen Mine has deposited waste rock in stockpiles. These stockpiles are classified as Witbank Form soils – manmade deposits, and are considered to be areas of misuse of land in the area.

2.6.4 Existing Structures

There are few existing structures on or within the immediate vicinity of the site, other than water reservoirs, temporary housing (caravans) and some permanent farmhouses. There are, however, a number of roads, tracks, power lines and railway lines traversing the site.



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Land Use

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Project Number: IV04.05.044

Figure Number: 2-10

2.7 Natural Vegetation

Refer to Appendix 3.

2.7.1 Aim

A 4-day survey of the study area comprising approximately 9000 ha was undertaken during the dry season of 2004 to determine the pre-mining fauna and flora conditions associated with the proposed BKM Mine area.

2.7.2 Background Description

Vegetation of the BKM area of interest consists mainly of the Kalahari Mountain Bushveld with elements of Kalahari Plateau Bushveld and Kalahari Plains Thorn Bushveld well represented*. Bushveld falls in the Savanna biome.

Though Rebelo and Low indicate the area as Kalahari Plains Thorn Bushveld (Rebelo, A.G. & A.B. Low, 1996), the ore body constitutes a geomorphology of its own and leads to Kalahari Mountain Bushveld species being represented in places. The botanical communities do therefore not represent climax compositions, but rather an ecotone between the 3 types of Kalahari Bushveld.

Of importance are changes from the typical Kalahari vegetation and botanical communities. These changes are found in pans and the riparian zones of streams and rivers. Further, the geology of the dolomitic areas allows a clayey consolidation that also allows changes in typical species composition.

Given the above pathways for species migration and evolution, these biogeomorpholocal factors have assisted in giving rise to a concentration of endemism in the area. The area has been seen as a centre of endemism by conservation authorities, namely the Griqualand West Centre of Endemism (GWC). The GWC is one of 84 African centres of endemism and one of 14 centres in southern Africa, and these centres are of global conservation significance. The two vegetation types present in the GWC, the Kalahari Plateau Bushveld and Kalahari Mountain Bushveld, are endemic to this centre.

The core area of the GWC coincides with surface outcrops of the Ghaap Group (Notably limestone and Dolomite and those of the Olifantshoek Supergroup (notably quartzite). There are phenomenon of endoriac drainage pattern forming pans that are characteristically found in the Ghaap plateau. Pans of this nature predominate on the plains of low relief, which results in poor drainage. Their bases are impervious and thus inhibit downward (vertical) drainage.

2.7.3 Project Site Description

2.7.3.1 Vegetation Types and Associated Species

In general the Kalahari Bushveld is not a sensitive system and does not face any dire threats. Given the expanse of the veld type and limited development potential and pressure, the general veld type is not under pressure. There is however the phenomenon of endoriac drainage pattern forming pans that are characteristically found in the Ghaap plateau.

- Dominant

Dominated by Camphor Tree *Tarchonanthus camphoratus*. In the south the Camphor Tree may become very sparse, and Kunibush *Rhus undulata* and Broom Karee *Rhus dregeana* become the principal shrubs. The tree layer is poorly developed and individuals of Black Thorn *Acacia mellifera* subsp. *detinens* are widely scattered. The grass layer is moderately developed depending on the rockiness of the area. The grass becomes more sour to the north and includes Broadleaf Bluestem *Diheteropogon amplectens*, Hairy Bluegrass *Andropogon schirensis* and Velvet Signalgrass *Brachiaria serrata*. Southwards Copperwire Grass *Aristida diffusa*, Lehmann's Lovegrass *Eragrostis lehmanniana*, Thimblegrass *Fingerhuthia africana and Digitaria eriantha* become dominant in sheltered areas.

From the Kalahari Plains Thorn Bushveld representation off the hill areas, Camel Thorn *Acacia erioloba* and Shepherd's Tree *Boscia albitrunca* may be locally conspicuous. The shrub layer may contain individuals of Black Thorn *Acacia mellifera*, Weeping Candle Thorn *A. hebeclada*, *Grewia flava* or *Acacia haematoxylon*. The grass cover depends on the amount of rainfall during the growing season. Grasses such as Lehmann's Lovegrass *Eragrostis lehmanniana*, Sour Bushmangrass *Schmidtia kalihariensis* and Silky Bushman grass *Stipagrostis uniplumis* occur in the typical cover.

Other typical species found were:

- Kleiia lngifola (Sjambokbos)
- Acacia melifera (Black Thorn)
- Ziziphus mucronata (Buffalo Thorn)
- Malephora cf. sp. (Vygie Sp.)
- Rhigozum obovatum (Wild pomegranate - dominant in zones)
- Asclepias fruticosa (Milk weed)

- Eragrostis lehmanniana (Lehman's Love Grass)
- Eragrostis curvula (Weeping Love Grass)
- Digitaria eriantha (Finger Gass)
- Petronaria mucroata (Kersbossie)
- Pellaea rufa (Fern sp.)
- Trichocaulon cf. flavum
- Acacia karoo (Soetdoring)
- Acacia eroiloba (Camel thorn)
- Aptosimum sp.
- Euphorbia cf.braunsii
- Hibuscus sp.
- Senecio leptophyilus
- Rhus burchelli (Taaibos)
- Pelargonium sp. (Malva)

In the dolomitic areas some of the following species were found;

- Acacia hebaclada (Candle thorn)
- Boschia albitrunca (Shepards tree)
- Chenopodium album*
- Rhus pendulina
- Rhizogum trichototum
- Argemone mexicana*
- Nicotiana gluca*
- Trichonanthus camphoratus
- Rhus pyriodes
- Diplachne cf. fusca (Kuilgras)
- Opuntia sp.*

*Exotic species categorized as weeds by the Conservation of Agricultural Resources Act.

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2.7.3.2 Vegetation of Conservation Importance

Rare and endangered species that occur in the area according to the National Botanical Institute records are:

- Adenia repanda IK
- Antimima lawsoni IK
- Euphorbia planiceps IK

IK = Insufficiently known Red Data status of species. There are additional Red Data Species listed as not threatened and should be taken note of.

2.7.3.3 Endemic species

Endemic species are species that occur in a specific country and region and nowhere else in the world. Two species are of endemic importance in the study area namely *Rhus tridactyla* that is an endemic species to the area and *Trachonanthus obovatus* that is classified as a near endemic.

Refer to Appendix 3 for a list of species present in the BKM Mine area.

2.8 Animal Life

Detailed surveys were not undertaken. Fauna is limited to smaller mammals and specifically Duiker and Steenbuck are common. Kudu do occur but are scarce. Smaller carnivores are present and the Striped Pole Cat (Red Data Species) was observed on site.

Avifauna is well represented with unusual species for the area such as Black-winged Stilt and Common Sandpiper observed at pans holding water.

2.9 Sensitive Landscapes

Sensitive landscapes occur in the form of pans and river floodplains. The floodplain is fairly uniform with the riparian zone well represented with tree species and river bed containing hydrophyllic grasses and hardier sedges.

Pans and riparian zones are classified as wetlands and therefore have legal protection based on conservation status. Two types of pans can be distinguished based on geology and species composition. Various pans occur in the study area and 3 contained water at the time of the visit.

Some pans have a fine clay base retaining water Figure 2-11 while some have formed up against calcrete "outcrops" with a turf clay sustaining lush grass cover (Figure 2-12).

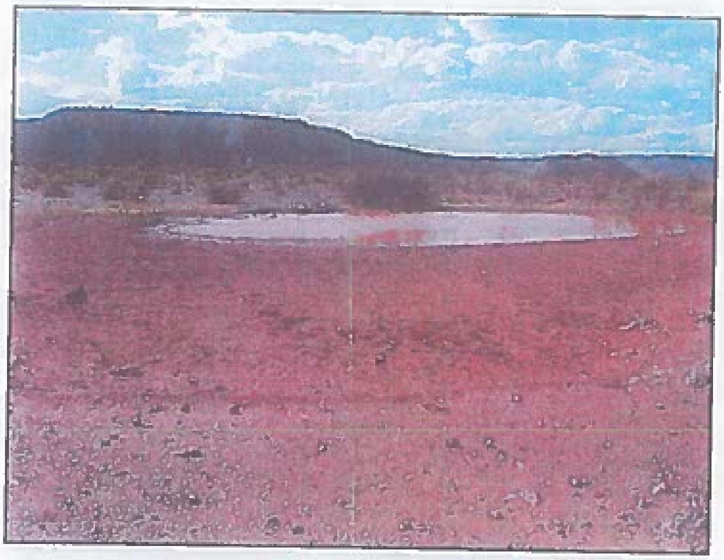


Figure 2-11: Pans with fine clay base retaining water

Figure 2-12: Pans against calcrete outcrop

Key Reference: *Noel van Rooyen & George Bredenkamp In: Low, A.B. & Robelo, A.G. (eds) Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

2.10 Surface Water

Refer to Appendix 4.

2.10.1 Aim

A surface water investigation was undertaken for the proposed BKM iron ore mining area. The aim of the investigation was to determine the potential impacts of the mining activities on the surrounding surface water resources and the most effective remedial measures to be implemented.

2.10.2 Surface Water Quantity

2.10.2.1 Catchment Area and Affected Water Course

The BKM Mine falls within the Lower Vaal Water Management Area (No. 10). The area is situated in the D41 catchment of the Gamagara River, the quaternary catchment being D41J (refer to Figure 2-13 – page 2-36).

The site is located on gently sloping to hilly terrain with rivers flowing in a north-westerly direction. The major river traversing the site is the Gamagara River, which flows from the east to west across the site. The river then flows north to join up with the Kuruman River.

There are six other minor watercourses depicted and labelled on Figure 2-14 (page 2-37). These watercourses are all tributaries of the Gamagara River.

It should be noted that all the watercourses depicted on Figure 2-14 (page 2-37) are normally dry. Flow of any measurable magnitude only occurs after significant rainfall events, and then only for short periods of time.

2.10.2.2 Mean Annual Runoff

The hydrology for the site is based on the nearest rainfall station, which is No. 0356 712 and is approximately 11 km to the west.

The rainfall statistics for the BKM Mine site are as follows:

- Mean Annual Precipitation: Approximately 358 mm
- Mean Annual Runoff: 1.3 mm
- Evaporation zone: D4A.

2.10.2.3 Normal Dry Weather Flow

The Gamagara River and the tributaries affected by the proposed BKM Mine development are normally dry and only flow for comparatively short periods after significant rainfall events. There is no normal dry weather flow that would be impacted by the mining development.

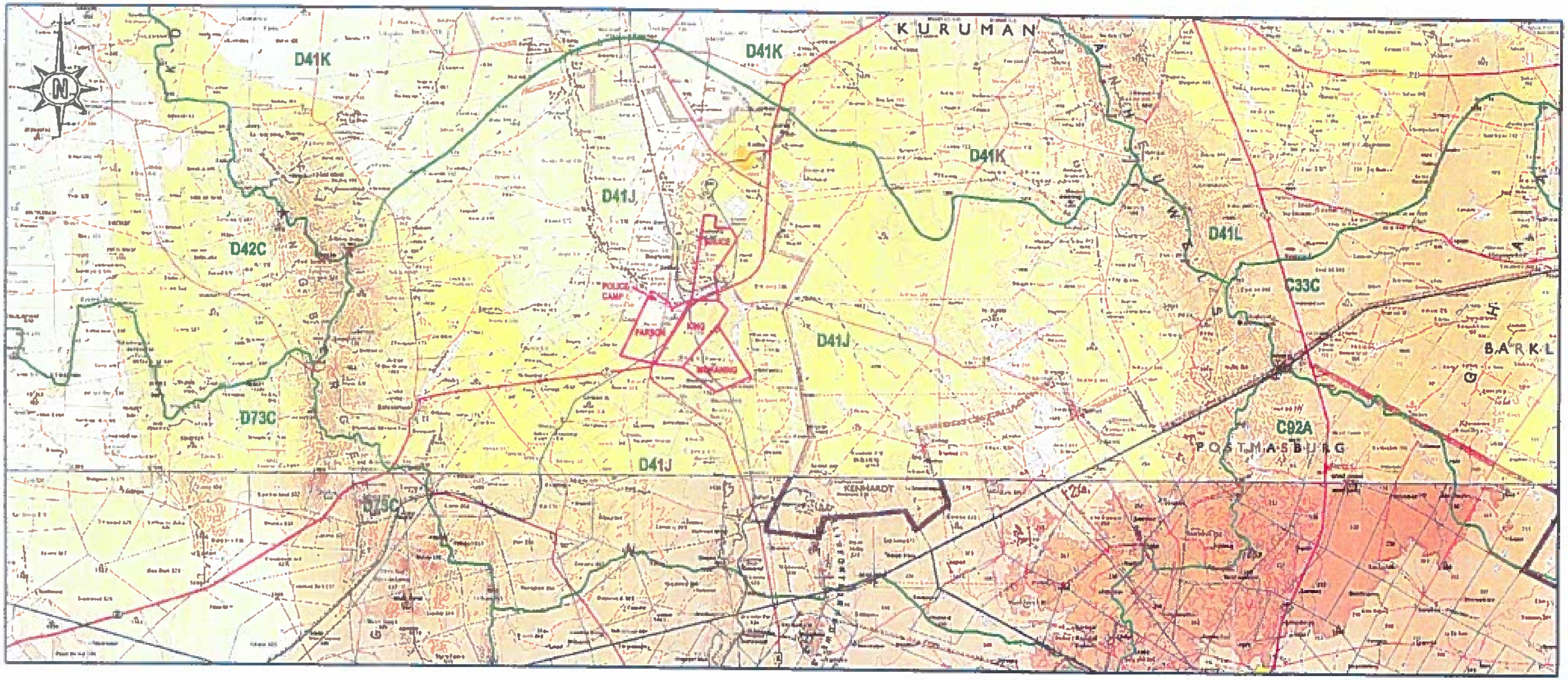
2.10.2.4 Flood Peaks and Volumes

The peak flows are calculated according to the Francou-Rodier and the Rational Methods. The Rational method assumes that a rainstorm of uniform intensity covers the catchment area. Runoff will increase as water from more distant parts of the catchment area reaches the outlet. When the whole drainage area is contributing, a steady state is reached, and discharge becomes a constant maximum. The time required to reach this steady state is called the time of concentration of the basin, and after this time, storm-flow discharge is fixed proportion of the rainfall intensity.

Table 2-9 summarizes the flood conditions of the BKM Mine catchment.

Table 2-9: Flood conditions

Watercourse	Catchment Area (km^2)	1:50 year (m^2/sec)	1:100 year (m^3/sec)	RMF Volumes (m^3/sec)
Gamagara	2120	190	258	600
No.1	5.6	26	32	50
No.2	24	29	39	90
No.3	2.5	8	11	17
No.4	0.8	3	4	6
No.5	1.3	4	5.5	8
No.6	25	29	39	90



LEGEND:

- MINING AREA FARMS
- QUATERNARY CATCHMENTS

0 5 10 15 20
KILOMETER

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DRAWING TITLE: BKM MINE QUATERNARY CATCHMENT

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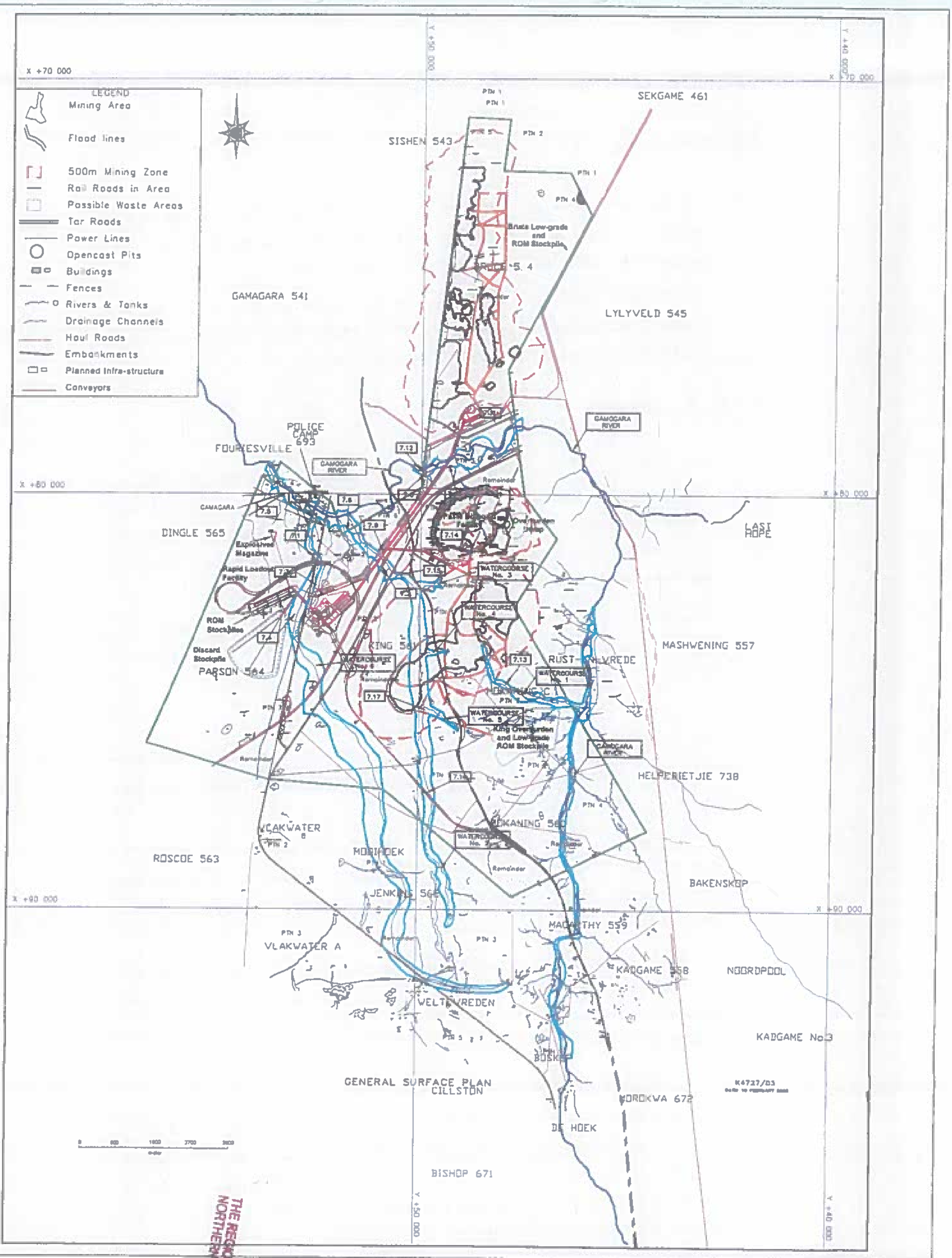

The Regional Manager Northern Cape Region

BKM Mine Floodlines and Water Management References

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Project Number: IV04.05.044

Figure Number: 2-14

2.10.2.5 Flood lines

The flood lines indicated on Figure 2-14 depict the extent of the 1:100 year volumes except the Gamagara, which also depicts the RMF volume and have been determined from 1:10 000 orthophotos and a contour map.

The six minor tributaries of the Gamagara River referred to above are inferred from contour information provided. There is little information to suggest that these are anything more significant than storm water drainage paths.

2.10.2.6 River Diversions

Due to the new mining operation it is required that various river crossings and alterations be constructed. It should, however be noted that the area is characterised by one non-perennial river (Gamagara River), which is dry for most of the year. The area is further characterised by various drainage channels, which are associated with low flow volumes during significant rain events.

Although the mining operation will be characterised by various crossings and alterations, only two significant river alterations will be undertaken. Both of these will be situated on the farms King and Mokaning.

- King / Mokaning Overburden and Low-grade ROM Stockpile

The upper reaches of the catchment of Watercourse No.1 encroach on the King / Mokaning ore body. The King Overburden and low-grade ROM stockpile straddles the central portion of the catchment.

Of the total Watercourse No. 1 catchment approximately 1.8 % will be occupied by the opencast mining operation. An area of approximately 7 % immediately downstream of this will be isolated from its normal drainage path (i.e. dammed up by the stockpile).

In view of the comparatively low flow and small volume of water that will be isolated by the stockpile, the water will be allowed to dam up against the stockpile after significant rainfall events. The high permeability of the rock will allow trapped water to seep away under the stockpile over a period of time.

- King / Mokaning opencast operations

In the year 2024, the KM_WST and KM_CENT opencast pits will be developed within the watercourse and 1:100 year flood line of Watercourse No. 2. The upper reaches of watercourse No. 2 will be diverted into the adjacent catchment (Watercourse No. 6) and the runoff form the area directly upstream of the opencast operations will be collected in catchment dams to prevent flooding of the opencast wordings.

The latter will be investigated in detail in future environmental studies as part of the associated railway diversion.

Refer to Section 4 for more detail regarding the diversions and associated alternatives investigated.

2.10.3 Surface Water Quality

At the time of the site visit, all watercourses inspected were dry, so it was not possible to obtain samples for testing of surface water quality.

2.10.4 Drainage density of areas to be disturbed

The total area of the Farms Bruce, King, Mokaning and Parson affected by the project is 88 km^2. The combined length of watercourses draining the area is 37.7 km, giving a drainage density of 0.43 km / km^2.

2.10.5 Surface water use

There are no significant surface water users downstream of the proposed mining development due to the unreliability of flow in the Gamagara River and its tributaries. The only significant water users would be the aquatic ecosystem, which relies on occasional storm flow and flushing action in the watercourses.

All other users (primarily the farming community) rely on groundwater abstraction for livestock watering and domestic consumption.

2.10.6 Water authority

The BKM Mine is situated in the jurisdiction of the Northern Cape Department of Water Affairs and Forestry (DWAF).

2.10.7 Wetlands

No wetlands occur within the BKM Mine area.

Various non-perennial pans, as well as the Gamagara River flood plain are present on the BKM Mine area. Due to the scarcity of water in this area, the pans are associated with sensitive vegetation. The pans are unique features that act as biodiversity hot spots. These are illustrated on Figure 2-14 (page 2-37).

The Gamagara River and various pans form a sensitive habitat and a corridor for animal movement through the ecosystem.

Protected species like the Acacia erioloba is present in the riverbed and on the banks of the Gamagaara River. Many sections of the Gamagara River have been severely disturbed (agriculture) and invaded by mesquite, and there are probably few sections of this river left undisturbed. It is therefore highly important to protect the sections of the Gamagara, which fall within the mining area. Therefore, no mining activities will be conducted within the 1:100 year flood line of the Gamagara River.

2.11 Groundwater

Refer to Appendix 5.

2.11.1 Aim

A groundwater investigation was undertaken for the proposed BKM iron ore mining area. The aim of the investigation was to determine the potential for mine dewatering, calculating groundwater inflow rates and the resulting radius of influence caused by mine dewatering.

All the main aspects required to assess geohydrological conditions in an area were addressed, including physical properties of the groundwater domain, geohydrological features, groundwater users and uses around the mining area, the geology, the hydraulic properties of the saturated zone, groundwater quality characteristics, groundwater flow velocities were calculated from first principles and all data was combined to construct conceptual and numerical models.

2.11.2 Approach and Methodology

2.11.2.1 Desktop Study

A hydrocensus of groundwater users was undertaken for the entire mining boundary and surrounds of the proposed BKM iron ore project. The data comprises existing and additional monitoring boreholes, groundwater quality data, water level and aquifer test measurements in boreholes committed for groundwater monitoring, as well as water supply holes. Groundwater information gathered during the initial hydrocensus study on existing boreholes was provided. Also in this database are water levels, yields and geological descriptions of geological exploration boreholes drilled on and around the iron ore reserves.

The second source comprised groundwater monitoring information (water levels and pumping rates) of the adjacent Sishen Iron Ore Mine of Kumba Resources that was incorporated in the database and used for calibration of the numerical model.

The third source comprises data retrieved from the National Groundwater Database (NGDB) for the area on and around the proposed BKM project. Information for more than 1200 boreholes in the database was provided, including water level information over time.

For the purpose of this study, the monitoring data, hydrocensus information as well as studies and findings of previous groundwater and related investigations in the area were combined and interpreted in a holistic manner.

For the purpose of compiling the EMP document, the physical and chemical properties of the groundwater regime were evaluated using the following methodology:

- Topographical and geological maps, orthographic photographs (where available) as well as geophysical investigations were used to describe the physical properties of the groundwater domain,
- Detailed site investigations such as drilling, borehole profiling and aquifer testing were performed during which the relevant geohydrological features were described,
- A hydrocensus was conducted during which groundwater users around the mining area were identified, boreholes were surveyed in terms of positions, flow and water quality and water uses were determined,
- A number of percussion and diamond boreholes were drilled and logged in the study areas for monitoring of the impact of the proposed project on the groundwater regime.
- Constant rate pumping or recovery tests were not performed on the drilled monitoring boreholes because the low blow-out yields made aquifer testing not feasible. Instead, the focus in obtaining the hydraulic properties of the saturated zone was the use of geological maps and the long term pumping records of Sishen mine during model calibration,
- Profiling was not conducted in the monitoring boreholes because the iron ore and host rock environment is free of polluting material like organic carbon or minerals like base metal sulphides that cause acid mine drainage or other contamination reactions.
- Geochemical testing was performed on the Paste Disposal Residue

- Groundwater flow velocities were calculated from first principles to use as guidelines in numerical model construction,
- All the above data types were interpreted with appropriate techniques in each case and were used to construct conceptual and numerical models of the groundwater regime,
- The numerical model was calibrated using groundwater levels, aquifer test information, groundwater qualities and mine dewatering (pump rates and water level response) information of the existing nearby Sishen iron ore mining operations. Data sources for water levels include the monitoring boreholes; the hydrocensus boreholes of the surrounding users; the NGDB and the water levels and inflow rates over nearly 30 years of Sishen mine.

The numerical model can be used as a predictive tool for future flow.

The location of groundwater data points (boreholes) used for different types of monitoring, testing and/or calibration on and around the proposed BKM project area is presented in Figure 2-15 (page 2-43).

2.11.3 Presence of Boreholes

A hydrocensus was conducted in and around the proposed BKM mining area. As part of the hydrocensus, water boreholes were mapped within an 8 to 10 km radius of the planned active mining areas. The potential radius of influence on the groundwater regime around an iron ore mine in this area has been shown from Sishen Mine to be potentially significant. The radius of influence depends strongly on geological structures such as faults (preferred groundwater flow paths), dykes (horizontal flow barriers), groundwater gradients and nearby mining operations where dewatering already occurs and the presence of other groundwater production boreholes in the area.

Groundwater use information was obtained for a total of 44 points during the hydrocensus undertaken during June and July 2004. The water supply source of each surrounding user was surveyed, uses were noted and water levels were measured where possible. The estimated (by farm owners) yields of the hydrocensus boreholes were also recorded and varied between 0.1 l/s and 2 l/s. The yields of the monitoring boreholes drilled and pump tested in the mining area compare very well with the yields of the surrounding boreholes recorded in the hydrocensus. Yields of some of the monitoring boreholes that intersected the Wolhaarkop breccia are expected to have been higher in the natural state, but dewatering from Sishen mine has caused dewatering to below the level of the potentially high yielding fractures.

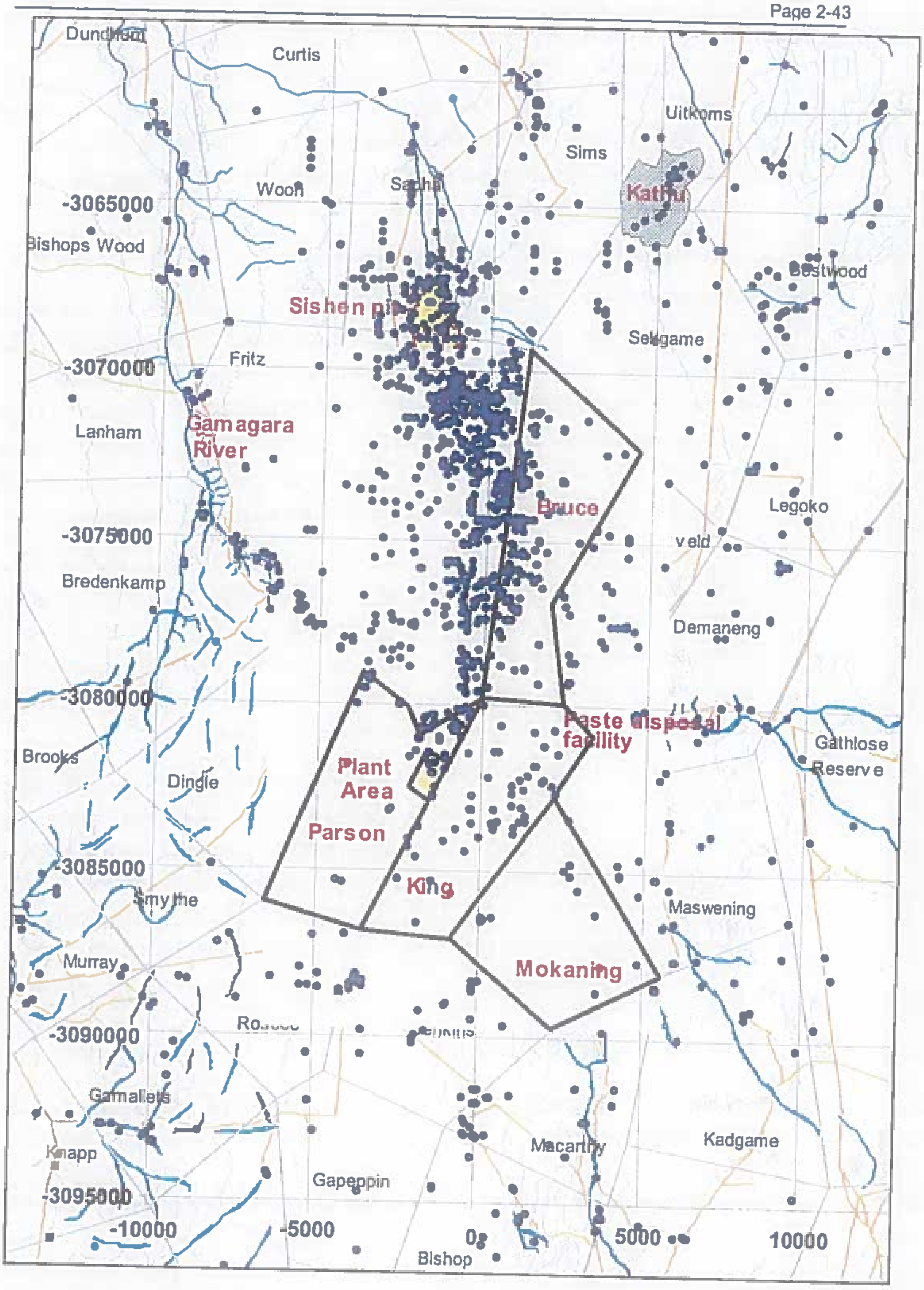

Figure 2-15: Locality map showing groundwater data points used in investigation

From the numerous boreholes reviewed in the National Groundwater Database of the area around the BKM project, a wider range of borehole yields was recorded. In the database of nearly 500 borehole yields, 90 % of the boreholes yield between 0 and 5 l/s. The remaining 10 % yield mostly less than 10 l/s. However, yields in excess of 40 l/s have also been recorded. Boreholes with yields in excess of 40 l/s have mostly intersected the Wolhaarkop breccia.

No springs were recorded during the hydrocensus.

The geohydrological logs of the groundwater monitoring boreholes are summarized below. The most important lithological intersections, yield and stratification trends and consequent sampling depths are summarised in Table 2-10 (page 2-45). This geohydrological data, together with water level information is invaluable for better understanding of geohydrological processes, groundwater types, flow and transport velocities. All information gathered from these boreholes was used, in the compilation of conceptual and numerical models, impact and risk assessments.

The groundwater monitoring boreholes in the proposed BKM mining areas have been sited down gradient of the planned opencast pits and within the hydrogeographical regime that may be affected by future mining activities. At the proposed BKM pits, 6 boreholes have been drilled down gradient of the pit areas specifically for monitoring purposes. Numerous exploration boreholes are open and available for monitoring, groundwater level impacts, and possible contaminant migration.

Drilling results indicate that most of the intersected aquifers (calcrete, quartzite, shale, lava, iron ore and chert breccia) have relative low groundwater yields. Yields vary from zero to less than 2 l/s around the proposed BKM open pits. The low yields in especially BKM02 and BKM04 are not considered accurate reflections of the aquifer potential, and could have been significantly higher had it not been for the Sishen dewatering that lowered the water level below the aquifer level. BKM04 indicated a 12 m cavity in the dolomite from 128 m to 140 m below surface. This feature would have yielded if the Sishen Mine dewatering operations did not decrease the groundwater to below the cavity level.

Borehole profiles (logs) are presented in Appendix 1 of this report and Appendix A of Appendix 5 of this report.

The most important geological, yield, stratification and construction features of boreholes in the vicinity of the pit are supplied in Table 2-10 (page 2-45).

Table 2-10: Borehole information (yield, stratification, sampling depth)

BH ID	Geology	Yield (l/s)	Construction	
			Steel 200 mm	Steel 150 mm
BKM01	CLCR, RBBL, CGLM, SHLE	0	8.3 m	36.4 m
BKM02	SAND, QRTZ, SHLE, HMTT, CHBR	0.28	16 m	30 m
BKM03S	CLCR, LAVA	0	1 m	0 m
BKM03D	CLCR, LAVA	0.42	16 m	30 m
BKM04	SAND, RBBL, CHBR, DLMT	0	30.3 m	144 m

Note:

CLCR = Calcrete, RBBL = Rubble, CGLM = Conglomerate, SHLE = Shale, QRTZ = Quartzite, HMTT = Hematite, CHBR = Chert breccia, LAVA = Lava, SAND = Sand, DLMT = Dolomite.

2.11.4 Groundwater Flow Evaluation

2.11.4.1 Depth to water level

Groundwater level records in and around the proposed BKM mining area are numerous and some date back to 1920. More intensive and continuous water level recording started in the late 1970's when Sishen mine dewatering commenced in earnest. The Department of Water Affairs and Forestry (DWAF) implemented a number of continuous water level data recorders and Sishen Mine monitored these over a large area. More recently, Sishen Mine conducted a hydrocensus and follow-up mapping, drilling and pump testing to verify the dolerite dykes' competency as barriers for groundwater flow towards the south. The drilled and tested boreholes were also commissioned as additional monitoring points with water level data loggers being placed in the most strategic points.

A map showing the distribution of monitoring points with water level data available for the past year is presented in Figure 2-16 (page 2-46). The latest groundwater levels are shown as thematic points with the point size proportional to the depth of water level below surface. Due to the great number of boreholes and high monitoring frequency at some points, the borehole information or water level data will not be provided in tabular or other format but could be made available on request.

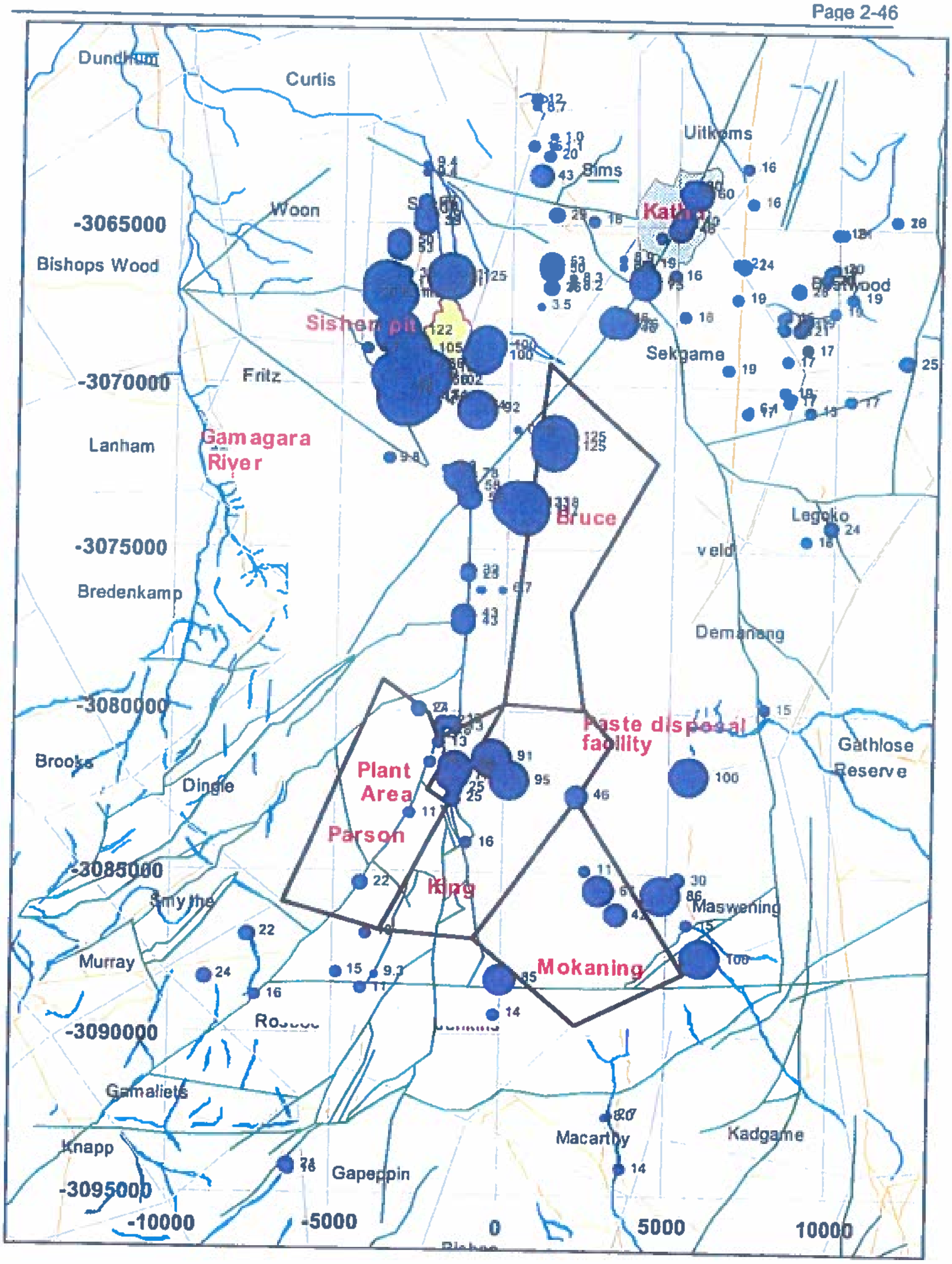

Figure 2-16: Thematic map showing groundwater level data last measured during the past year

Regional static groundwater levels around the proposed BKM mining areas vary between 8 meters below surface in the plains outside the compartments where dewatering impacts, to a maximum of 150 meters below surface near Sishen mine where the dewatering impact is the most significant. Because of the existing dewatering impact from Sishen, the groundwater level no longer follows the trend of the surface topography. The highest static water level elevations are about 1 260 mamsl and occur in the topographically higher regions namely to the south of the proposed pits on King/Mokaning. The lowest elevations (not induced by mine dewatering) are at approximately 1 140 mamsl in the downstream direction (north-west) where the Gamagara River exits the Sishen mining area.

Average water levels are indicated in Table 2-11 below.

Table 2-11: Average water levels at the BKM Mine

Location (farm)	Water Level (meters below surface)
Bruce North	130
Bruce South	120
King North	95
King South	80
Mokaning North	70
Mokaning South	35 to 40
Parsons North-east	70
Parsons Overall	8 to 12

The groundwater levels in the proposed mining area together with levels measured during the hydrocensus survey, water levels measured by Sishen over the past thirty years and water levels from the NGDB were used as calibration points for the numerical groundwater model to verify the conceptual model and construction thereof. Seen in the light of water level differences because of mining, pumping and recharge effects, filtering and processing of water levels are conducted to remove water levels considered anomalous high or low. The final interpolated digital terrain model of the water levels is thus bound to contain local over- or under estimations of the actual water levels but it will be representative of the general regional trend of the static groundwater level.

The natural interpolated groundwater level contours (before impacts from mine dewatering) estimated through Bayesian interpolation are presented in Figure 2-17 (page 2-48). The natural flow direction for groundwater differs locally but as a generalisation could be described as towards the north-north-east.

A static groundwater level map (Figure 2-18 – page 2-49) of the area was constructed through the utilisation of the Bayesian interpolation technique whereby the natural relationship between topography and depth-to-groundwater level is used to estimate groundwater levels in areas where borehole data is scarce. Because impacts on the natural groundwater level exist in some areas only boreholes where the linear correlation between borehole collar elevations exist were used in the estimation.

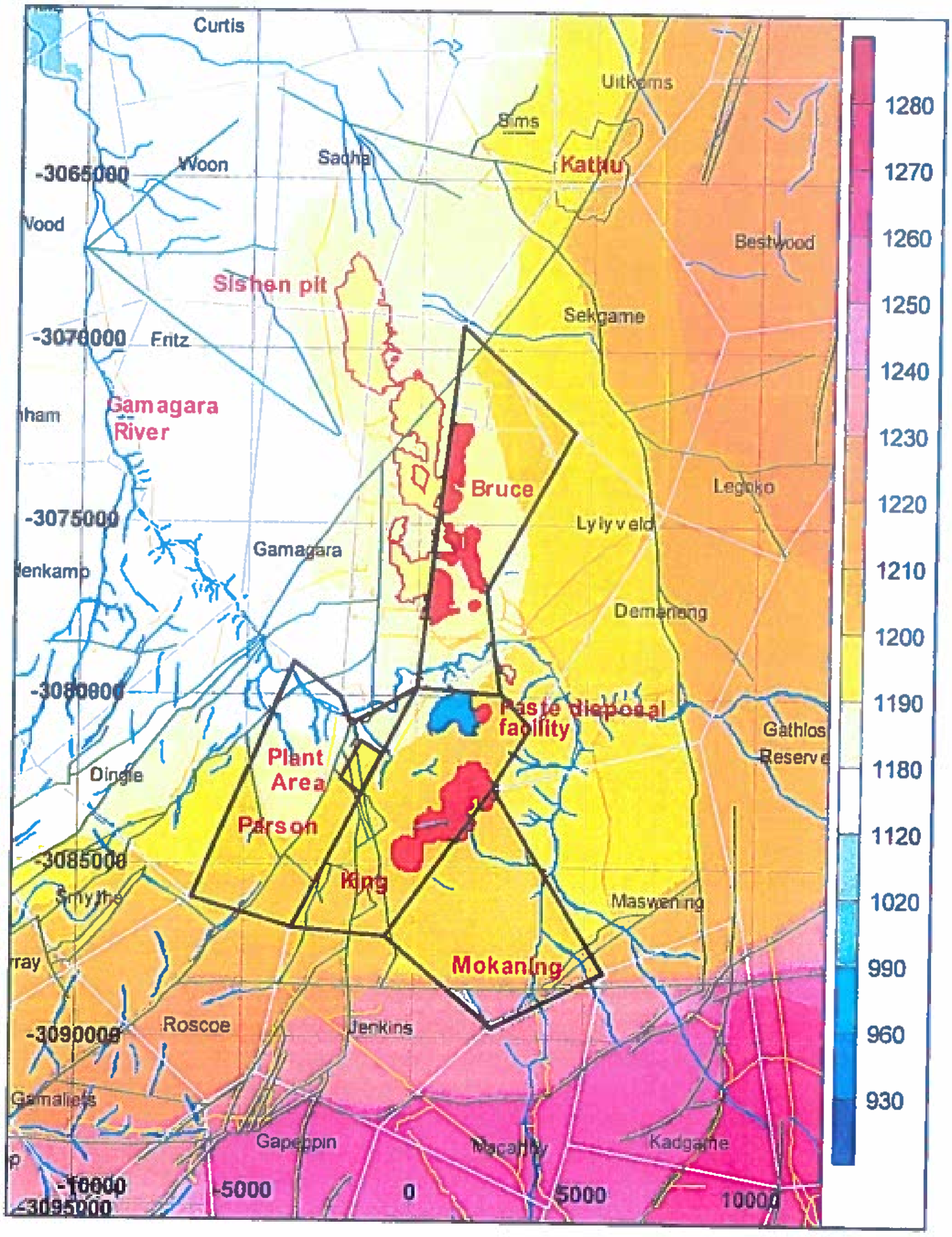

Figure 2-17: Interpolated pre-mining groundwater level contours

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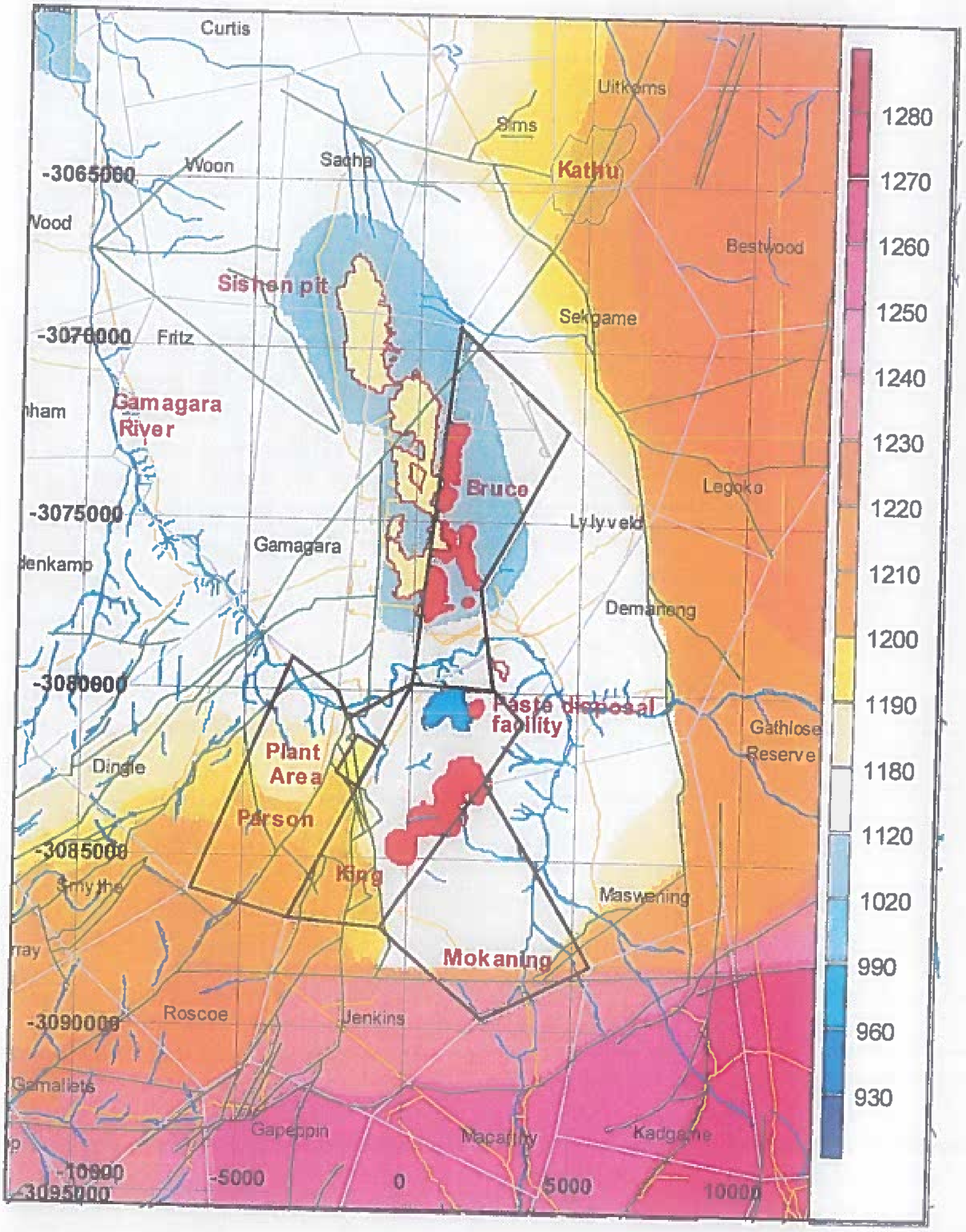

Figure 2-18: Simulated current groundwater level contours showing dewatering impacts

The resulting groundwater level contours represent average water levels expected among an unknown number of co-existing fracture aquifers. A contour map of the most recent groundwater levels is presented in Figure 2-18 (page 2-49) to illustrate the significant impact of mine dewatering at Sishen. The dolerite dykes that serve as impermeable boundaries are also shown in the figure and the steep water level gradients along these dykes are evident.

2.11.4.2 Flow gradients

Groundwater contours and flow lines for the current water level distribution in the proposed BKM mine boundary area are shown in Figure 2-19 (page 2-51). The particles were inserted around the current and planned mining areas to estimate impacts on particle movement. The path line model PMPATH.exe was used to simulate particle movement over a 50-year period. The lengths of the pink path lines are thus the distance that a groundwater particle is expected to travel in 50 years time. It should be noted that, depending on the position in the aquifer, the path line and groundwater flow velocity differ significantly. Particles from all the proposed BKM pits travel at a high rate to Sishen mine where dewatering takes place at a high rate. The particles outside the groundwater compartments defined by the dolerite dykes (green lines in Figure 2-19) travel very slow and are evidence that dykes serve as groundwater flow barriers and that groundwater gradients are unaffected outside the dykes.

Within the dewatering compartments where high groundwater gradients are induced by pumping, groundwater seepage rates are significantly higher such as in the southern compartment of Sishen mine. Seepage rates on the other hand are much lower outside the compartments where active dewatering occurs.

The placement of the plant and other processing infrastructure on the farm Parsons to the west of the mining areas and outside the southern compartment will prevent high flow and mass transport velocities from these sites. The tailings facility, however, is situated within the southern compartment and contamination from the facility will move at higher rates to the dewatering areas.

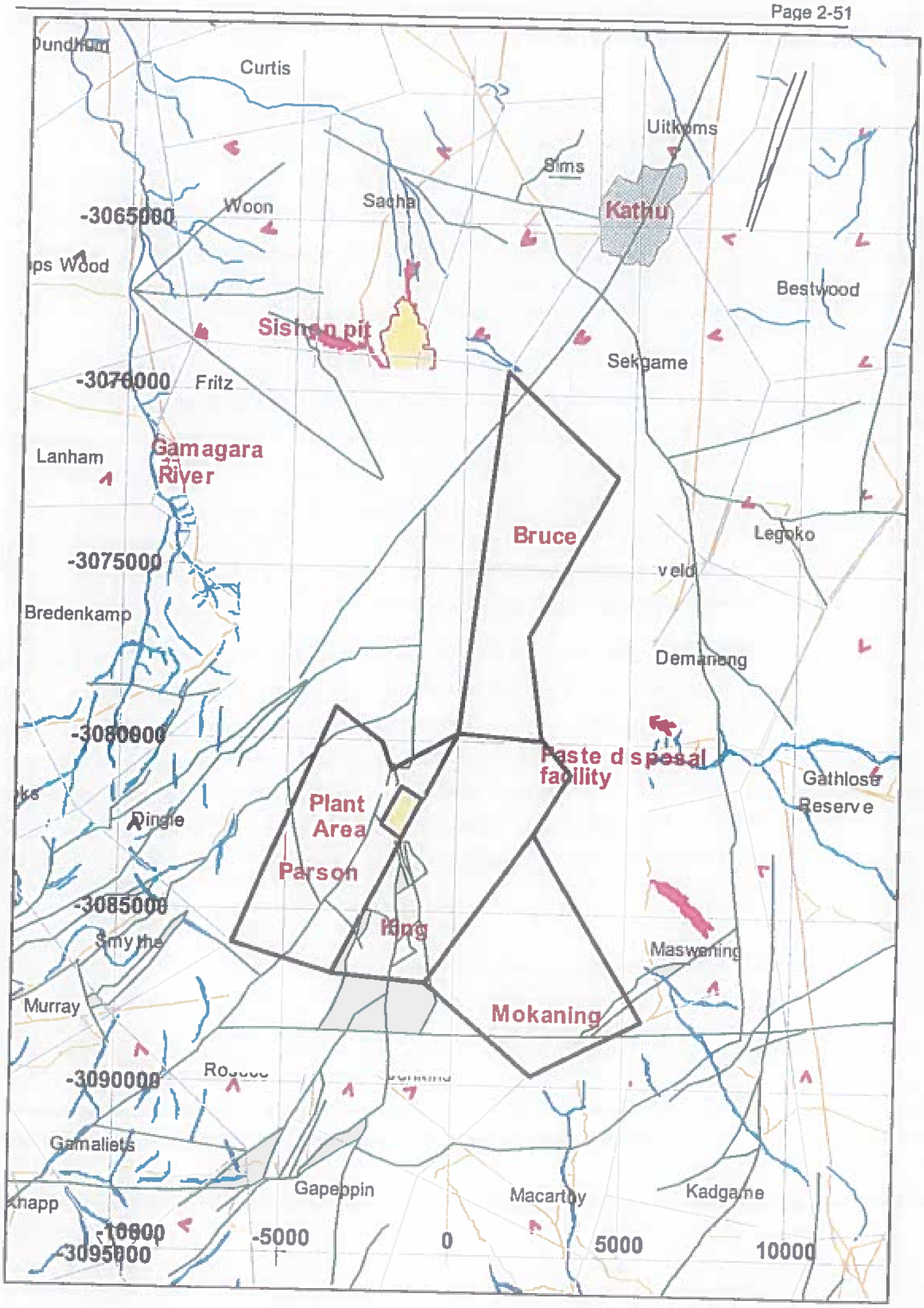

Figure 2-19: Path lines in the BKM Mine area

2.11.4.3 Aquifer types and yield

A discussion on aquifer types has largely been completed. From drilling and hydrocensus results two possible aquifer types have been found present in the study area. For the purpose of this study an aquifer is defined as a geological formation or group of formations that can yield groundwater in economically useable quantities. According to this definition of an aquifer, only the aquifer developed on the soft rock – hard rock interface (weathered zone) or on deeper fracture zones present in the unweathered or slightly weathered rock mass, could be defined as aquifers.

All significant groundwater strikes, indicating the presence of aquifers, occurred in fractures or fracture zones caused by faulting, bedding plane fracturing or small discontinuity fractures developed on hard rock / soft rock interfaces or in unweathered bedrock. The majority of aquifer yields in the upper calcrete are low to very low, indicating poor fracture development except for fault zones or contacts with the dolerite dykes occurring in the study area. Even the contact zones around the intrusive dolerite dykes that are usually fractured and highly transmissive did in some cases not yield any significant water strikes.

Significant water strikes occur in the deeper fractured rock aquifer and most notably in the Wolhaarkop chert breccia at the base of the Kuruman Formation. The underlying dolomites of the Ghaap Group have high storage characteristics but transmissivities are often low and borehole yields not very high. It is concluded that the dolomites serve as a good storage unit for groundwater but the chert breccia and banded iron formations (Kuruman, Gamagara Formations) are the main conveyors/transmitters/conduits for high groundwater flow rates to boreholes or mine voids.

2.11.4.3.1 Aquifer transmissivity and storativity

Aquifer transmissivity is defined as a measure of the amount of water that can be transmitted horizontally through a unit width by the full-saturated thickness of the aquifer under a hydraulic gradient of 1. Transmissivity is the product of the aquifer thickness and the hydraulic conductivity of the aquifer, usually expressed as m^2/day (Length^2/Time).

The transmissivity of the aquifer host rocks in the proposed BKM opencast mining area is highly variable and ranges between 10^{-2} (dolerite dykes, consolidated rock matrix) and 10^3 m^2/day (fracturing / dissolution cavities).

2.11.4.3.2 *Aquifer recharge and discharge rates*

Recharge in the BKM area and surrounds is estimated to be between 2 and 4 % of MAP. Based on this estimate, the average recharge to the modelled area is 28 300 m^3/d (10 300 000 m^3/y). Numerical modelling at Sishen has shown that effective recharge could easily increase to more than 30 % of MAP in the open pit areas where aquifer host rock is exposed and all drainage is captured in the pit.

2.11.4.3.3 *Direction and rate of groundwater movement in potentially impacted areas*

The pre-mining groundwater contours have been presented in Figure 2-17. These contours represent steady state conditions without impacts from sources or actions other than natural conditions.

A large number of manmade actions could impact on the groundwater regime; including the aquifer structure, flow paths and directions, storage, discharges and recharge. Possible impacts relevant to the proposed project will be discussed briefly:

- Aquifer structure, flow paths and directions

Open pit mining has been ongoing next to the proposed BKM project area for nearly 40 years. The mining activities included a significant dewatering program to enable dry mining conditions. Mine voids could be compared to areas of very high (even infinitely high) transmissivity and also high storativity. Because groundwater will, after recovery from the mining and dewatering programs, follow the route of least resistance, groundwater will prefer to move through the mined-out areas. Impacts on the natural flow pattern at BKM will only be noticeable in the immediate vicinity of the operations because of BKM's location within an enclosed groundwater compartment. The extent of the impact depends mostly on the transmissivity of the *in situ* aquifer material. Given the fact that the transmissivities in the formations around the ore reserves are high, the extent of impact will be more significant and would include most of the area covered by the groundwater compartment.

- Aquifer discharge

A mining and processing operation may impact significantly on the discharge of an aquifer in different ways. The dewatering in this mining area will directly decrease the discharge of the aquifer. As no definite spring discharge areas or perennial streams originate in the area, the larger groundwater resource will be adversely affected and not the discharge directly. Aquifer yield may also increase with the use of return water dams and tailings dams, through leakage of water to the subsurface, especially if water is imported to the project from other sources. Other factors that may decrease the aquifer discharge are compacted surfaces, haul roads and concrete surfaces that prevent infiltration to the aquifer and decrease groundwater discharge, although increasing surface runoff.

- Aquifer recharge

All the aspects mentioned under aquifer discharge apply to aquifer recharge. Opencast mining usually causes a significant increase in aquifer recharge %age. Surface water features like dams (paste disposal, process water, return water etc.) will also increase the recharge to the aquifer but compacted or concrete surfaces and roads will decrease the recharge.

2.11.5 Groundwater quality

During the June and July 2004 hydrocensus and user survey, water qualities around the proposed BKM mining areas were measured at 7 boreholes. A map showing the distribution of these boreholes is presented in Figure 2-20 (page 2-55). The water quality data was interpreted with the aid of diagnostic chemical diagrams and by comparing the inorganic concentrations with the South African Drinking Water Guidelines for Domestic Use.

Because only once-off monitoring data exists for these points, time-series data, statistical analysis and trend analysis were not possible. The first step in the water quality interpretation was to classify the groundwater quality. The classification was based on the following:

- The spatial distribution of the monitoring points, and
- The proximity of the monitoring points to certain known pollution sources that are expected to impact on the groundwater and / or surface water in the downstream flow direction area.

The four main factors usually influencing groundwater quality are:

- Annual recharge to the groundwater system,
- Type of bedrock where ion exchange may impact on the hydrochemistry,
- Flow dynamics within the aquifer(s), determining the water age, and
- Source(s) of pollution with their associated leachates or contaminant streams.

Where no specific **source of groundwater pollution** is present upstream of the borehole, only the other three factors play a role.

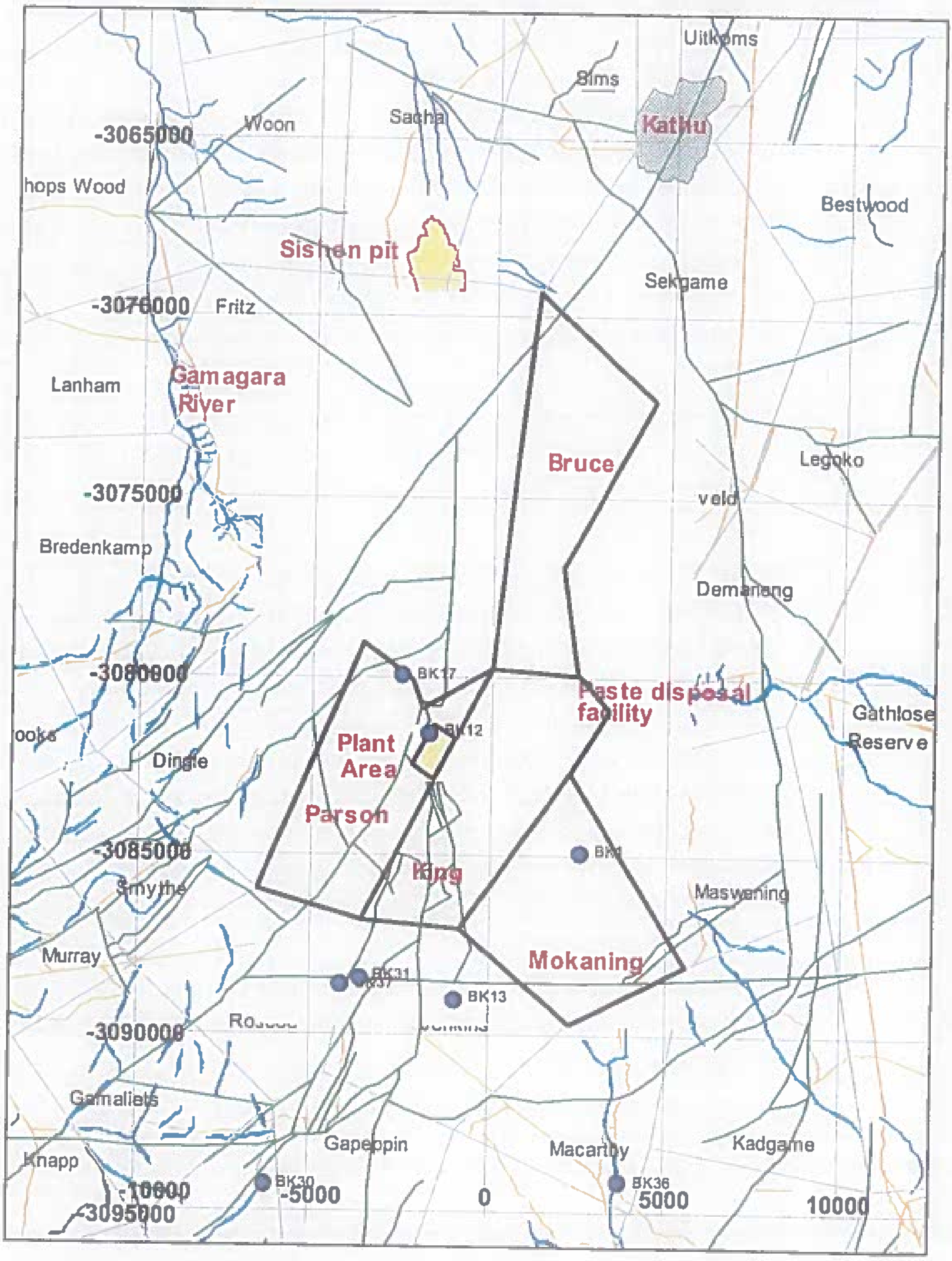

Figure 2-20: Positions of water quality monitoring points

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Around the proposed BKM mining area most of the boreholes display good groundwater quality with the exception of relatively high hardness. The hydrocensus points with the poorest qualities are BK17 followed by BK12. Only some water quality parameters (like EC, Hardness and Ca) of BK17 exceed the recommended limits for domestic use but the rest are all suitable for such use. The positions of the sampled boreholes are shown in Figure 2-20. The ambient groundwater levels in the sampled boreholes outside the impact zone from mine dewatering are usually relatively shallow with rest water levels generally less than 25 m below surface. The average rainfall is in the order of 390 mm per year but studies have shown that effective recharge %age is relatively high, especially in the calcrete and Kalahari sand cover areas.

The hydraulic conductivities of the bedrock in the vicinity of the boreholes are usually higher than 10^{-3} m/d. Such conductivities facilitate a sufficient flow rate to prevent stagnant groundwater conditions, especially where significant groundwater gradients occur.

Aquifer flow dynamics is good to very good and facilitates the existence of fresh groundwater in the BKM opencast area. A slight deteriorating trend occurs when moving from the topographical higher to the lower lying areas. This slight increase in inorganic ion content is owed to ion exchange reactions occurring from the moment that recharge enters the land surface and continues all the way down the geohydrological cycle. The groundwater infiltrates the subsurface and aquifer, thereby encountering different rock types where different degrees of ion exchange occur, especially in the calcrete and dolomite. The seepage rate (caused by groundwater gradient, storativity and transmissivity), the type of aquifer host rock and the prevailing redox conditions determine the degree of ion exchange that will take place.

In the BKM area the surface cover and type of bedrock that hosts the aquifer does impact on the chemical composition of the groundwater with Mg, Ca and alkalinity dominating the macro element inorganic compositions.

One of the most appropriate ways to interpret the type of water at a sampling point is to assess the plot position of the water quality on different analytical diagrams like a Piper, expanded Durov and Stiff diagrams. Of these three types, the expanded Durov Diagram probably gives the most holistic water quality signature.

The characteristics of the different fields will be discussed briefly:

- Field 1:

Fresh, very clean recently recharged groundwater with HCO_3 and CO_3 dominated ions.

- Field 2:

Field 2 represents fresh, clean, relatively young groundwater that has started to undergo Mg ion exchange, often found in dolomitic terrain.

- Field 3:

This field indicates fresh, clean, relatively young groundwater that has undergone Na ion exchange (sometimes in Na - enriched granites or felsic rocks) or because of contamination effects from a source rich in Na.

- Field 4:

Fresh, recently recharged groundwater with HCO_3 and CO_3 dominated ions that has been in contact with a source of SO_4 contamination or that has moved through SO_4 enriched bedrock.

- Field 5:

Groundwater that is usually a mix of different types – either clean water from fields 1 and 2 that has undergone SO_4 and NaCl mixing / contamination or old stagnant NaCl dominated water that has mixed with clean water.

- Field 6:

Groundwater from field 5 that has been in contact with a source rich in Na or old stagnant NaCl dominated water that resides in Na rich host rock / material.

- Field 7:

Water rarely plots in this field that indicates NO_3 or Cl enrichment or dissolution.

- Field 8:

Groundwater that is usually a mix of different types – either clean water from fields 1 and 2 that has undergone SO_4, but especially Cl mixing / contamination or old stagnant NaCl dominated water that has mixed with water richer in Mg.

- Field 9:

Old or stagnant water that has reached the end of the geohydrological cycle (deserts, salty pans etc) or water that has moved a long time and / or distance through the aquifer or on surface and has undergone significant ion exchange because of the long distance or residence time in the aquifer.

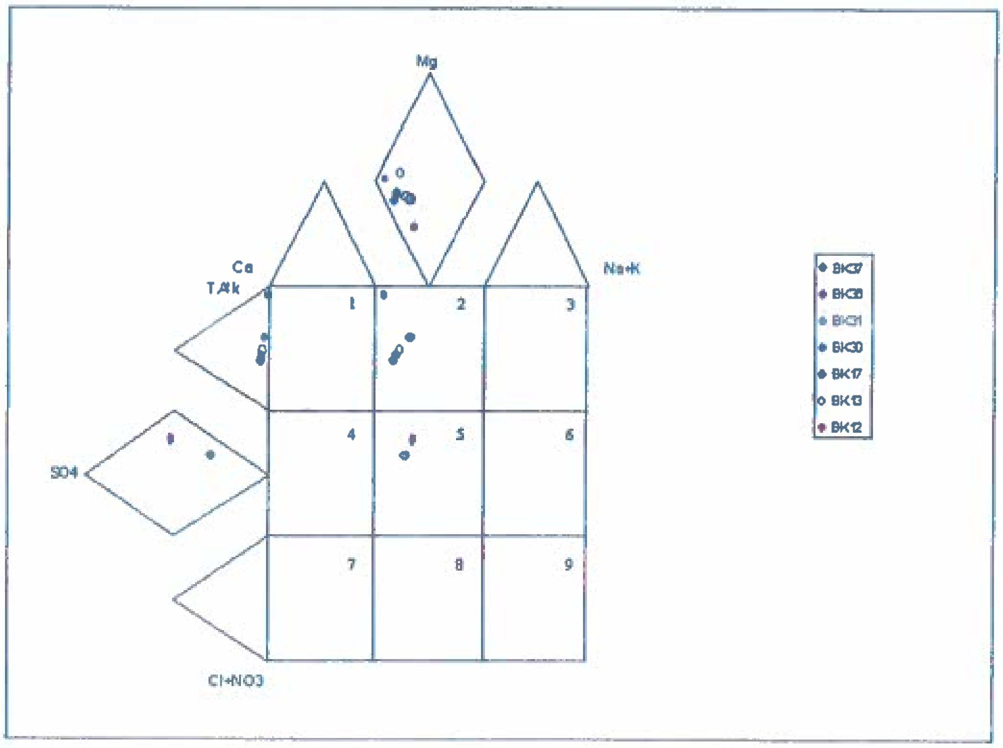

Figure 2-21: Expanded Durov diagram of water qualities in the BKM area

In spite of the large area under investigation with different aquifer types, different compartments, recharge rates and residence times, the groundwater qualities measured during the hydrocensus only plot in two different fields of the expanded Durov diagram included in Figure 2-21. As could be expected from a dolomitic terrain with calcrete surface cover in many areas, the majority of the points are grouped in field 2 of the diagram where magnesium (Mg) and bicarbonate alkalinity (HCO_3^-) are the dominating cation and anion. The only exception is boreholes BKM17 and BKM12. These boreholes are situated in the topographically lower lying areas and have the highest inorganic ion contents. BKM17 with the poorest quality overall is situated very close to the Gamagara River, which indicates both a mixture of water types and also that significant ion exchange has taken place because the borehole is far downstream in the catchment. The quality of BKM12 water is better but the borehole is also situated close to the river and thus far down in the catchment. These two boreholes have undergone the most significant ion exchange and display definite signs of mixing with other water types. BKM17 and 12 plot in field 5 of the expanded Durov diagram (please refer to field characteristic description above).

Another way of presenting the signature or water type distribution in an area is by means of Stiff diagrams. These diagrams plot the equivalent concentrations of the major cations and anions on a horizontal scale on opposite sides of a vertical axis. The plot point on each parameter is linked to the adjacent one resulting in a polygon around the cation and anion axes. The result is a small figure / diagram of which the geometry typifies the groundwater composition at the point. Groundwater with similar major ion ratios will show the same geometry. Ambient groundwater qualities in the same aquifer type and water polluted by the same source will for example display similar geometries.

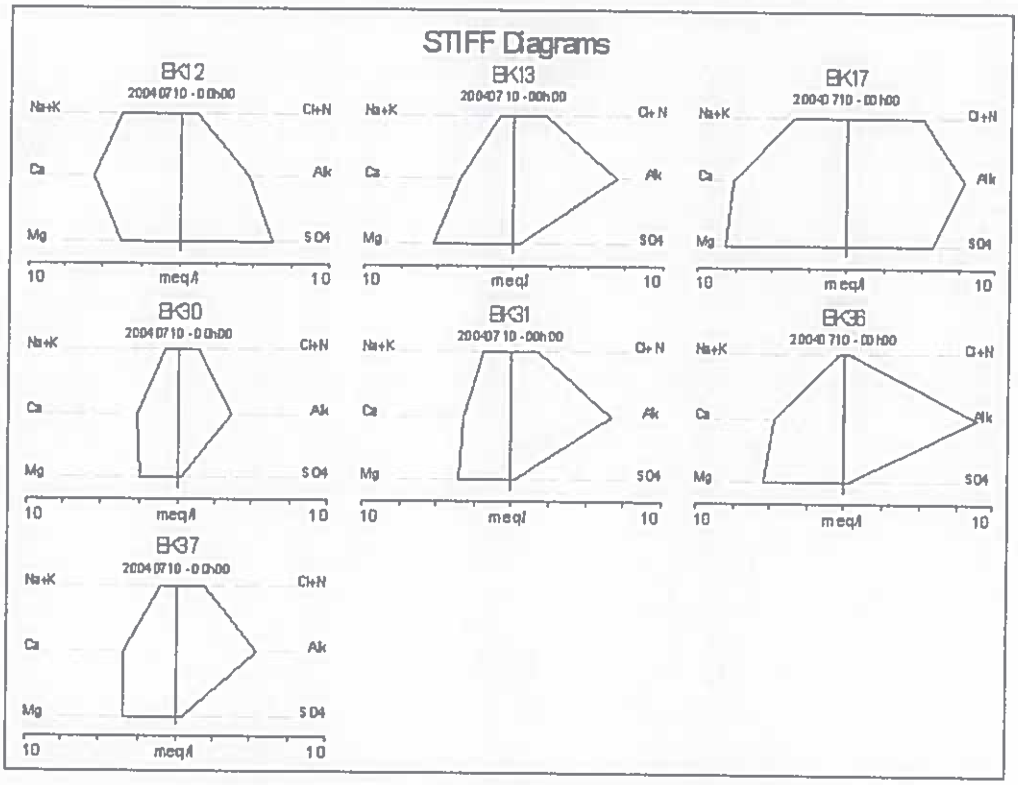

Figure 2-22: Stiff diagrams of water qualities in the BKM area

Stiff diagrams of the regional groundwater monitoring points around the proposed BKM opencast are presented in Figure 2-22. Most of the water qualities show the same geometry with BKM17 and BKM12 being the exceptions. In most boreholes Mg and $HCO3^-$ dominate the inorganic content. As with the expanded Durov diagram boreholes BKM17 and BKM12 also have Mg as dominating cation but the increased SO4 and Cl/NO3 anion contents with respect to alkalinity is evident

For the suitability of the groundwater for agricultural use (irrigation) the SAR diagram (Sodium Adsorption Ratio) is a handy tool. Sodium enrichment with respect to Ca and Mg in groundwater will present a risk of sodium accumulation in soils (especially when clayey) and cause deterioration in soil structure and increase erodibility because of dispersion reactions in the soil. Soils will form surface crusts, compaction rates will increase which will in turn cause poorer infiltration, higher runoff and more erosion. The Ca and Mg dominance of the cations results in very low SAR values for the groundwater in the area. As arable land is relatively scarce in many parts of the project area, the SAR is not considered a high priority parameter in water quality rating. From the SAR diagram in Figure 2-23 it follows that most of the regional water types present a very low risk for sodium hazard but a medium or relatively higher salinity risk. Refer to Table 2-12 (page 2-61) for the tabulated water qualities.

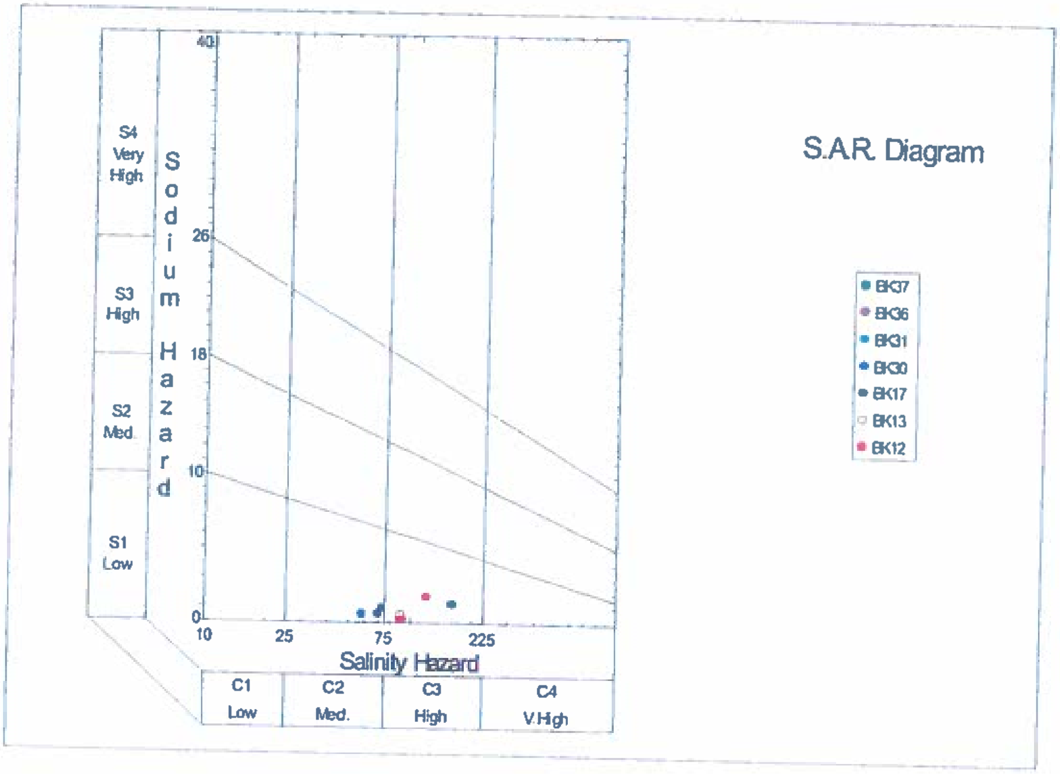

Figure 2-23: SAR diagram of water qualities in the BKM area

Table 2-12: Groundwater quality

	BK12	BK13	BK30	BK31	BK17	BK37	BK36
PH	7.5	7.4	7.6	7.6	7.2	7.5	7.4
EC mS/m	118	89.1	57.5	72.1	158	69.3	89.8
T.D.S.	848	640	438	624	1132	476	652
Ca	113	74	53	66	152	66	96
Mg	46	64	29	43	98	40	64
Hardness	472	448	252	342	783	329	503
Na	85	22	18.3	40	79	23	8.9
K	6.5	1.8	0.1	2.3	3.7	1.7	2
MAlk	228	340	180	336	396	264	444
HCO3	278	414	219	410	483	322	541
CO3	0	0	0	0	0	0	0
Cl	40	43	12.8	24	162	19.7	5.4
SO4	300	18.4	14.2	12.3	279	16.6	5.4
NO3	3.6	56	65	61	30	81	5.5
F	0.8	0.2	-0.1	0.1	0.7	0.1	-0.1
PO4	0.6	-0.1	0.6	1	0.9	0.6	0.2
NO2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
NH4-N	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Al	-0.009	-0.009	-0.009	-0.009	-0.009	0.03	0.1
Ni	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	0.005
Mn	0.08	-0.001	0.002	0.001	0.002	0.006	0.11
Fe	0.04	0.04	0.18	0.19	0.002	0.006	0.11
V	-0.002	0.006	0.005	0.02	-0.002	0.01	-0.002
Zn	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Pb	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Si	11.5	28	30	38	20	33	15.9

Note: Negative(-) values indicate parameters are below the detection limit

2.11.6 Groundwater use

The hydrocensus and water user survey showed that groundwater from boreholes and wells is used only for domestic supply and livestock watering. Farmers often tap the shallow calcrete/clay aquifer in which borehole yields vary between 0.3 and 2 l/s.

Widespread pollution or depletion of the groundwater resource will thus impact negatively not only on the resource. The users depend on the groundwater source as a sole source of domestic water, as well as water for livestock watering.

2.11.7 Groundwater zone

The following aspects would delineate the applicable "Groundwater zone":

- The thickness, soil characteristics, infiltration rate and water bearing properties of the unsaturated zone,
- The geological properties and dimensions of each unit in the geological sequence that could potentially be impacted. This includes rock type, thickness of aquifer(s) and confining units, aerial distribution, structural configuration, storativity, water levels, infiltration or leakage rate, if appropriate,
- Aquifer recharge and discharge rates,
- The direction and rate of groundwater movement in potentially impacted units,
- Groundwater and surface water relationships,
- Background water quality of potentially impacted units, and
- Potential sources and types of contamination.

2.11.7.1 Unsaturated zone

Soils in the unsaturated zone of the BKM project area are virtually non-existing. The topographically higher lying areas consist of scree and rubble rock material from weathering and the lower-lying areas are often covered by calcrete. Some areas do have sandy soils. Near the drainage and low-lying areas these soils have been preserved from erosion and are the only places where any degree of cultivation and crop irrigation is possible.

Although the calcretes at surface are very hard and seemingly impermeable, groundwater model calibration and experience of the nearby Sishen mine as well as at Postmasburg have shown that the infiltration rates are high and effective recharge through the unsaturated zone is relatively high.

Calcrete can be described as hydrophilic and retains water. Even the most solid calcrete bedrock retains water to some extent and remains moist long after rainfall events. Vegetation growth is also sustained in the unsaturated zone in the harsh climate where heat, cold and droughts are often severe.

The thickness of the unsaturated zone was determined by subtracting the Sishen Mine pre-mining static water levels in the study area from the topography. From the hydrocensus borehole water levels in Figure 2-16 (page 2-46) it is clear that the depth to water level, and thus the unsaturated zone, varies between approximately 8 and approximately 150 meters below ground level. The deeper levels are often the result of the boreholes being situated in the partly dewatered compartment of Sishen's dewatering program.

2.11.7.2 Aquifer thickness

The aquifer thickness in the mining environment is often taken as the difference between the estimated static water level of the aquifer and the base of the lowest mined reserve. In the BKM mine boundary area, such an assumption cannot be made because of mainly two reasons:

- Significant groundwater yields often occur below the deepest level of the iron ore reserves.
- Given the secondary aquifer types, the nature of the fractured rock aquifers combined with the sloping topography will result in very thick 'aquifers' in places where deep ore zones occur and in no 'aquifer' whatsoever where the iron ore is shallow or where it is situated topographically higher.

The actual 'aquifer' consists of transmissive fractures, fissures or cracks of any orientation, extent or aperture in any of the rock types underlying the site.

In the boreholes drilled in the BKM mine boundary area, few water-yielding fractures were intersected, mainly due to the area being already partly dewatered by Sishen mine. Those that were intersected occurred from approximately 35 m to a maximum depth of more than 130 mbgl. The highest groundwater yields at Sishen Mine often occur in the Wolhaarkop (chert) breccia and this formation occurs from less than 100 mbgl to more than 350 mbgl in the area. It is thus considered more accurate or appropriate to calculate the aquifer thickness from the piezometric water level to the deepest water yielding fractures in the study area. On this basis, the aquifer thickness in the BKM area varies between 20 and 300 meters if the effect of dewatering is not considered.

2.11.7.3 Generalised conceptual model

In an attempt to predict the movement of water in the subsurface, a conceptual geohydrological model of the area was postulated. The basis of such a model is the structural geological make-up of the study area.

It is likely that the geohydrological regime in the study area is made up of two aquifer systems. The first, the upper, semi-confined aquifer occurs in the calcrete or on the contact between the calcrete and underlying Kalahari clay formation, if the latter is present. This aquifer is, however, often poorly developed in the study area and only sustains livestock and domestic water supply. Where thick clay layers are developed in this aquifer, a recharge lag time to the underlying aquifer(s) often occurs.

The lesser, deeper aquifer is secondary in nature and is associated with fractures, fissures and joints and other discontinuities within the older hard rock geology of the Transvaal Supergroup and associated intrusives. The aquifer occurs at depths of between 20 and 350 meters or even deeper in the study area. Where the upper aquifer is present, mining in the BKM mine boundary area will completely destroy the aquifer but the dewatering effects will not be widespread. The most significant dewatering effect will be on the deeper secondary aquifer with higher transmissive properties and more dynamic hydraulical properties.

Rainfall related recharge entering the system will migrate vertically downwards until a perched aquifer is encountered. As the perched aquifer did not feature very prominently during drilling at the BKM Mine area it is likely that the recharging water might be temporarily retarded but the majority will continue to migrate downwards into the saturated zone. From there it will migrate in the direction of the hydraulic gradient until it eventually enters surface water bodies (i.e. rivers or springs) from where it will flow out as surface water. The lateral rate of migration usually exceeds the vertical rate and this situation also applies to the BKM Mine area.

2.11.8 Groundwater Supply

As a large-scale mining operation with associated crushing, washing and beneficiation infrastructure, the proposed BKM project will require water for numerous different processes. With the start of the Sishen iron ore mining operation, the Vaal-Gamagara water scheme was built with one of the main purposes to supply water from the Vaal River to the Sishen mining operations. The magnitude of the dewatering requirements at Sishen necessary to create dry mining conditions was not foreseen at the time of the construction of the Vaal-Gamagara pipeline. In recent years, the dewatering programs at both Sishen and further south at Assmang's

Beeshoek Mine near Postmasburg have started pumping increased volumes of water into the pipeline.

Although Sishen Mine currently discharges excess water into the pipeline, water demand from the pipeline is also on the increase. Population numbers in the Kathu area as well as the manganese mines that rely on water from the pipeline are on the increase. More importantly, however, is the fact that water pumped from the Vaal River is very expensive and projects are underway to substitute the water from the Vaal River with groundwater from the Sishen and Beeshoek mines, as far as possible.

The discussion above indicates that water for the BKM project is not available in abundance or at low cost, unless groundwater could be sourced from its own mining area. This report has already shown that the cone of depression from the Sishen dewatering program extends well past the BKM pits, although spreading of the cone is effectively contained by relatively impermeable dolerite dykes. The dewatering is thus limited to a large aquifer compartment that stretches from the central parts of Sishen Mine to approximately 3.3 km south of the southernmost pit on the farm King. The dimensions of the compartment are roughly 19 km north-south by 8 km east-west for a total area of approximately 152 km^2.

Given the aquifer types and associated yields, draw down behaviour in the BKM area, compartmentalisation and surrounding groundwater users, it is recommended that water for the plant and rest of the mining operation is sourced from within the aquifer compartment described above. The main reasons for recommending the existing aquifer compartment as source of water are:

- By far the most significant yields occur in the Wolhaarkop chert breccia that is situated in this aquifer. Borehole yields to the west of the compartments closer to the proposed plant position on Parsons are significantly lower and many boreholes will have to be developed to supply the required demand.
- The storage characteristics of the chert breccia aquifer combined with the underlying dolomites are also much higher in the aquifer compartment than for example in the lava and quartzites that constitute the aquifers to the west and outside the compartment. This means that the extent of dewatering would be more significant when the aquifers outside the compartment are pumped at the same rates as those inside the compartment with higher storage properties.
- The most important reason from an environmental perspective for recommending the utilisation of the groundwater compartment underlying the pits is the fact that existing impacts already occur in this aquifer but impacts are effectively contained within the dolerite dykes that define the boundaries

of the aquifer. Pumping outside this compartment will inevitably impact on groundwater users that are currently unaffected and such impact might not be as well contained as the existing one.

- By supplying groundwater from the King/Mokaning area, less dewatering will be required later in the mine's life because the groundwater level will already have started to decline and pumping infrastructure would be well established. Moreover, the flow characteristics in the area will be better understood through regular monitoring and dewatering design will be much more effective and accurate.

The main disadvantages of using this aquifer as a water supply source are the relatively deeper boreholes that will need to be developed and the longer piping distance from the boreholes to the plant infrastructure area. Another possible problem is that sinkhole formation might be increased through the additional pumping and draw down of the water table but this has never been a problem at Sishen mine where widespread pumping and dewatering has occurred for nearly 30 years.

In conclusion the BKM Mine design requires 800 m^3/hr for 6 000 hours per year (4.8 million m^3 per year). According to the groundwater model run for the BKM Mine, the calculated dewatering rates at the King/Mokaning pits would be in the order of 500 m^3/hr, which concludes that an additional 300 m^3/h water will be required to supply the 800 m^3/hr demand of the processing plant, which will be obtained form the southern section of the pipeline. The potential for excess water at the BKM Mine (which will require discharge, i.e. into the Vaal Gamagara) is therefore not foreseen.

2.12 Air Quality

Refer to Appendix 6.

2.12.1 Aim

The aim of the study was to undertake an air quality impact assessment for the proposed operations at BKM Mine to determine the impacts the mine will have on the surrounding environment and human health. The main objective of the study was to bring the air quality management of the proposed mining operations at BKM in compliance with proposed legislation, with specific reference to particulates.

2.12.2 Approach and Methodology

The air quality investigation comprised of two main components, viz. a baseline study and an impact assessment, and dust management plan.

The baseline study included the review of site-specific atmospheric dispersion potentials, and existing ambient air quality in the region, in addition to the identification of potentially sensitive receptors. The South African Weather Bureau has a weather station located at Kathu just north of the proposed mine, measuring hourly average meteorological data, including wind speed, wind direction and temperature. Mixing heights will be estimated for each hour, based on prognostic equations, while nighttime boundary layers will be calculated from various diagnostic approaches.

Use was made of readily available information in addition to meteorological and air quality data recorded in the vicinity of the mining site in the characterisation of the baseline condition. Where possible, existing air quality data from the region (i.e. from industries and mines) was incorporated to establish a baseline. Air quality data typically included dust fallout and particulate air concentrations. In addition, sensitive receptor areas such as residential areas, schools and hospitals, which are located within close proximity to BKM, were to be cited.

In assessing the potential impacts associated with specific sources at BKM, an emissions inventory was compiled, atmospheric dispersion simulations undertaken and predicted concentrations and depositions evaluated. All sources of fugitive dust associated with mining activities were identified and quantified for BKM. These included opencast mining operations (scraping, dozing and loading), unpaved roads utilised by mining vehicles, crushing and screening operations, areas where blasting take place and wind blown dust from open and exposed areas such as discard stockpiles and storage piles.

Dispersion modelling of all sources of fugitive dust emissions was undertaken using the US.EPA approved Industrial Source Complex (ISC) Model version 3. This model is based on the Gaussian plume equation and is capable of providing ground level concentration estimates of various average times, for any number of meteorological and emission source configurations (point, area and volume sources for gaseous or particulate emissions). The evaluation of simulated concentrations was based on ambient air quality and exposure guidelines, while predicted dust deposition levels were assessed based on acceptable dust fall limits. The comparison of predicted concentrations with ambient air quality guidelines facilitated a preliminary assessment of health risks. Based on the zones of impact, the dust fallout-monitoring network was evaluated and modified.

Particulates represent the main pollutant of concern in the assessment of opencast mining operations. Particulate matter is classified as a *criteria* pollutant, with air quality guidelines and standards having been established by various countries to regulate ambient concentrations of this pollutant. Particulates in the atmosphere may contribute to visibility reduction, pose a threat to human health, or simply be a nuisance due to their soiling potential. In assessing the health and environmental impact of particulate emissions, the composition of the particulates being released was examined.

2.12.3 Baseline Characterisation

2.12.3.1 Identification of Sensitive Receptors

The town of Kathu is located on the northern periphery of the proposed BKM mining lease area. Dingleton is directly on the western border with the mine (approximately 2.5 km to the west of Bruce) with Vlakwater, Mooihoek and Weltevreden located to the south of the mine boundary. Other nearby towns include Olifantshoek (approximately 26 km west of King and Mokaning, and 25 km west of Parsons) and Kuruman (approximately 8 km north of Bruce) (Refer Figure 1.3). These will be included as sensitive receptor areas in the vicinity of the proposed BKM mine.

The general topography of the area is characterised by fairly flat terrain with no steep inclines except for the two mountain ranges to the west (Langberg range) and a smaller range to the east (Kuruman Heuwels).

2.12.3.2 Identification of Existing Sources of Emission in the vicinity of the proposed BKM Mine

There are not many sources of air pollution within the region besides the mining operations. Source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants which may be of importance in terms of cumulative impact potentials. The main types of sources include:

- Fugitive emissions from mining operations (Sishen Iron Ore mine and other smaller mines)
- Vehicle tailpipe emissions (the R27 running on the eastern and southern side of the mining property area and various smaller roads)
- Household fuel combustion (particularly coal and wood used by smaller communities)

- Biomass burning (veld fires in agricultural areas within the region)
- Various miscellaneous fugitive dust sources (agricultural activities, wind erosion of open areas, vehicle-entrainment of dust along paved and unpaved roads).

2.12.3.3 Mining operations

Fugitive emissions from opencast and underground mining operations mainly comprise of land clearing operations (i.e. scraping, dozing, and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas and drilling and blasting. These activities mainly result in fugitive dust releases with small amounts of NO_x, Carbon Monoxide, Sulphates, and Methane, Carbon Dioxide being released during blasting operations.

The most significant mine located near the proposed BKM Mine is Sishen Iron Ore Mine directly to the west and north of BKM. Sishen proposes to expand their operations to 47 million tons of iron ore production per year (http://www.mbendi.co.za). Sishen Iron Ore Mine is a significant source near BKM and would contribute to the cumulative impacts in the region. It is proposed that Dingleton will be relocated due to the Sishen expansion.

2.12.3.4 Biomass burning

Crop-residue burning and general wild fires (veld fires) represent significant sources of combustion-related emissions associated with agricultural areas. The quantity of dry, combustible matter per unit area is on average 4.5 ton per hectare for savannah areas.

Biomass burning is an incomplete combustion process with carbon monoxide, methane and nitrogen dioxide being emitted during the process. About 40 % of the nitrogen in biomass burning is emitted as nitrogen, 10 % remains in the ashes and it is assumed that 20 % of the nitrogen is emitted as higher molecular weight nitrogen compounds. The visibility of smoke plumes from vegetation fires is due to their aerosol content.

2.12.3.5 Vehicle tailpipe emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HCs), sulphur dioxide (SO_2), oxides of nitrogen (NO_x), particulates and lead. Secondary pollutants include: nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid and nitrate aerosols. Toxic hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85 % to 90 % of benzene emissions emanating from the exhaust and the remainder from evaporative losses.

2.12.3.6 Household fuel combustion

It is likely that certain households within local communities are likely to use coal or wood for space heating and/or cooking purposes. Based on the resources in the Northern Cape it is most likely that the main source of fuel would be wood. Pollutants arising due to the combustion of wood include respirable particulates, carbon monoxide and sulphur dioxide with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde. Coal burning emits a large amount of gaseous and particulate pollutants including SO_2, heavy metals, total and respirable particulates including heavy metals and inorganic ash, CO, polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene, NO_2 and various toxins. Pollutants from wood burning include respirable particulates, NO_2, CO, PAHs (benzo(a)pyrene and formaldehyde). Particulate emissions from wood burning have been found to contain about 50 % elemental carbon and about 50 % condensed hydrocarbons.

2.12.3.7 Fugitive Dust Sources

Fugitive dust emissions may occur as a result of vehicle entrained dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling) and mining.

The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and on the silt loading on the roadways. The extent, nature and duration of agricultural activities and the moisture and silt content of soils is required to be known in order to quantify fugitive emissions from this source. The quantity of wind blown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

Fugitive dust emissions from *tailings impoundments* are associated with the nearby Sishen Mines.

2.12.3.8 Ambient Air Quality and Dustfall Data

Particulates represent the main pollutant of concern in the assessment of opencast mining operations. Particulate matter is classified as *criteria pollutant*, with ambient air quality guidelines and standards having been established by various countries to regulate ambient concentrations of this pollutant. Particulates in the atmosphere may contribute to visibility reduction, pose a threat to human health, or simply be a nuisance due to their soiling potential.

In this study, reference is made to data from Sishen Iron Ore Mine's existing ambient air monitoring network and dust fallout network, which have been in place since 2002. PM10 concentrations are recorded at six locations around the Sishen mining property, mainly within residential areas (Liebenberg-Enslin, 2004). The dust fallout network comprises directional dust buckets (collecting dust from the four predominant wind directions) at eleven sites around the mining boundary with two sites within the mining property. Both ambient monitoring and dust fallout monitoring were conducted by Gerry Kuhn Consultants (Liebenberg-Enslin, 2004). In addition, a dust fallout network comprising of 10 single dust fallout buckets has been installed at the proposed BKM mine. GCS is managing the network and dust fallout data has been reported since mid-October 2004. The locations of the dust fallout buckets for both Sishen and BKM and the PM10 samplers are indicated in Figure 2-24 (page2-72).

In order to assess monitored data, ambient concentrations are typically screened against guidelines and standards. The latter are provided for specific averaging periods to determine compliance. Air quality monitoring is however conducted to meet various objectives, and depending on the objective the monitoring equipment and methodology will be established. The main objectives of ambient air quality monitoring and dust fallout include the following:

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

It is clear that the main objectives of the monitoring network at Sishen Mine are to assess temporal and spatial trends, and to track progress made by control measures, provided the monitoring periods are on average over a 14 day period for both PM10 concentrations and dust fallout levels (Liebenberg-Enslin, 2004). The dust fallout network at BKM serves as compliance assessment monitoring, to assist in source apportionment once the mine is operational and reflect both spatial and temporal trends.

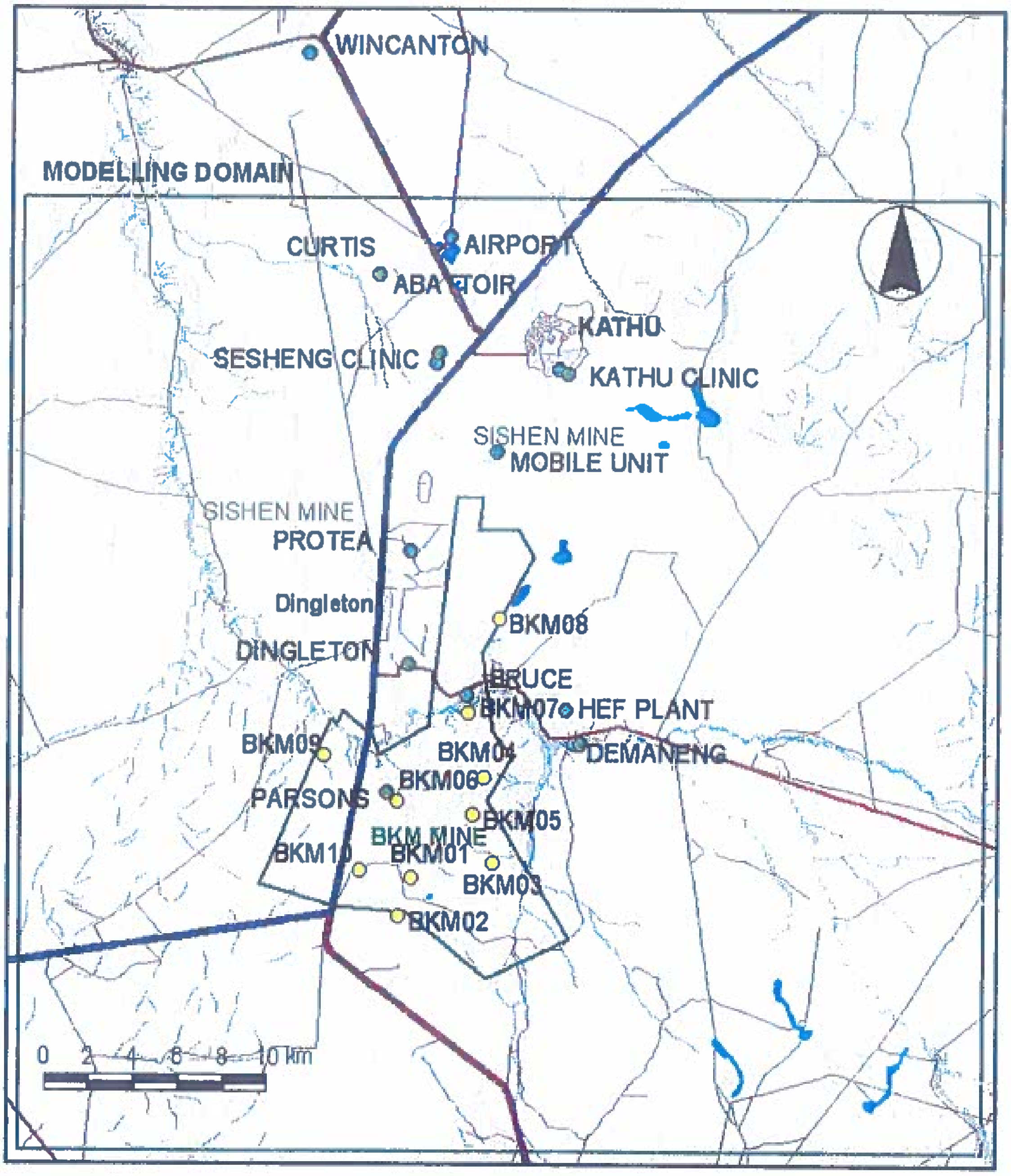

Figure 2-24: Locations of the dust fallout and ambient monitoring network for Sishen Mine and for the proposed BKM Mine

2.12.3.9 Monitored Air Quality Data from Sishen Mine

For monitored air quality data, ambient PM10 concentrations were continuously recorded, and the analysis done for 14-day periods. The monthly average PM10 concentrations recorded from April 2003 to March 2004 are shown in Figure 2-25 to Figure 2-30 (page 2-73 to 2-76). No data for July 2003 and August 2003 were available, thus the averaging periods of the PM10 monitoring could be used for compliance assessment but could only be used for analysis of the spatial and temporal trends.

Monthly averages concentrations exceeding 50 µg/m³ were recorded during May 2003, June 2003 and September 2003 at Dingleton. The PM10 concentrations above 40 µg/m³ were found to occur at Kathu (June 2003 and October 2003), at Sesheng (September and November 2003), and at Demaneng (June and September 2003). The majority of 2003 was marked by the highest concentrations of PM10 at Dingleton. The 2004 recording indicated a significant reduction in PM10 concentrations.

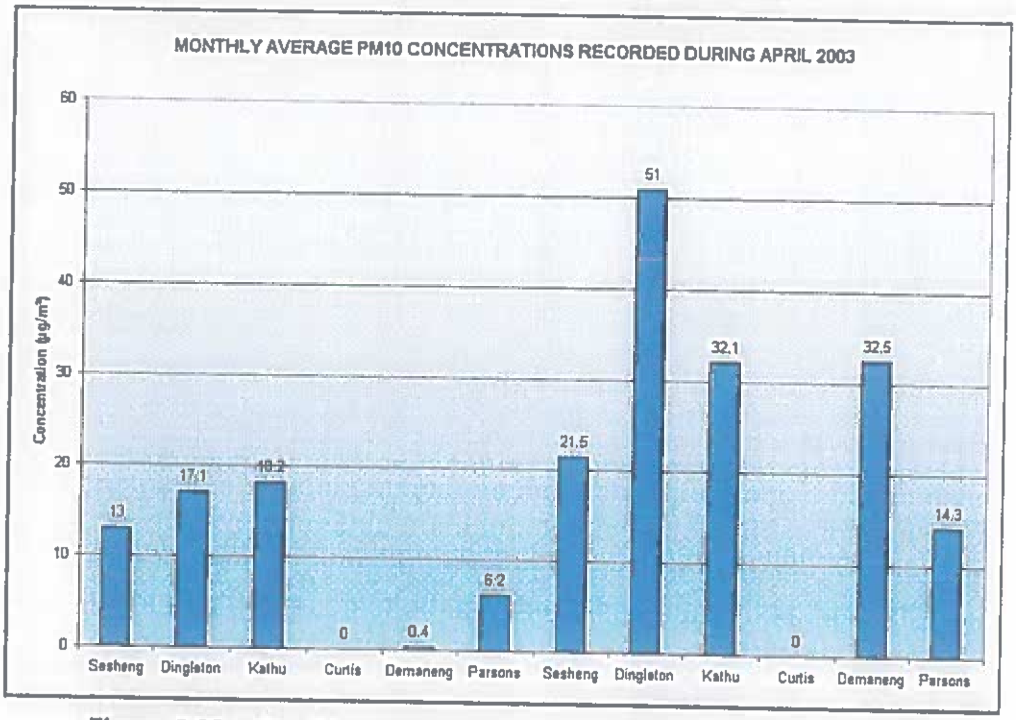

Figure 2-25: Monthly average PM10 concentrations (µg/m³) for April 2003. Credit: Liebenberg-Enslin, 2004

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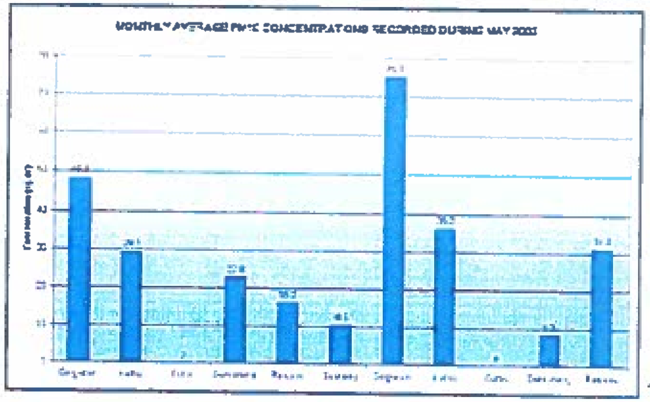
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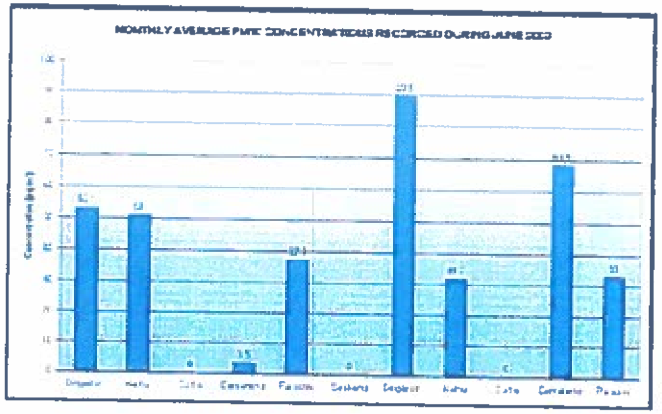
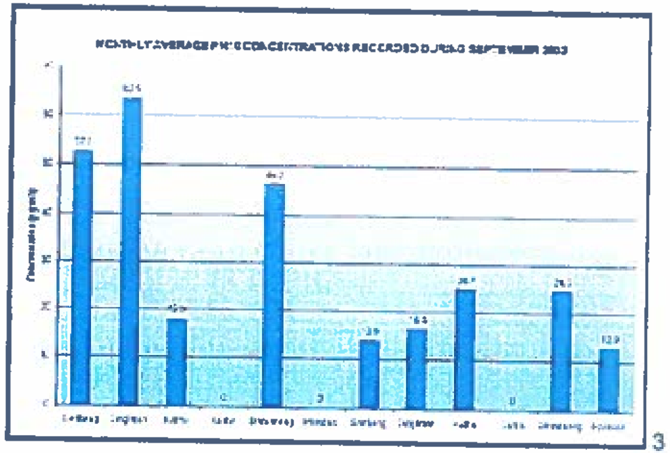

2

Figure 2-26 (1) and (2): Monthly average PM10 concentrations (µg/m³) for May and June 2003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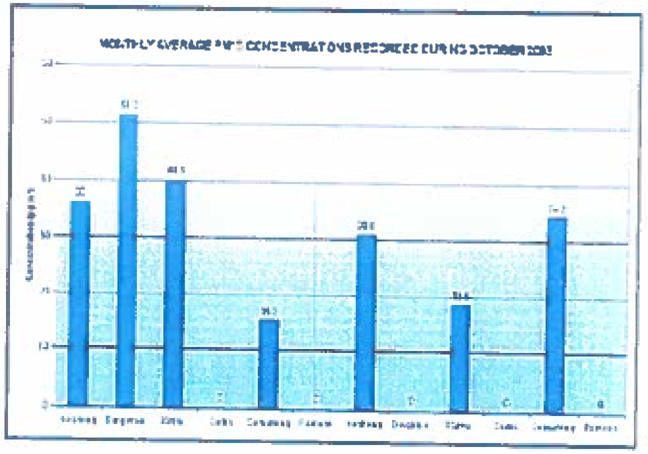
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Figure 2-27 (3) and (4): Monthly average PM10 concentrations (µg/m³) for September and October 2003

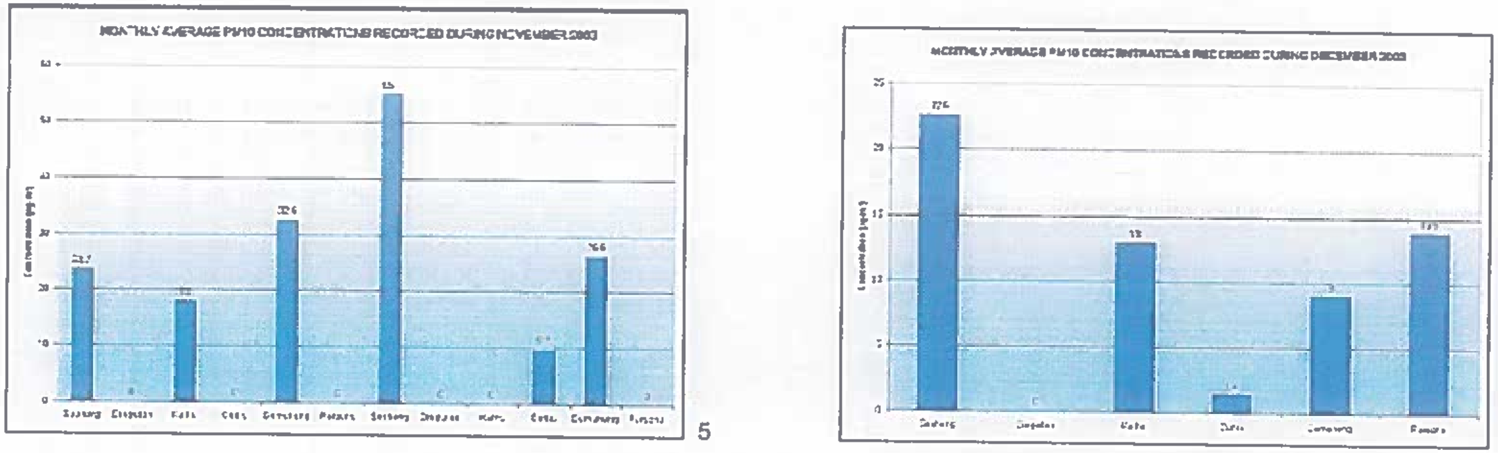

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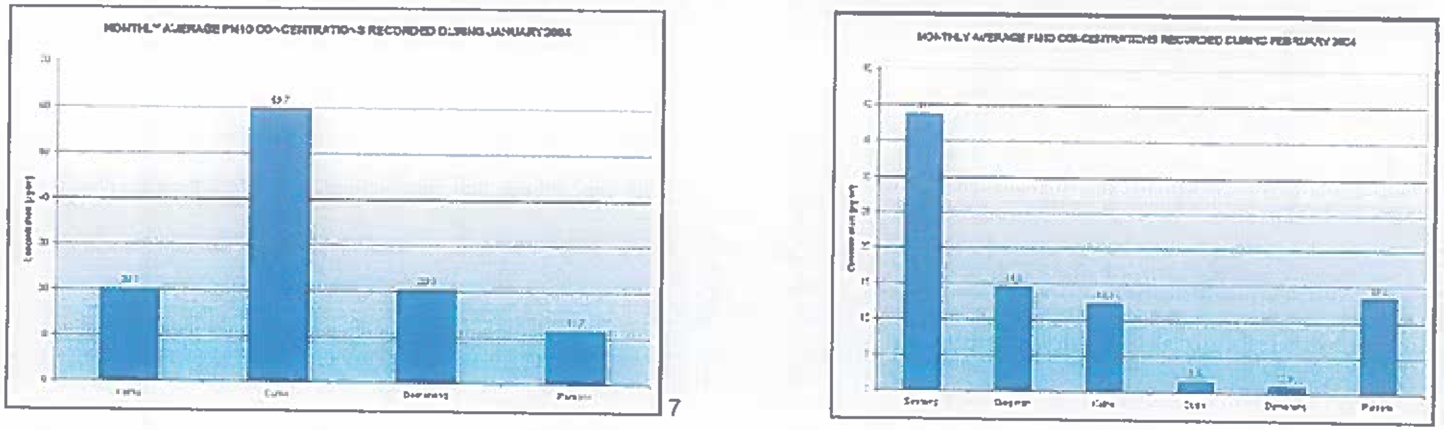
Figure 2-28 (5) and (6): Monthly average PM10 concentrations (µg/m³) for November and December 2003



7 8

Figure 2-29 (7) and (8): Monthly average PM10 concentrations (µg/m³) for January and February 2004

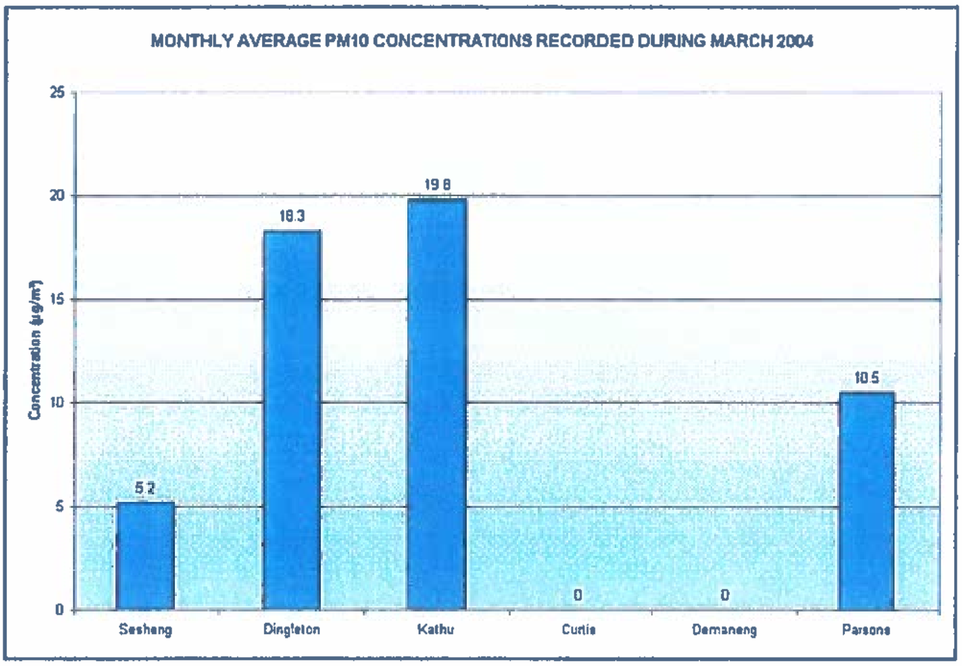


Figure 2-30: Monthly average PM10 concentrations (µg/m³) for March 2004

2.12.3.10 Dust fallout data from Sishen Network

Some of the dust fall data used for this study was from the SEP project conducted on behalf of Sishen Mine (Liebenberg-Enslin, 2004). The other data was obtained from Sishen for the remaining period of April 2004 to January 2005. In the analysis of such data, reference was made to the dust fall categories published by the DEAT (Refer to Section 3.2 of Appendix 6). However, the dust fallout data should also be used to determine the spatial and temporal trends and to assist as performance indicators for mitigation measures applied.

Wind directional dust buckets are called DustWatch. These comprise of four cylindrical containers, which are half-filled with de-ionised water that is treated with inorganic biocide to prevent algae growth in buckets. The buckets are also covered with a net and a ring that is raised above the rim to prevent contamination from birds perching, and are exposed for one calendar month (~30 days). Only one bucket is exposed to the atmosphere at any given time and this is determined by the direction the wind is blowing as shown in Figure 2-31 (page 2-77).

Monitoring for dust deposition data at Sishen mine was undertaken during the period September 2002 to January 2005 at 11 sites and measurements are being continued at these sites. Dust deposition data from these sites was analysed by Gerry Kuhn consultants and results for these periods are presented. The locations of these sites are listed in Table 2-13 and will be discussed in the subsequent subsection. The results are presented in Figure 2-32 to Figure 2-34 (pages 78 to 80).

Table 2-13: Names of the Dust Fallout Sites

Off-Site locations		On-site locations
Sesheng	Kathu	Mobile unit [1]
Airport	Wincanton	HEF plant
Lyllyveld	Demaneng	
Parsons	Dingleton	
Curtis		

Note: [1] The mobile unit was moved to its current location in January 2004.

The DustWatch system allows for the collection of dust from only one of the four main wind directions, which acts as an indication of key contributing sources at any time. The system is, however not linked to an anemometer and therefore the frequency of exposure to a certain wind sector cannot be determined. Once returned to the laboratory the water is filtered and the residue dried before the insoluble dust is weighed.

Figure 2-31: A DustWatch Unit at Sishen Mine

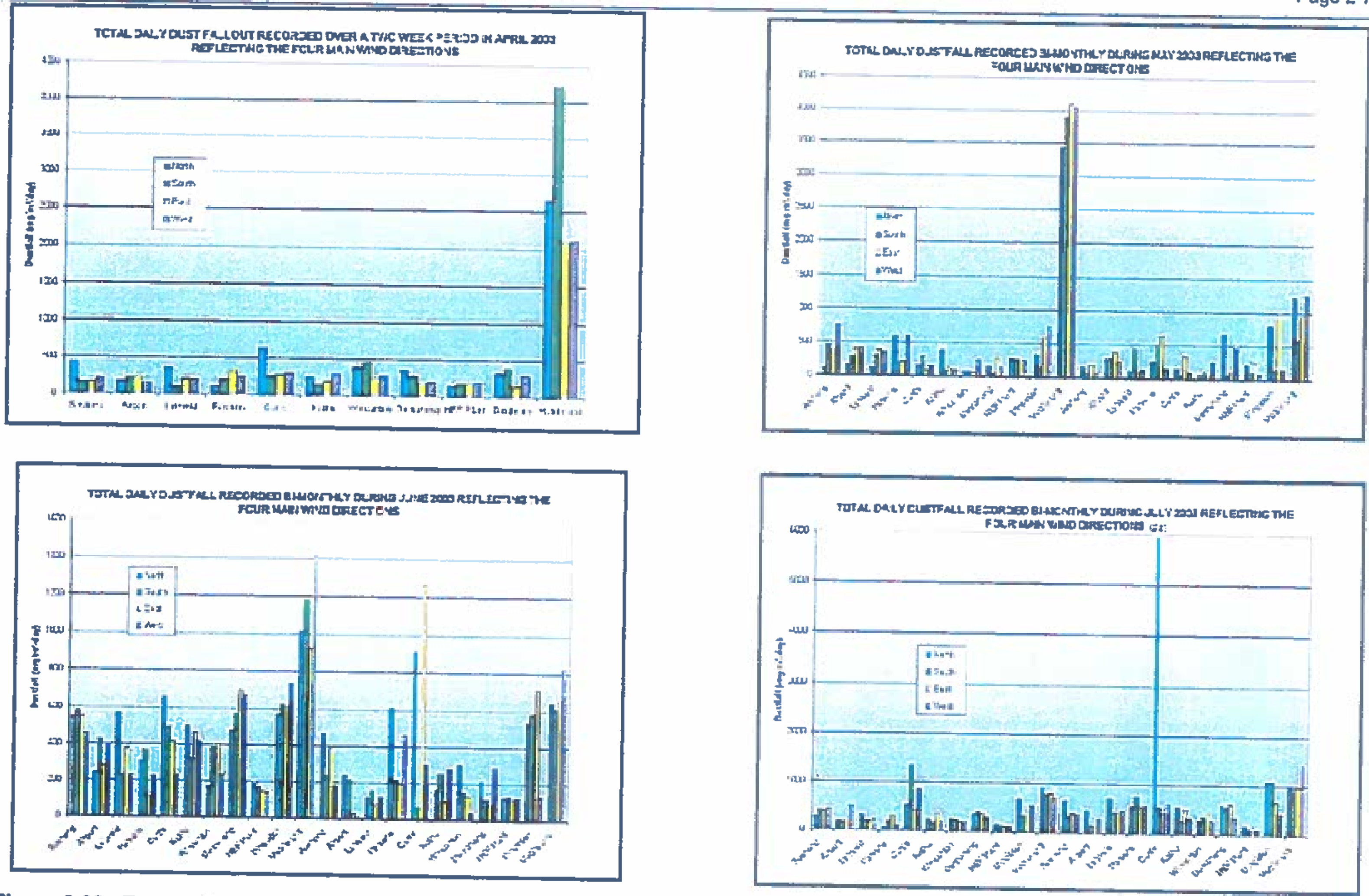


Figure 2-32: Total daily dustfall (mg/m²/day) for the four main wind direction for April 2003, May 2003, June 2003 and July 2003

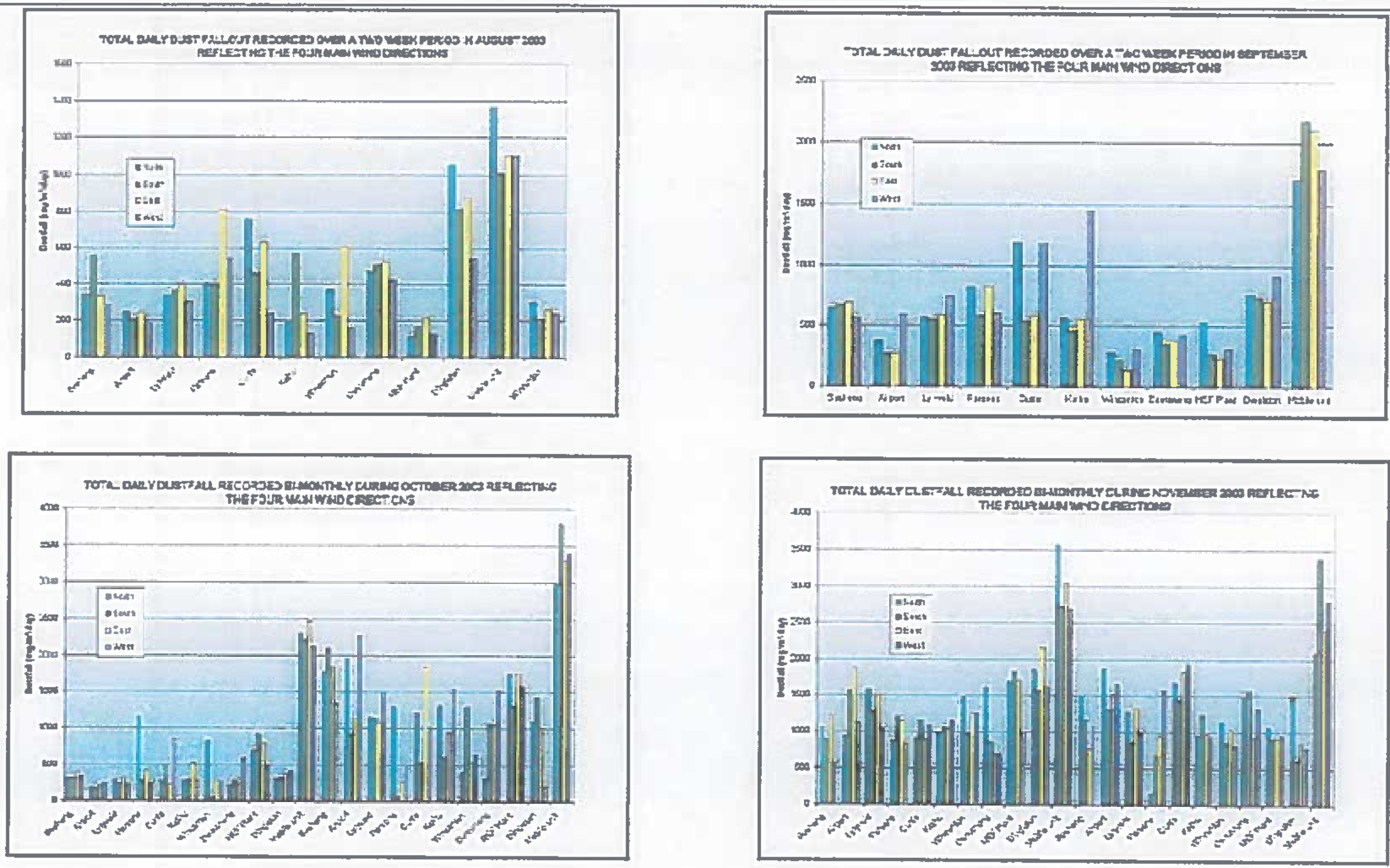


Figure 2-33: Total daily dustfall (mg/m²/day) for the four main wind direction for August 2003, September 2003, October 2003 and November 2003

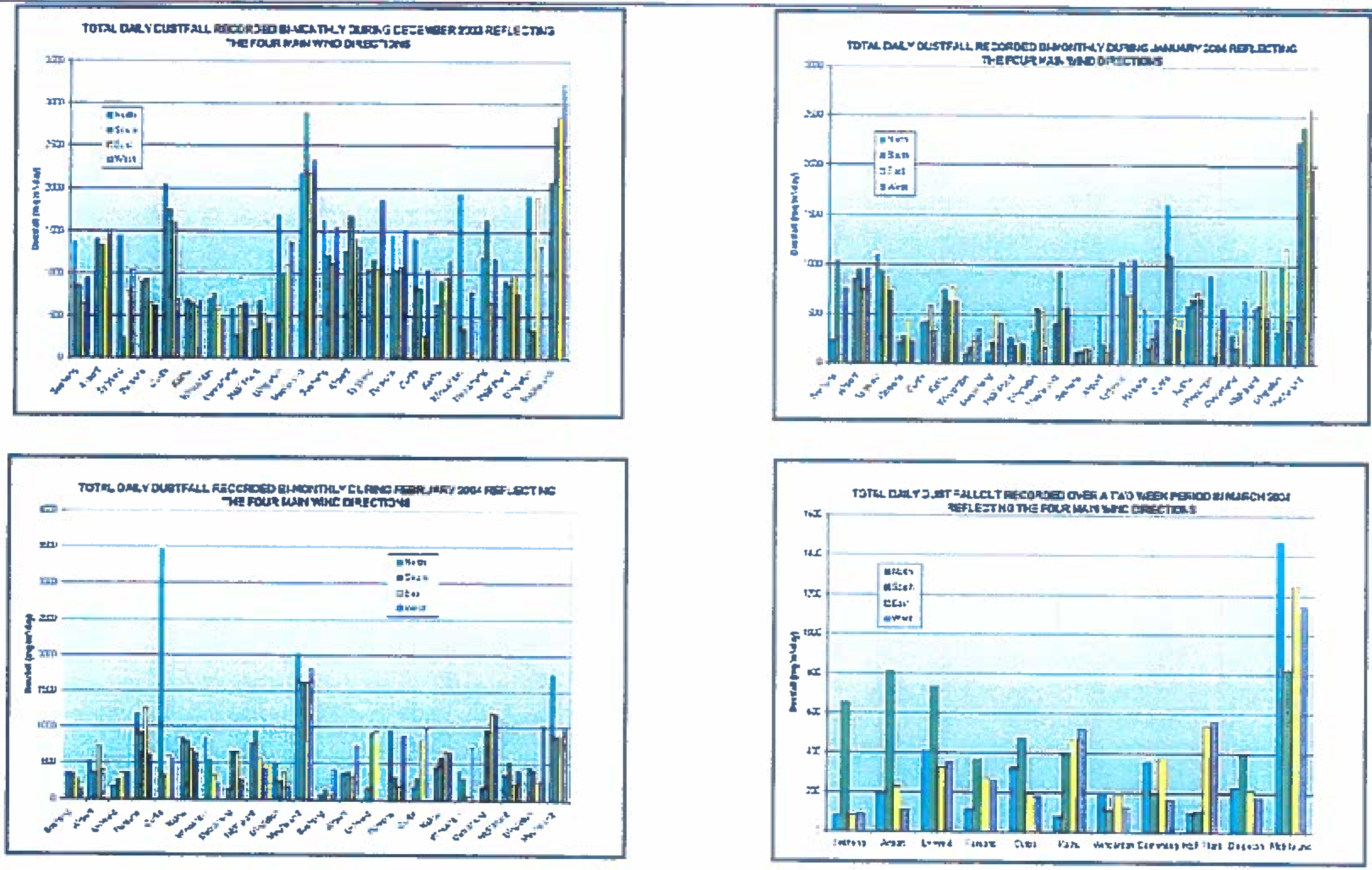


Figure 2-34: Total daily dustfall (mg/m²/day) for the four main wind directions for December 2003, January 2004, February 2004 and March 2004

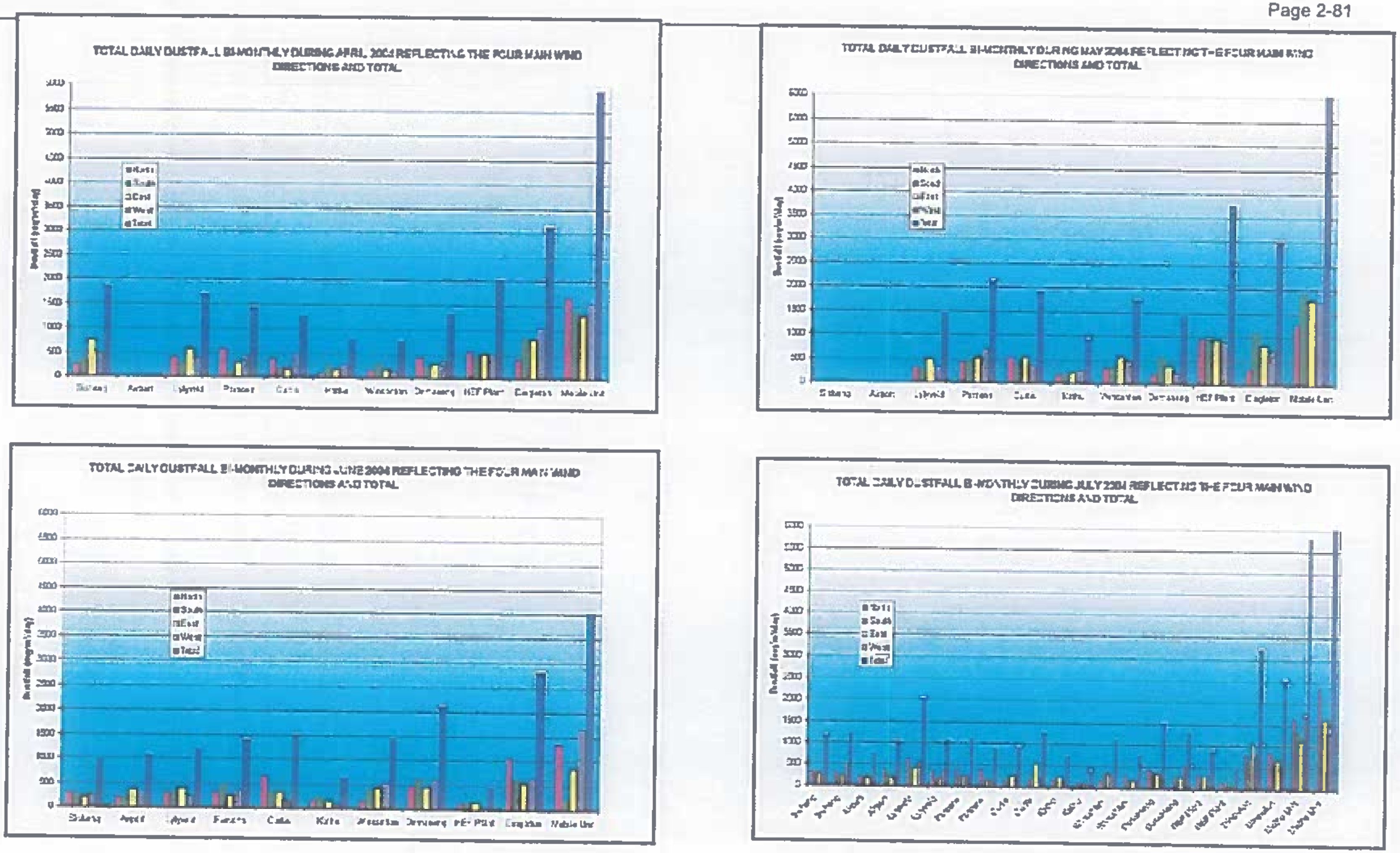


Figure 2-35: Total daily dustfall (mg/m²/day) for the four main wind directions for April 2004, May 2004, June 2004 and July 2004

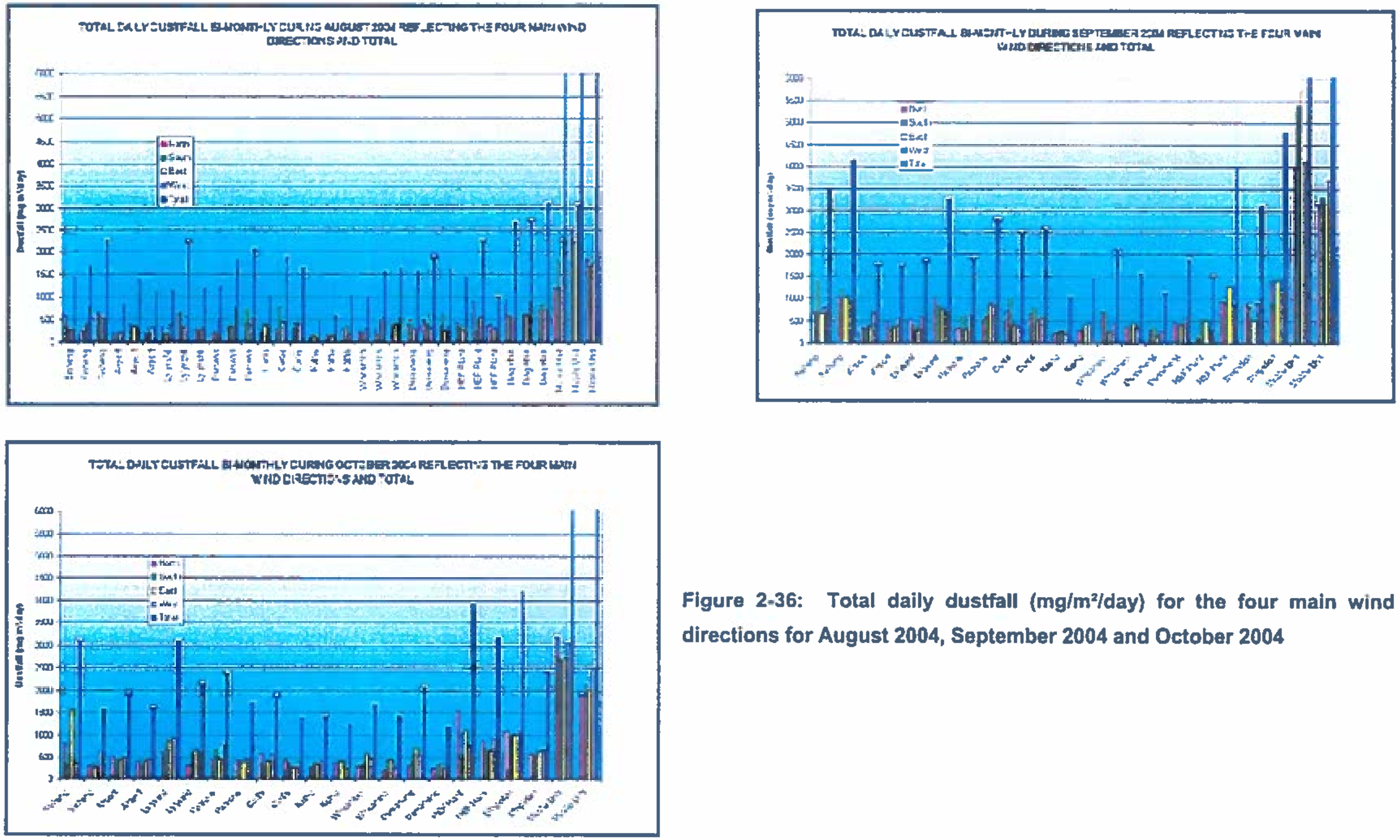


Figure 2-36: Total daily dustfall (mg/m²/day) for the four main wind directions for August 2004, September 2004 and October 2004

Figure 2-32 to Figure 2-36 (pages 2-79 to 2-83) present the dust fallout collected during each month for the four predominant wind directions from April 2003 to October 2004. The data was used to indicate the main sources contributing to the dust fallout at each monitoring station. There was no data recorded from Sishen and Airport for months of April and May (2004) respectively.

It has been observed that for all eleven stations around the Sishen Iron Ore mine, the dust fallout levels are within the moderate (250 mg/m²/day to 500 mg/m²/day) to VERY HEAVY (> 1 200 mg/m²/day) fallout categories as specified by DEAT. The highest levels are recorded at the Mobile Unit, which is onsite next to the main haul road. There is no change in main contributing wind direction at each station, just like the scenarios at Sishen Report (Liebenberg-Enslin, 2004). However, most of the monitoring sites depicted dust fallout above the DME threshold level for action.

2.12.3.11 Ambient Air Quality and Dust fall Data from BKM

A dust fallout-monitoring network, comprising of 10 single dust fallout buckets for the proposed BKM Mine, was initiated on the 12th of October 2004 by GCS. Single bucket fallout monitors are deployed following the American Society for Testing and Materials standard test method for collection and analysis of dust fall (ASTM D1739) (Egami *et al.*, 1989). This method employs a simple device consisting of a cylindrical container half-filled with de-ionised water exposed for one calendar month (~30 days) (Figure 2-37). The water is treated with an inorganic biocide to prevent algae growth in the buckets. The buckets are also covered with a net and a ring that is raised above the rim, to prevent contamination from birds perching. Once returned to the laboratory the water is filtered and the residue dried before the insoluble dust is weighed.

Figure 2-37: Single dust bucket monitors as established for BKM Mine

Dust fallout data from the proposed BKM network has been provided by GCS for the months of October 2004 to January 2005. The project only commenced in October, so unfortunately the critical months of July to September were excluded, which is known to be a significantly windy period of the year. Three sampling periods were completed and the results are included in Table 2-14 with the plots presented in Figure 2-38 (page 2-85) to Figure 2-40 (page 2-86).

Table 2-14: Dust fallout bucket sites at proposed BKM Mine (GCS, 2005)

Point ID	Dust Fallout (mg/m²/day)			
	RUN 1	RUN 2	RUN 3	Average
BKM 01	126.8	94.41	115.52	112.24
BKM 02	107.41	57.02	66.23	76.89
BKM 03	80.55	145.35	141.73	122.54
BKM 04	74.03	71.23	82.96	76.07
BKM 05	84.77	84.98	92.55	87.43
BKM 06	91.64	108.48	125.78	108.63
BKM 07	96.71	110.14	84.95	97.27
BKM 08	172.82	128.73	100.65	134.07
BKM 09	129	129.15	106.57	121.57
BKM 10	55.66	95.44	67.57	72.89

For all ten stations around the proposed BKM Iron Ore mine, the dust fallout levels are within the SLIGHT (< 250 mg/m²/day) fallout categories as specified by DEAT for all 3 months considered. Interestingly, the site locations for BKM07 and BKM06 are similar to those of Lylyveld and Parsons from the Sishen network, respectively. The Lylyveld buckets however recorded dust fallout within the SLIGHT to HEAVY range for both two weekly periods recorded whereas BKM07 indicated SLIGHT fallout for the same period (97 mg/m²/day). Parsons also recorded high dust fallout levels within the MODERATE to HEAVY dust fallout categories with BKM06 also in the SLIGHT category (92 mg/m²/day).

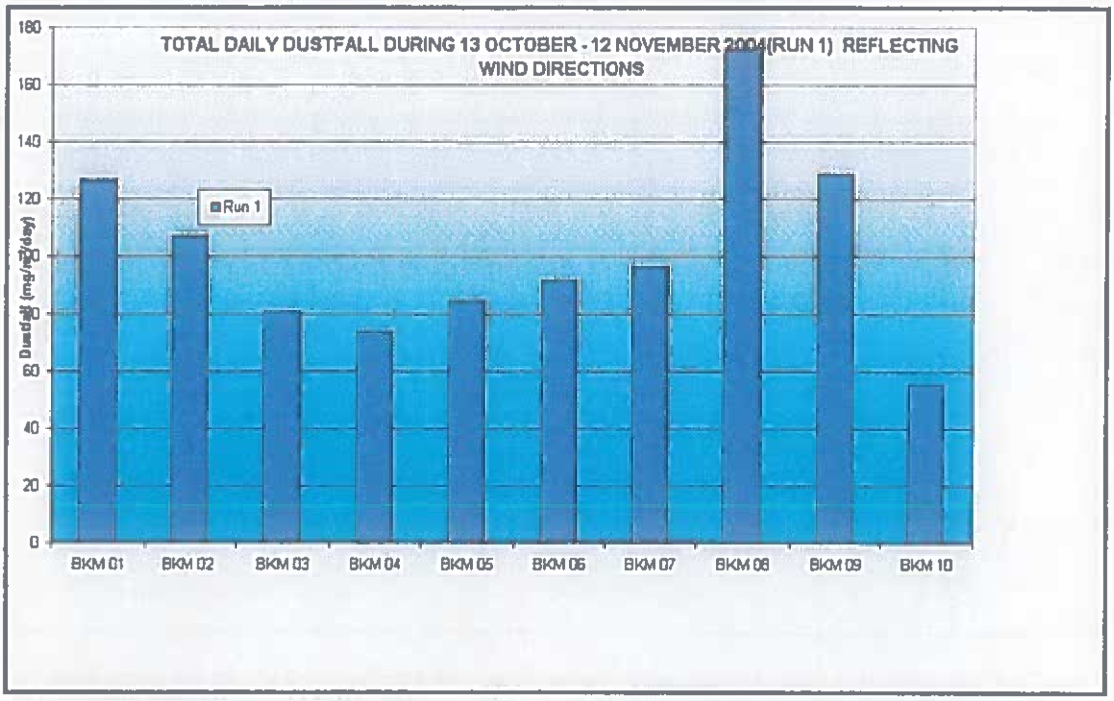


Figure 2-38: Total daily dustfall (mg/m²/day) for October 2004 to November 2004

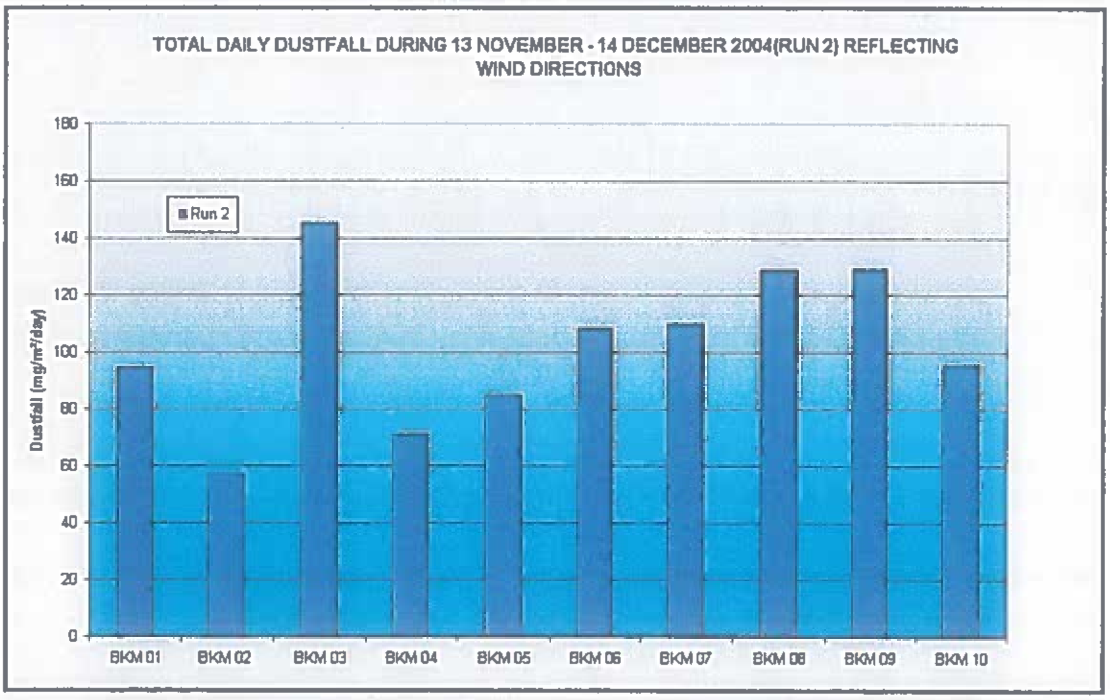


Figure 2-39: Total daily dustfall (mg/m²/day) for November 2004 to December 2004

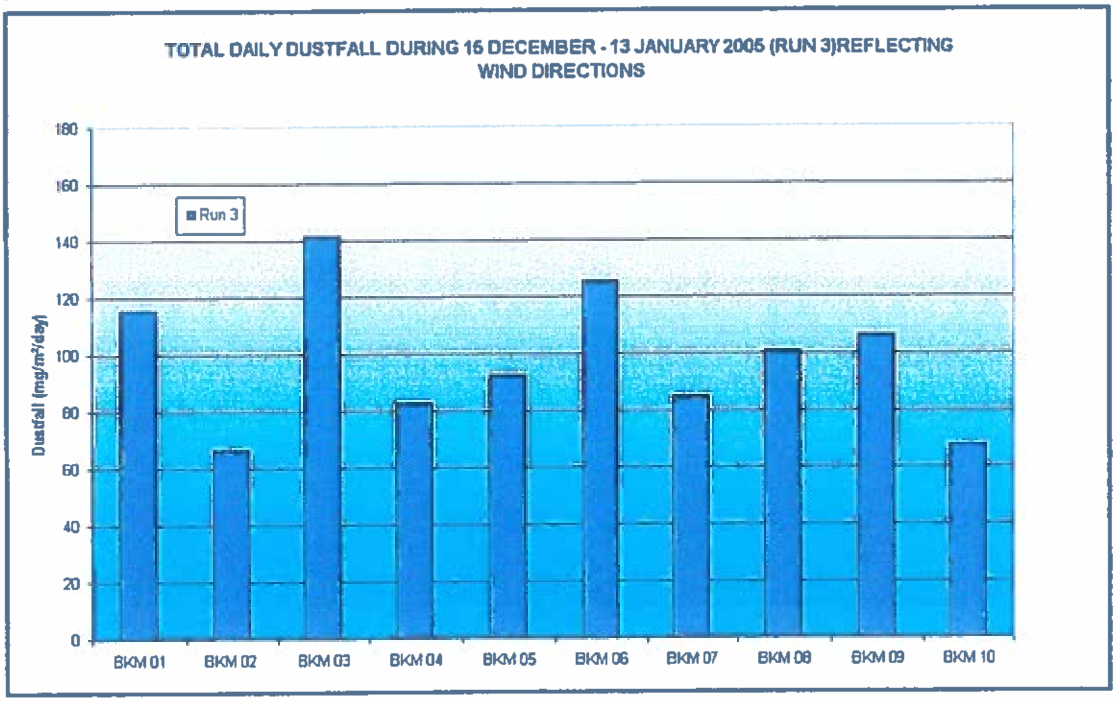


Figure 2-40: Total daily dustfall (mg/m²/day) for December 2004 to January 2005

2.13 Noise

Refer to Appendix 7.

2.13.1 Aim

The noise emissions from the highly mechanised equipment and processes associated with opencast mining are likely to have an impact on the rural character of the surrounding environment.

Therefore, it is the purpose of this report to quantify the impact noise emissions associated with the BKM Mine will have on the typical existing ambient noise levels.

2.13.2 Approach and Methodology

2.13.2.1 Measurement of Ambient Noise Levels

The present ambient noise levels were measured at two locations during the day and night in the noise sensitive rural area to the West of the development site of the BKM Mine:

- Measurement Point 1: On the tarred road that turns off the N14 in a northerly direction, approximately 200 m north of the road bridge over the Sishen – Saldanha railway line.
- Measurement Point 2: On the gravel road leading onto the Dingle farm area, approximately halfway between the Dingle and Bredenkamp farmsteads.

All the measurements were taken in accordance with the procedures specified in SANS 10103[1]. Notes were made of the subjective impressions of the ambient noise levels and dominant sources of noise during each sampling period.

A map indicating the locations of the measurement points is given in Figure 2-41 (page 2-88).

A list of the measurement instrumentation is given in Appendix A of the Noise Report (Refer to Appendix 7).

2.13.2.2 Estimation of Present Ambient Noise Levels

The measurement results and the guidelines given in SANS 10103[1] were used to estimate the current ambient noise levels during the day (06:00 to 18:00) and night (18:00 to 06:00). For this the approach was to make a conservative estimate of the pre-development ambient noise levels, i.e. one that would tend to over estimate the impact of noise emissions from the BKM Mine.

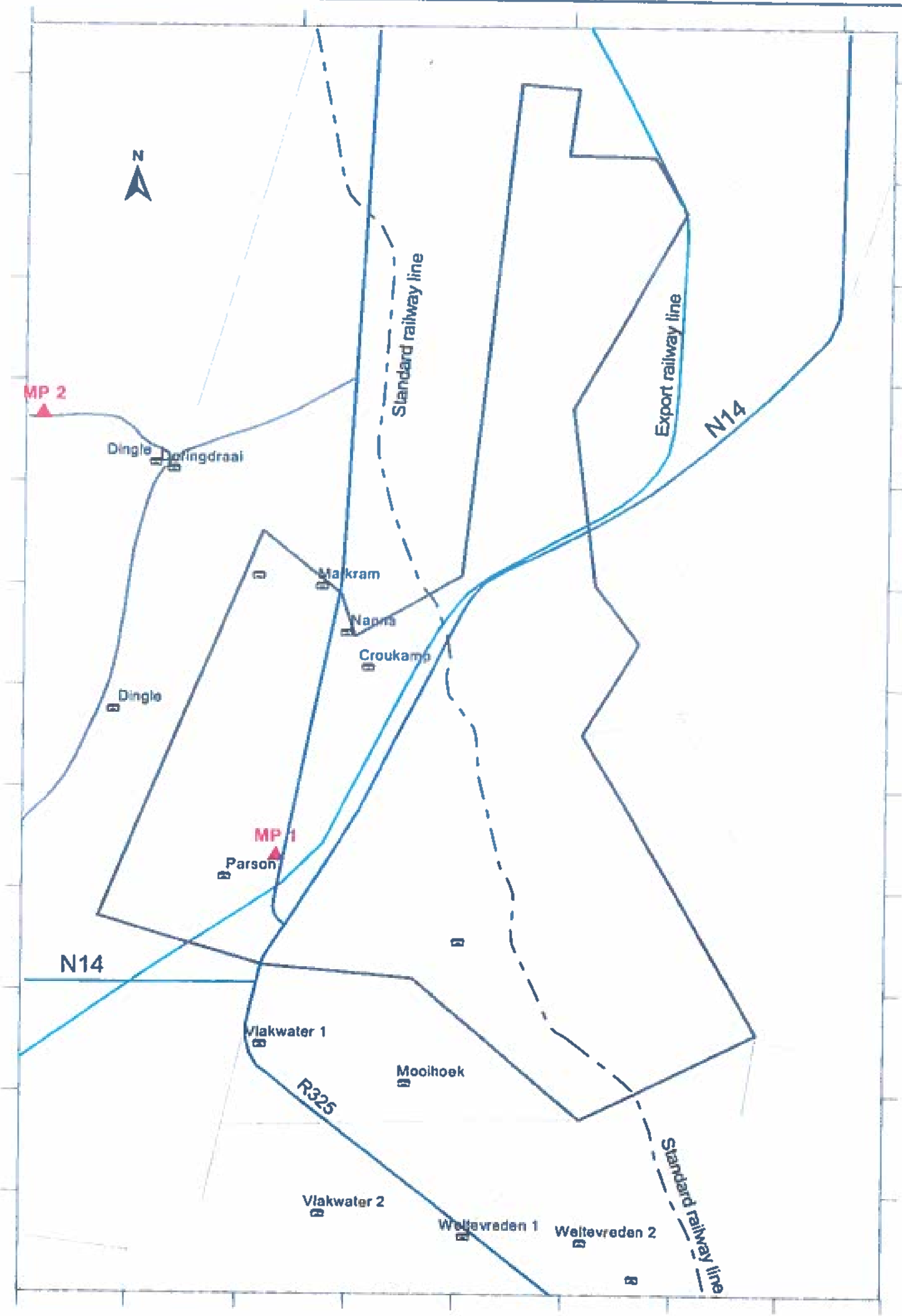


Figure 2-41: Map Indicating the location of the measurement points

2.13.2.3 Measurement of Equipment Noise Levels

Additional measurements of equipment and process noise emission levels were taken at the existing plant at Beeshoek Mine near Postmasburg. These measurements were used to estimate the octave band sound power emission levels that could be used in the noise prediction model.

The following equipment was measured:

- Primary crusher
- Secondary crusher
- Tertiary crusher
- Washing plant
- Load out station

The calculated sound power emission levels are listed in Appendix B of the Noise Report.

2.13.2.4 Calculation of Future Ambient Noise Levels

The detailed model for the BKM Mine and the surrounding environment was developed, and the propagation of noise calculated in accordance with the procedures described in SANS 10357[2]. The model included the following details:

- The acoustical ground conditions between source and receiver. It was assumed that the %age of acoustically 'soft' ground is 50 %.
- The average minimum and maximum temperatures: 5 °C and 31 °C (South African Weather Service).
- The average minimum (pm) and maximum (am) relative humidity: 20 % and 70 % (BBC World Weather Service).
- The average static air pressure: 89 kPa.
- Wind speed and direction: 2 m/s W (i.e. blowing in a westerly direction).
- The diurnal atmospheric conditions.
- The octave band sound power emission levels of the equipment and processes.
- The operational details of the mining operations.
- Sites of Archaeological and Cultural Interest.

- Sensitive Landscapes.
- Visual Aspects.

2.13.2.5 Investigated Scenario

The following scenarios were investigated:

- Scenario 1: The construction period.
- Scenario 2: Mining operations in the King West 2 and North, Bruce A South and Central, and Bruce C West pits.
- Scenario 3: Mining operations in the King West and Central, Bruce C Central and North, and Bruce A North pits.
- Scenario 4: Mining operations in the King East and East 1, Bruce B South, Central and North pits.

2.13.2.6 Assessment and Expression of the Noise Impacts

The noise impacts were assessed in terms of the guidelines provided in SANS 10103[3] and the Noise Regulations applicable in the North-West Province[3].

SANS 10103[1] was issued in 2003 and conforms to the guidelines of the World Health Organisation[4]. In accordance with these documents the ambient noise level in any residential area, averaged over the period of respectively a day (06:00 to 22:00) and night (22:00 to 06:00), should not exceed 55 dBA and 45 dBA.

Therefore, the impact of noise emissions from the BKM Mine was expressed as contours of the resulting total ambient noise level, i.e.:

- 40 dBA or less;
- 45 dBA;
- 50 dBA;
- 55 dBA; and
- 60 dBA or more

Table 5 of SANS 10103[1] provides a useful guideline for estimating a community's reaction to increases in the ambient noise level due to an intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- **Δ ≤ 0 dBA:** An increase of 0 dBA or less will not cause any response from a community. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level will not be noticeable.
- **0 < Δ ≤ 10 dBA:** According to Table 5 of SANS 10103[1], an increase of between 0 dBA and 10 dBA will elicit 'little' community response with 'sporadic complaints'. However, between 5 dBA and 15 dBA the strength of the response will gradually change to 'medium' with 'widespread complaints'.
- **5 dBA < Δ ≤ 15 dBA:** Between 5 dBA and 15 dBA an increase will elicit a 'medium' community response with 'widespread complaints'. In addition an increase of 10 dBA is subjectively perceived as a doubling in the loudness of a noise. For an increase of more than 15 dBA the community reaction will be 'strong' with 'threats of community action'.
- **10 dBA < Δ ≤ 20 dBA:** For an increase of between 10 dBA and 20 dBA the community response will gradually increase in strength to 'strong' with 'threats of community action'.

It will be noted that there are overlapping areas in the categories of responses to increases. This is specifically done to underline the fact that there is no clear-cut transition from one community response to another. Instead, the transition is more gradual and may differ substantially from one scenario to another, depending on a large number of variables.

The Noise Regulations[3] define an intruding noise as 'disturbing' if it increases the ambient noise level by 7 dBA or more. It must be noted that the new National Noise Regulations are due to published in the near future, and which will then replace the current Provincial Noise Regulations, which differ from one Province to the next. The new National Noise Regulation will discard this '7 dB rule' and will define 'disturbing noise' if it exceeds the guideline values listed in Table 5 of SANS 10103[1]. Therefore, in addition to the resulting total ambient noise levels the noise impact was also expressed in terms of the following increases in noise level:

- Δ ≤ 3 dBA;
- 3 dBA < Δ ≤ 5 dBA;
- 5 dBA < Δ ≤ 7 dBA;
- 7 dBA < Δ ≤ 10 dBA;
- 10 dBA < Δ ≤ 15 dBA; and
- Δ > 15 dBA.

2.13.3 Description of Present Environment

At present the area west and south of the proposed development site (with specific reference to the farms King, Mokaning and Parson) is very rural, with occupied farmsteads spaced at large distances from another. However, to the far west and south-west mining activities can also be discerned. To the north of the farm Parson and directly to the west of the farm Bruce, the present Sishen mining complex is very much the dominating feature in the landscape. East of the development site there are hills of substantial enough height to serve as effective screens against the propagation of noise in that direction.

The topography of the area is generally quite flat and, apart from the hills mentioned in the previous paragraph, will provide negligible screening against the propagation of noise.

Although this is a dry region, the vegetation mostly consists of tall shrubs and medium sized trees with substantial foliage cover. This will cause an excess attenuation of noise propagating across this landscape, especially over larger distances. This excess attenuation is due to the sound absorption provided by the vegetation of the area. In terms of the sound propagation model developed for the area as part of this study, this is described as 'soft' ground conditions.

2.13.4 Major Sources of Noise

The major sources of noise in the area were identified as the following:

- The existing Sishen mining operation. The large scale mining operation in the greater Sishen environment very much forms a constant presence, both as part of the landscape and the noise climate. The noise emissions are mostly characterised by the presence of a constant low frequency noise, caused by diesel powered equipment such as haul trucks.
- The N14 main road connecting North West Province in the east with Springbok in the west. This road in essence bisects the BKM Mine area. Although it is the main road in the area (but not currently recognised by SANRA as a national route), the traffic density is very low. The noise emissions from traffic on this road are characterised by the occurrence of single noise events. These single noise events quickly lose significance with distance from the road, i.e. they could be discerned at MP1, but not at MP2.

- The R325 that splits off from the N14 towards Postmasburg in the south. In terms of the audibility of traffic on this road, the same remarks as for the N14 are applicable.
- The old main access road to the evacuated old Sishen mining town north of the BKM area. In terms of the audibility of traffic on this road, the same remarks as for the N14 and R325 are applicable.
- The OREX railway line for the export of iron ore. Inside the BKM Mine area this railway line in essence runs in parallel and in close proximity to the N14. The very long trains travel very slowly on this section of the line, due to the proximity of the end station at Sishen. This means that the rolling noise of the locomotives and ore-carrying wagons is negligible[4], especially over larger distances. The only significant sources of noise would then be those caused by the electric locomotives, which generally are quite low.
- The standard railway line running in a north – south direction through the BKM Mine area. Traffic on this line is probably also very little, since there are only two stations of any significance further north, i.e. Dingleton and Hotezel. This means that this traffic cannot be viewed as a major source of noise in the area. Furthermore, research[5] has shown that railway noise is generally perceived as less disturbing than either road traffic or aircraft noise.

In summary it can be said that road and rail traffic have very little or no influence on the general ambient noise level in the area. Apart from very localised noise sources, such as the wind in the foliage of plants or farming related activities, the only major noise source is the existing Sishen mining complex.

2.13.5 Noise Sensitive Areas

The only noise sensitive areas that could be identified are the various farmsteads and associated farm workers houses in the areas west and south of the proposed development site.

Those closest west of the site are the following (see Figure 2-41 – page 2-88):

- Parson (which Assmang has options to purchace);
- Police Camp (which Assmang has options to purchace);
- Nanna;
- Markram;

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- Dingle; and
- Doorndraai.

Those closest south of the site are the following (see Figure 2-41):

- Vlakwater 1 and 2;
- Mooiwater; and
- Weltevreden 1 and 2.

The latter farmsteads are all in proximity to either the N14 and R325, i.e. even though the traffic density is very low, the noise caused by the single events of vehicles passing may be assumed to dominate the ambient noise levels at Vlakwater 2 and Weltevreden 1.

It should be noted that Assmang has options to purchase Remainder of Portion 2 and the Remainder of the farm Parson and Police Camp.

2.13.6 Ambient Noise Measurements

The results of the ambient noise samples that were taken on 11 and 12 September 2004 are summarised in Table 2-15.

Table 2-15: Measured ambient noise levels

Measurement point	Period	$L_{Aeq,I}$, dBA	Comments
1	Day	42,5 (L_{A90})	No measurement of the $L_{Aeq,I}$ possible due to high wind conditions. However, the statistical level L_{A90} provides a good indication of the residual ambient noise level in the absence of the disturbance caused by wind related noise.
	Night	41,6	Vehicles passing at a distance on the N14 and R325.and no gusts of wind. Further natural sounds, e.g. crickets.
2	Day	40,7	Bird sounds and light wind in the foliage of bushes and trees. Low frequency noise from the existing Sishen mine can be heard.
	Night	39,9	Very quiet but low frequency noise from the existing Sishen mine can be heard.
Average	Day	41,6 (≈ 42)	
	Night	40,9 (≈ 41)	

The measurement results given in Table 2-15 (page 2-94) may seem somewhat surprising in that there is very little difference between the day- and night-time results. However, the consultant has regularly found this to be the case where noise measurements are taken in the vicinity of industrial developments. The reason is that the noise emissions from the industrial sources remain fairly constant during both the day and night. Therefore, as the noise contributions due to other noise sources drop at night the industrial component remains unchanged and holds the general ambient noise level constant.

Based on the results presented in Table 2-15, the following pre-development ambient noise levels were assumed:

- Day-time: 42 dBA; and
- Night-time: 41 dBA.

2.14 Sites of Cultural and Archaeology Significance

Refer to Appendix 8.

2.14.1 Aim

The aim of the investigation was to detail observations based on a field survey on the properties in question and to assess significance of impact should mining proceed. The report was to provide: Site description; Methodology; Impact assessment (including all linear infrastructure) for construction, operation and decommissioning phases; and Mitigation measures and recommendations.

The study was undertaken in terms of the National Heritage Resources Act (No 25 of 1999).

2.14.2 Methodology

A background literature/museum database search provides indications of what might be expected in the region.

During the site investigation, areas of proposed mining and associated infrastructure construction were examined in some detail. In several instances, there were extensive areas that were not considered to be of high potential. These were checked at various points, while features in the respective landscapes that were more likely to have been foci for past human activity were assessed more carefully.

When assessing archaeological resources, surface indications may be regarded as providing a fair estimate of the nature and range of material present in this environment, where soils are generally shallow. However, some tracts are mantled with Kalahari sands (Refer to section 2.14.3). It was not considered necessary in this environment to sink test trenches to assess potential subsurface occurrences since archaeological visibility (density of resources) was expected to be low.

Basic documentation of cemeteries has been included in this report, but heritage features such as old farming and mining infrastructure have not been detailed. No such features or buildings that were considered to be of special note from a heritage perspective were observed.

Appendix 8 indicates criteria used here in archaeological significance assessment.

2.14.3 Background: Archaeological Resources in the Region

While much of the surrounding region has yet to be examined from an archaeological viewpoint, certain areas have been investigated in great detail, particularly in the last quarter century. This is especially true of the Kathu area (Beaumont & Morris 1990; Beaumont 2004; Morris & Beaumont 2004), to the north of Bruce, where renewed research by an international team in partnership with the McGregor Museum was commenced in August 2004. This existing work suggests that sites of great significance may yet be brought to light in the region. Broadly speaking, the archaeological record of this region reflects the long span of human history from Earlier Stone Age times (more than one and a half million to about 270 000 years ago), through the Middle Stone Age (about 270 000 – 40 000 years ago), to the Later Stone Age (up to the protocolonial era). The last 2000 years was a period of increasing social complexity with the appearance of farming (herding and agriculture) alongside foraging, and of ceramic and metallurgical (Iron Age) technologies alongside an older trajectory of stone tool making. Of interest in this area is evidence of early mining of specularite, a sparkling mineral that was used in cosmetic and ritual contexts from early times (Beaumont 1973). Rock art is known in the form of rock engravings.

In the area within and immediately to the north of the BKM Mine farms, the Earlier Stone Age is represented by 11 known sites (including one on the farm Bruce, as well as Kathu, Uitkoms, Sishen, Demaneng, Lylyveld and Mashwening); the Middle Stone Age by 5 sites (all in the vicinity of Kathu); various phases of the post-12 000 year old Later Stone

Age by 10 sites (including one on King, one at Mashwening and eight at Kathu); the Iron Age by 3 sites (Demaneng, Lylyveld and Kathu); while rock engravings are (or have been) known from Sishen and Bruce (the latter site was salvaged and recorded by Fock & Fock 1984), as well as Beeshoek, to the south (Fock & Fock 1984; Morris 1992; Beaumont 1998). Specularite sources are known on Demaneng and Lylyveld, and were mined in Stone Age times at a site on Doornfontein to the south (Beaumont 1973; Beaumont & Boshier 1974) and at Tsantsabane on the eastern side of Postmasburg (Beaumont 1973; Thackeray *et al.* 1983): numerous other specularite workings are on record (Beaumont 1973).

Information on these sites is on hand at the McGregor Museum in Kimberley (Beaumont 1973; Beaumont & Morris 1990; Beaumont 2004; Morris & Beaumont 2004; Fock & Fock 1984).

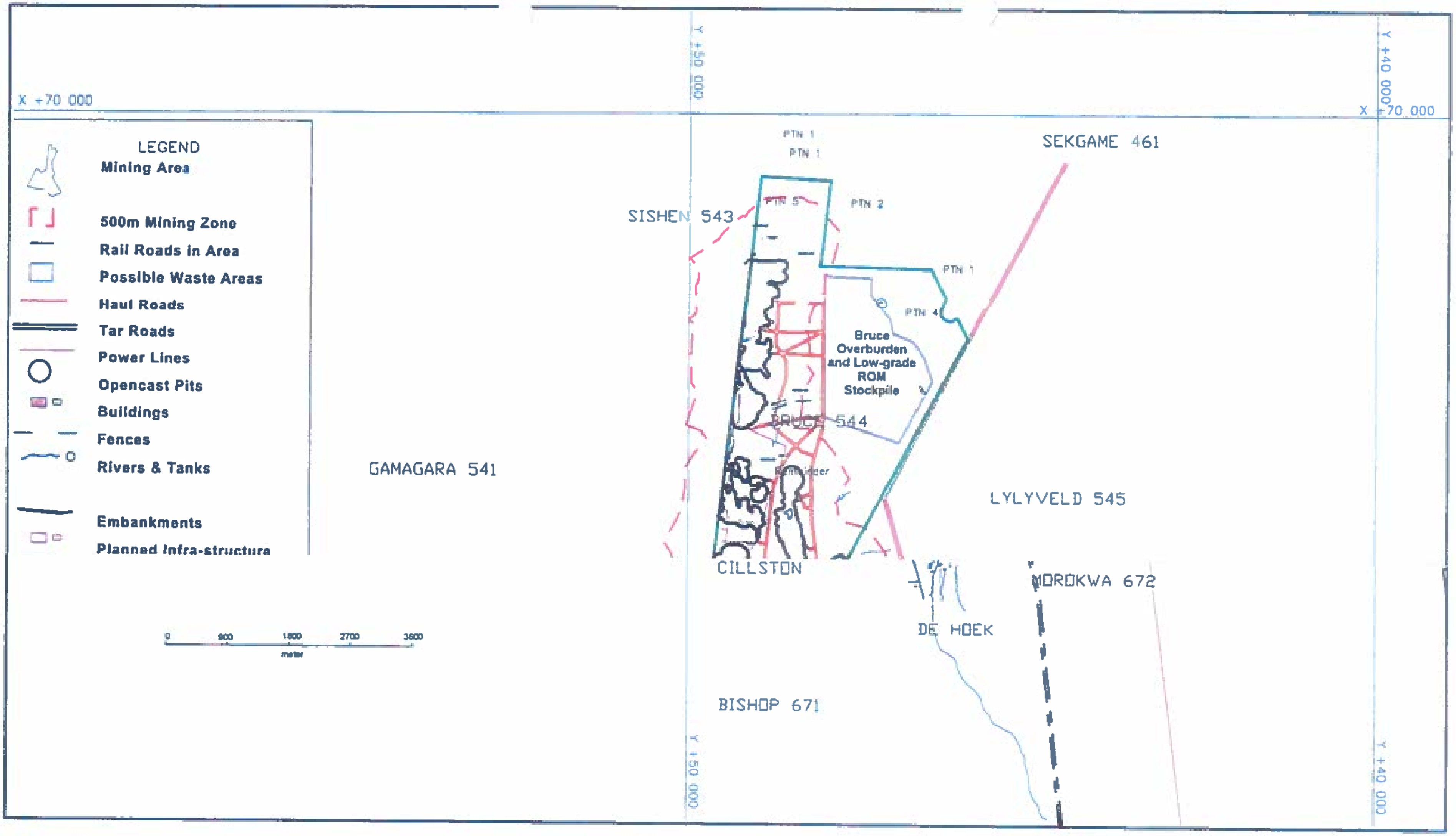
At a regional level, the sites of Wonderwerk Cave (east side of the Kuruman Hills) and the Kathu complex of sites provide important sequences against which to assess the age and significance of finds made during the present survey.

2.14.4 Observations

2.14.4.1 General Description of the Terrain

The terrain comprises, broadly, three kinds of topographical elements: undulating plains; hills with occasional prominent rocky outcrops; and non-perennial water courses, the principal one being the valley of the Gamagara River. Each of these has represented different opportunities in terms of human settlement and activity in the past, and cultural/heritage residues are not likely to be evenly distributed across them. It was expected that areas of higher sensitivity would include the margins of watercourses, and sheltered locales such as in the vicinity of rocky outcrops. The plains are mantled with aeolian sand with thornveld and *Tarchonanthus* vegetation, while the hills comprise mostly scree with combinations of *Tarchonanthus* and *Acacia mellifera* vegetation.

All these zones were examined. Observations indicated that archaeological visibility is generally lower on the plains and higher along the riverbanks and on hills, especially in the vicinity of prominent outcrops. It is possible that on the plains, in particular, archaeological material would occur mainly below the surface, and hence eroded and disturbed areas were examined especially to assess how much material might be expected to be sub-surface. The impression of lower visibility on the plains was sustained.



BKM Mine

Archaeology

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Project Number: IV04.05.044

Figure No: 2-42

However, the possibility of sub-surface features in those areas constitutes one of the limitations of this report and is a reason for monitoring to take place during the construction phase. Refer to Figure 2-42 (page 2-98).

2.14.4.2 Archaeological and heritage observations

Following are the archaeological and heritage sites observed during the site investigation.

- Cemeteries/graves

Four cemeteries were identified, inspected and briefly characterised. Only the last of these appears to be threatened by the proposed mining and associated infrastructure.

- Small farm cemetery (Cemetery 1)

On the property King, a small farm cemetery, with four graves, each with a headstone inscribed as follows:

Grave A: "In tere herinnering aan PIETER WILLEM VD WALT Geb 13 Julie 1940 Ov 9 Maart 1941. Rus in Vrede"

Grave B: WALT. Geb 1884, Oorl 21 Des 1944. Haar lewe was met haar God. Ps 146:3"

Grave C: "In liefdevolle herinnering aan ons dierbare eggenoot en vader NICOLAAS VD WALT. Geb 18 Feb 1908 Oorl 30 Jan 1946. Tot weersiens liefling. Ps 116:15. Veilig in Jesus arme."

Grave D: "In tere herinnering aan my eggenoot en ons vader PIETER WILLEM VAN EEDEN. Geb 3 Des 1868 Oorl 13 Julie 1943. Ps 116:vi".

Figure 2-43: Grave A

Figure 2-44: Grave B

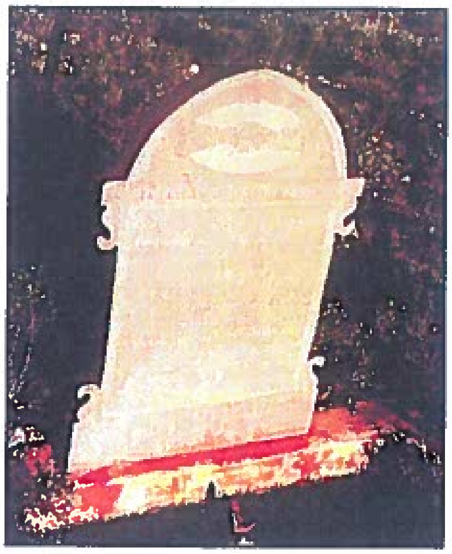

Figure 2-44: Grave C

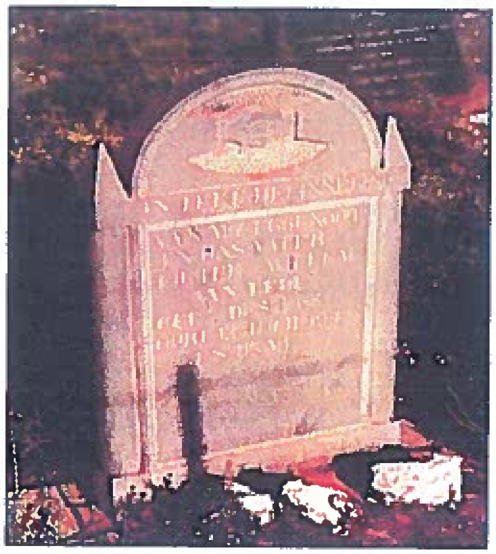

Figure 2-46: Grave D

- Small farm cemetery probably used by farm workers (Cemetery 2)

On the property Parson, on a hill south of and overlooking the GaMogara valley, there is a small farm cemetery probably used by farm workers. There are at least 10 graves, none of which has any inscribed headstone. The present generation of farm-workers do not know who is buried here. The style of burial is similar to that observed in other mainly rural farm-worker or related graves, having an oval shape in plan, with upright stones at the head and foot ends. .

Figure 2-45: Small farm grave cemetery

- Small farm cemetery (Cemetery 3)

On the property Parson, on the north bank of the GaMogara, a small farm cemetery with four graves, only two of which have inscriptions:

Grave E: "In memory 1955C P L E. PRICE 5th SAMR [South African Mounted Rifles] 14-2-16. Erected by his comrades."

Grave F: "HENRY MARKRAM Gebore 6 April 1940 Oorlede 27 Junie 2003. Ps 23. Die swerwer het tot rus gekom".

Figure 2-46: Unmarked grave

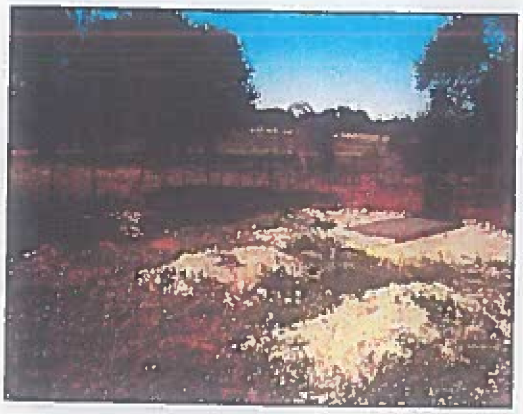

Figure 2-49: Grave E

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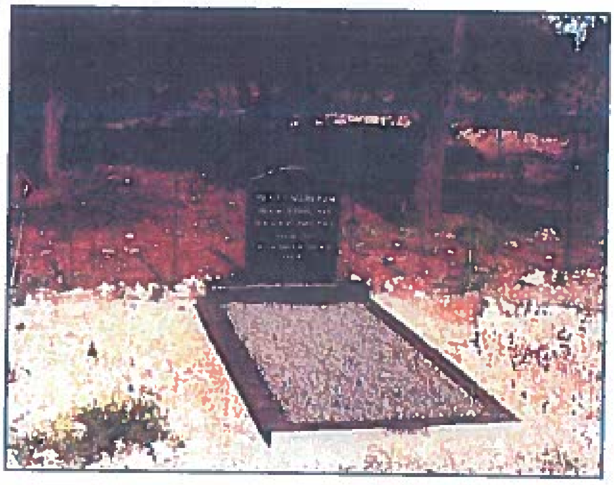

Figure 2-48: Grave F

- Rectangular cemetery (Cemetery 4)

On the property Parson, a large rectangular cemetery with north east and south west corners at GPS positions: 27°50.005' S; 22°58.125' E and 27°50.121' S; 22°58.098' E respectively. This cemetery with several tens of graves dates from about the late 1960s to within the last few years. It has an interesting lych gate with half "ossewa" wheel design element. Burials are markedly segregated along racial lines.

Figure 2-49: King cemetery

2.14.4.3 Plains

A very sparse scatter of Stone Age artefacts, principally on jaspilite, was observed at several points inspected on the flat and gently undulating plains on the four properties.

No major sites could be distinguished and it was determined that on the whole this topographic feature has generally low archaeological visibility.

2.14.4.4 River courses

The lower banks of the GaMogara bore traces of Stone Age sites, of generally low density. However, an area with much higher density was noted on the south bank of the GaMogara on the property Parson.

Artefacts of jaspilite included flakes with prepared platforms, ascribable to the Middle Stone Age or Fauresmith.

2.14.4.5 Hills

As on the plains, a low density of artefacts was found on some parts of hills, for example in the vicinity near the eastern boundary of King. It was possible that prominent rocky outcrops could have been locales offering shelter or a range of resources making them more attractive for dwelling or other activities in the past, and hence sites of greater archaeological visibility. Amongst the outcrops in the vicinity of the above GPS position it appeared possible that cavities amongst the rocks had been formed by artificial extraction possibly of specularite, a substance used for cosmetic and ritual purposes (Refer to Figure 2-42 – page 2-98).

The prominent outcrop of rocks, one of the landmarks of the area, some hundreds of metres to the north of there, clearly had been a focus of human activity in the past. Pot fragments reflecting Tswana settlement in the region were found, in addition to rich surface spreads of Middle Stone Age or Fauresmith stone artefacts.

Figure 2-50: Shelter

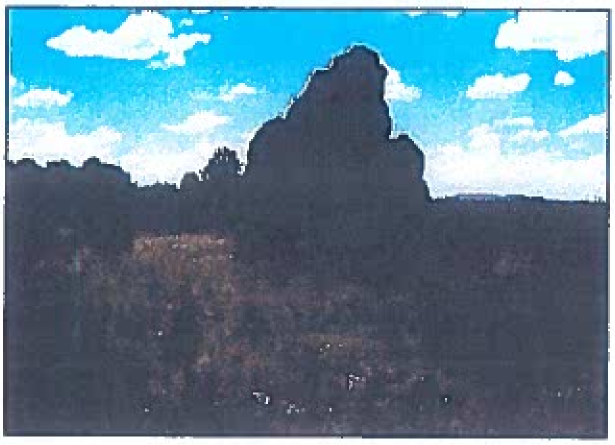

Figure 2-53: Outcrop

2.14.4.6 Other observations

None of the rock outcrops examined appeared to be of a nature suitable for rock engravings and no rock art was found (at Beeshoek, Gamagara shale was favoured – no outcrops of this rock were encountered in the course of the survey).

No indubitable specularite workings with associated artefacts were found, although, as noted above, there were places where cavities may have been hollowed out artificially and were possibly sources for pigment in the past.

The very scattered low visibility dispersal of artefacts observed over much of the terrain examined is consistent with a scenario of sporadic discard over perhaps millennia by hunter-gatherers away from their home-base, while the more concentrated spreads at places along the GaMogara and near prominent rocky outcrops on hills probably represent places where people were living or focusing activities.

It is possible that sub-surface features of an archaeological nature (ostrich eggshell cache, high density artefact horizons, burials) may be found during mining. In the event of these being found, an archaeologist should be contacted immediately to assess significance and recommend mitigation measures.

2.15 Visual

Refer to Appendix 9.

2.15.1 Aim

The main aim of the study is to ensure that the visual consequences of the proposed BKM Mine are understood and adequately considered in the environmental planning process.

2.15.2 Approach and Methodology

A field survey was undertaken over a two-day period to establish the quality and characteristics of the receiving environment. The study area was defined as a 15,0 km radius about the proposed project sites. Beyond 15km the visual impact of the proposed project will have diminished to insignificant.

Landscape character, landscape quality and sense of place were used to evaluate the visual resource. A qualitative evaluation of the landscape is essentially a subjective matter, and in this study the evaluation is determined using the criteria discussed in Appendix 9 and the professional opinion of the author.

The landscape impact of the BKM Mine was measured as the change to the fabric and character of the landscape caused by the physical presence of the mining activities.

Visual impacts are a subset of landscape impacts. They relate solely to changes in available views of the landscape, and the effects of those changes on people. The intensity of that change (i.e. visual impact) is the degree to which the change compromises, enhances or maintains the visual quality of a particular area.

The intensity (or magnitude) of the visual impact is determined using visual intrusion, visibility, visual exposure and viewer sensitivity criteria and is concerned with:

- The direct impacts of the project upon views of the landscape through intrusion or obstruction;

- The overall impact on visual amenity, which can range from degradation through to enhancement.

The significance of the impact is then further qualified by *frequency*, *extent (spatial)* and *duration* of potential impacts. For a detailed description of the method, refer to Appendix 9. The diagram below graphically illustrates the visual impact process.

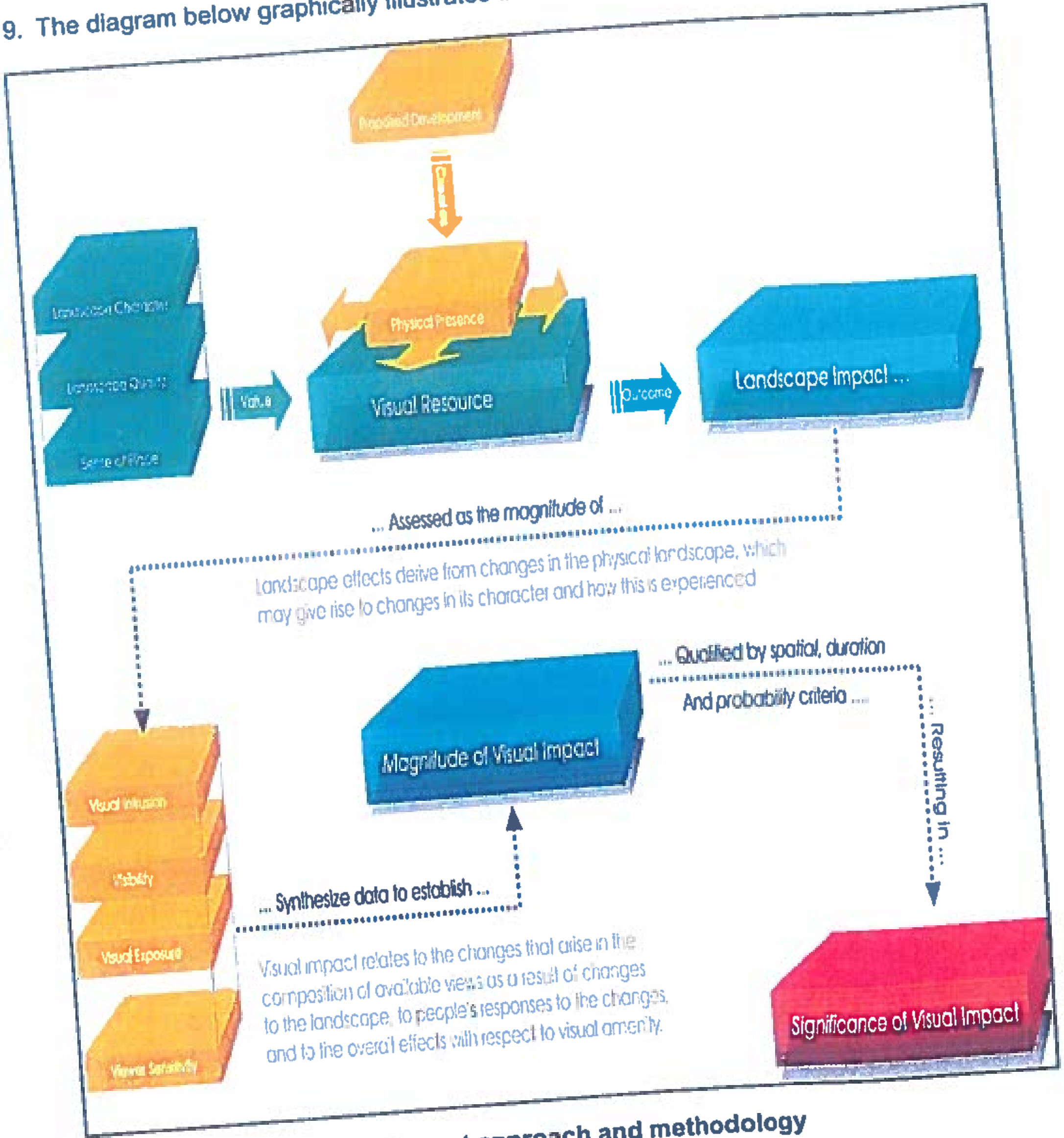

Figure 2-51: Visual assessment approach and methodology

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2.15.3 Landscape Setting

Where landscape quality and a strong sense of place coincide, the visual resource is considered to be very high. The impact of development on a landscape that is considered a highly valued visual resource is greater than on a landscape with a moderate or low rating, because the aesthetic value of the area has 'more to loose'.

2.15.3.1 Landscape Character, Aesthetic Value and Sense of Place

2.15.3.1.1 Landscape Character

The regional landscape is characterized by semi arid, open, undulating to flat sandy plains. A series of hills, orientated in a north south axis runs across the site, and protrude above the surrounding plains. Sishen is situated to the north-west of the site along with associated mining activities and mine infrastructure. Other mining activities are evident to the south and south east of the proposed BKM mine. Farming is the other main activity in the area. The town of Kathu lies north-east of the site of the site. The N14 passes through the proposed mining area in a southwest to northeast direction.

According to Low and Rebelo (1998) the natural vegetation for the sub-region is characterized by a fairly well-developed tree stratum with *Acacia erioloba* and *Boscia albitrunca* as the dominant trees. The shrub layer is moderately developed while the extent of the grass cover depends on the amount of rainfall in any given growing season. The mining site vegetation consists predominately of a shrub layer with very few large tree species.

The semi-arid open nature of the landscape renders it particularly sensitive to visual intrusion, especially from mining activities of the nature and scale of the existing Sishen Mine and the proposed BKM mine.

2.15.3.1.2 Aesthetic Value

In determining the value(s) of the *visual resource* for the study area, both the objective and the subjective or aesthetic factors discussed above were considered. In doing this, a balance between landscape character and individual landscape features and elements are used in the assessment.

The landscape as described above can be divided into five basic types each with its own set of physical, visual and aesthetic characteristics. These landscape types are:

mining/utilities; urban/built up; rural/undulating to flat sandy plains; riverine; and natural hills as delineated in Figure 2-52 (page 2-109).

Figure 2-53 (page 2-110) to Figure 2-56 (page 2-111) illustrate various views of the hills, from a distance as well as from within them. The combination of the more dramatic topography, rocky outcrops and natural vegetation give this land-type a strong sense of place and aesthetic value.

The areas with the *lowest* value are the existing mining activities and associated infrastructure. These areas occur immediately to the northwest of the proposed mine. The mine dumps tend to dominate views in the area and due to the relative flatness of the landscape can be seen from great distances. Figure 2-55 and Figure 2-56, illustrate that the dumps protrude above the horizon line and how their angular features contrast with the 'softer' lines of the natural landscape. The sense of place for the study area is determined, to a large extent, by these existing mining activities. Presently, the Sishen mine spoil dumps can be seen from distances of 15 - 20km, both from the west and east along the N14. The expectation of visitors to the area will therefore be of a mining area and not a pristine landscape devoid of human intervention. To the south of the proposed mine, along the Postmasburg road, are extensive areas where mining activities (current and past) are evident. These 'intrusions' into the landscape therefore contribute to the sense of place and landscape characteristics of the study area.

The remainder of the study area, spatially the largest component, comprises gently undulating rural plains used for grazing animals and game. These areas have aesthetic appeal but are not rated as high as the riverine or natural hill areas mentioned above. They conjure up images of an open, peaceful scene characterised by the vastness of the landscape. Their value is rated moderate. Refer to Figure 2-56 (page 2-111).

2.15.3.1.3 Sense of Place

The perception and expectation of visitors to the area will be of a mining area and not a pristine landscape devoid of human intervention. Presently, the Sishen mine dumps can be seen from distances of 15 - 20km, both from the west and east along the N14. To the south of the proposed mine, along the Postmasburg road, are extensive areas where mining activities (current and past) are evident. These 'intrusions' into the landscape therefore contribute and to a large extent define the sense of place and landscape characteristics of the study area i.e. on leaving the area the enduring image that will remain is of the dumps protruding above the horizon line.

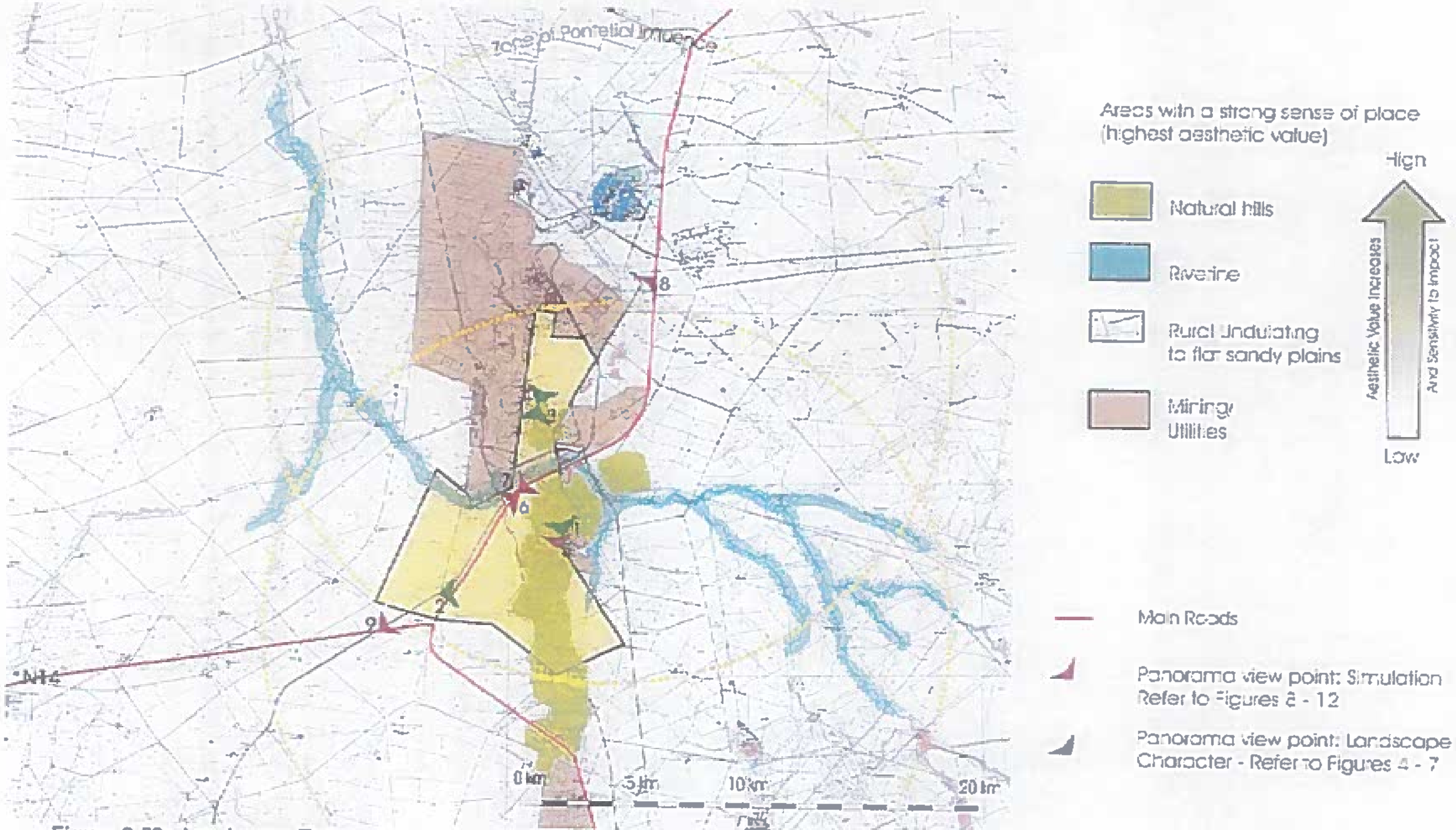
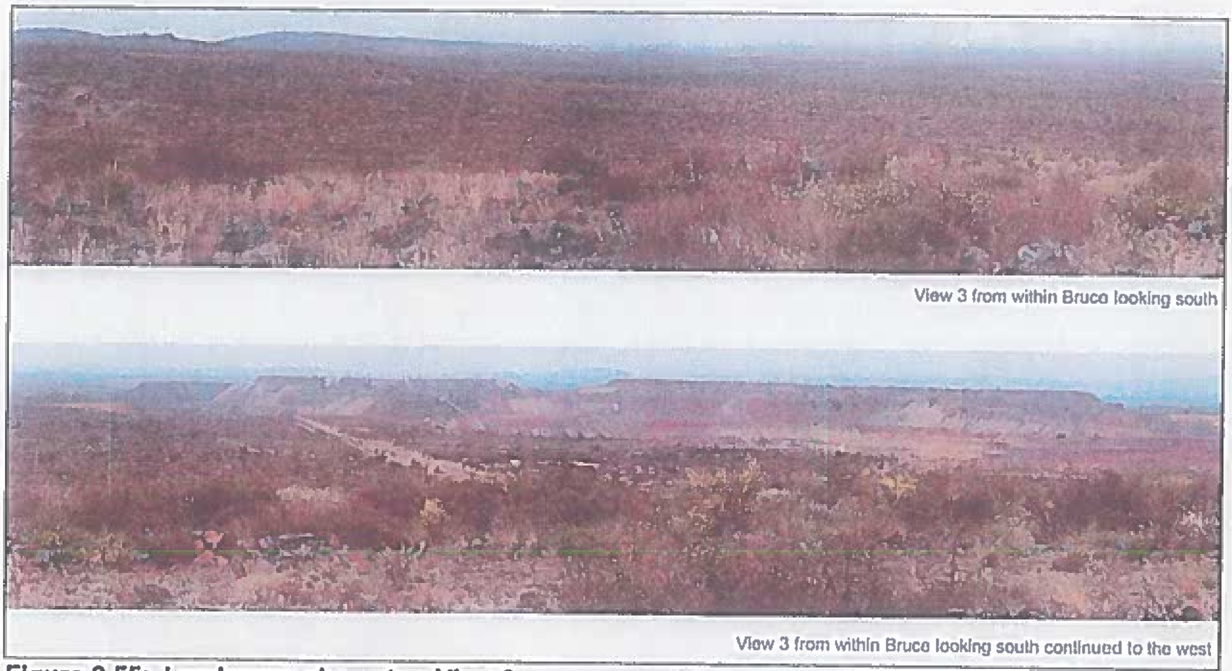


Figure 2-52: Landscape Types

Figure 2-53: Landscape character: View 1

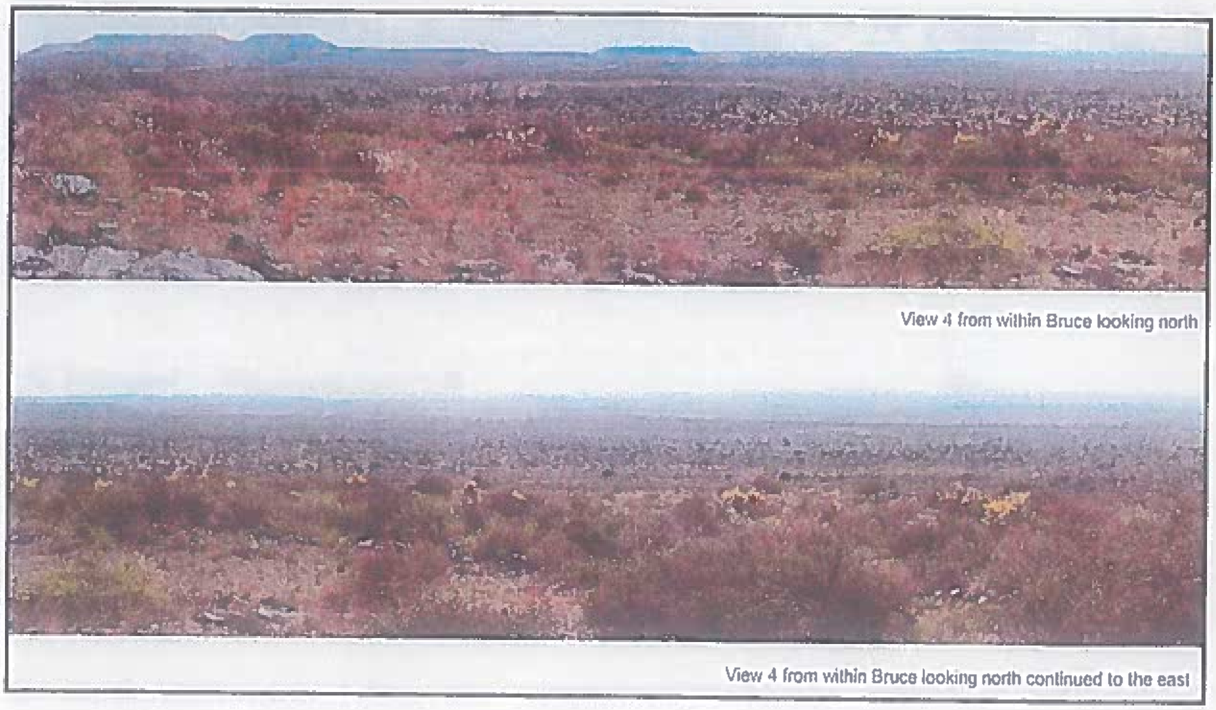
Figure 2-54: Landscape character: View 2



View 3 from within Bruce looking south

View 3 from within Bruce looking south continued to the west

Figure 2-55: Landscape character: View 3



View 4 from within Bruce looking north

View 4 from within Bruce looking north continued to the east

Figure 2-56: Landscape character: View 4

2.15.4 Views

Generally, sensitive viewing areas are considered to be views from residential properties, public rights of way (roads), tourist destinations and natural conservation areas. Areas considered not sensitive would be where industry or mining activities occur. In this study the sensitive viewing areas are the N14 and R325 roads and the residential areas of Kathu. As far as the author is aware, there are no tourist lodges within the study area.

2.15.4.1 Sensitive viewing areas

Sensitive viewing areas include:

- N14;
- R325; and
- Western periphery of Kathu.

The existing Sishen Mine dumps will however be evident and dominant on the horizon and will form the backdrop of the area.

2.16 Regional Socio-Economic Structure

The Regional Socio-Economic Structure of the BKM Project will be described within four sections, in order to provide a broad understanding of the population structure in which the proposed BKM Project will be situated. These will included:

- Northern Cape Province
- Tsantsabane Local Municipality
- Gamagara Local Municipality
- Local Town (i.e. Kathu).

2.16.1 Northern Cape Province

2.16.1.1 Background

The Northern Cape province comprises six regions of which the Kalahari region covers an area of 50 015 km^2, which is 13 % of the area of the Northern Cape. The Northern Cape is delineated by the Diamond Fields Region in the south, the Lower Orange Region in the west, Botswana border to the north and the North West Province in the east (Mawatsan, 2004).

2.16.1.2 Population Statistics

The population of the Kalahari region is estimated at 84 234, resulting in a population density of 1.68 people / km^2. The majority of the population is urbanised, with 77 % based in the small towns.

2.16.1.3 Age Structure

Thirty-two % of the population are under 15 years of age. This is significantly lower than the %age usually found in developing countries, where half the population is less than 15 years of age, making communicable diseases the primary health problems (Mawatsan, 2004).

2.16.1.4 Education

There are primary and secondary schools in all the towns as well as a number of farm schools. There is a technical college at Kathu. The literacy rate for the region is considered to be above the provincial average (Mawatsan, 2004).

2.16.1.5 Employment Statistics

There are no accurate unemployment figures for the region nor for the Northern Cape province, but the October Household Survey of 1994 estimated that 32,5 % of an estimated 278 743 economically active people were unemployed. Rates were higher for Coloureds (37,9 %) and Blacks (39,4 %) than for Whites (7,2 %). Almost seventy-five % of unemployed people were not trained or skilled for specific work.

In 1991, formal sector employment in the Kalahari region was:

- Mining – 35 %,
- Government – 28 %, and
- Agriculture – 13 %.

2.16.1.6 Land Use

Currently the Kalahari region is the principal mining area of the Northern Cape province, although there has been a strong decline due to the closure of asbestos mines. Agriculture activities in the region are limited by the lack of water, resulting in farms not being labour intensive. Of the 1 880 farms in the region, 25 % run as cattle posts with a foreman in charge of the farm.

More than 3 680 households, most of which are presently based in the North West Province are involved in land claims. Assuming that there are five people per household, up to 18 415 people may move back into the region. This will represent a 20 % increase for the area (Mawatsan, 2004).

2.16.1.7 Services

There are no accurate figures for service provision in the region. In general, levels of service provision are good in the province, but there are still many people living without access to adequate water supply and sanitation (Mawatsan, 2004).

2.16.2 Tsantsabane Local Municipality

2.16.2.1 Background

The farm Mokaning is situated within the jurisdiction of the Tsantsabane Local Municipality and the Siyanda District Municipality.

The area is linked to the west coast port of Saldanha because of the iron deposits that are sold to the international market (Mawatsan, 2004).

2.16.2.2 Population Statistics

The total population of the Siyanda Districts Municipality is 209 890, and has a low population density. In 1985, the average population density of the district was 0,65 persons / km^2. By 1994, this density had increased to an average density of 1,27 persons / km^2 (Mawatsan, 2004).

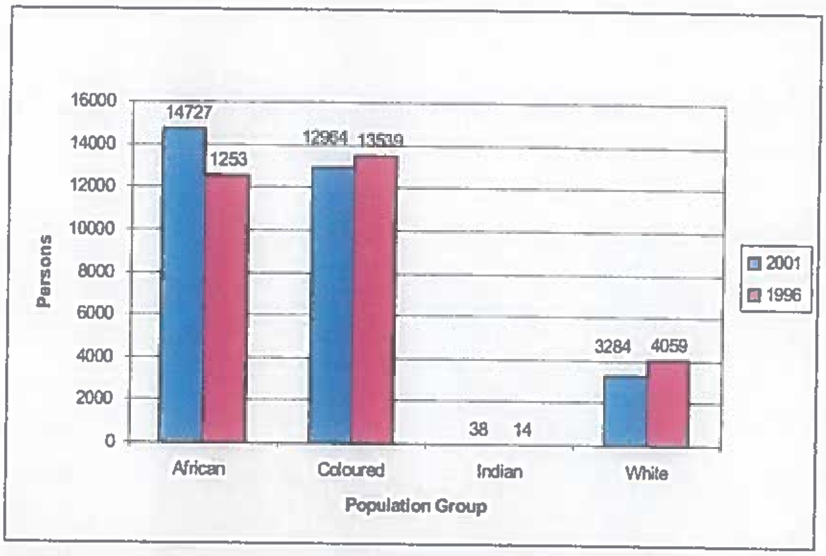


Figure 2-57: Tsantsabane population groups (Mawatsan, 2004)

Forty-seven % of the population of Tsantsabane is African, while 42 % are Coloured and 11 % White. Most common languages spoken are Afrikaans (62 %) and Setswana (31 %) (Mawatsan, 2004).

2.16.2.3 Age Structure

Forty-eight % of the population is male and 52 % is female. Thirty-three % of the population is under 14 years of age, while 33 % is over 35 (Mawatsan, 2004).

Figure 2-58 Tsantsabane age distribution (Mawatsan, 2004)

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2.16.2.4 Education

Sixty-three % of the population in the 5 to 24 year age group attend school. Twenty-four % of the population has not had any schooling (Mawatsan, 2004).

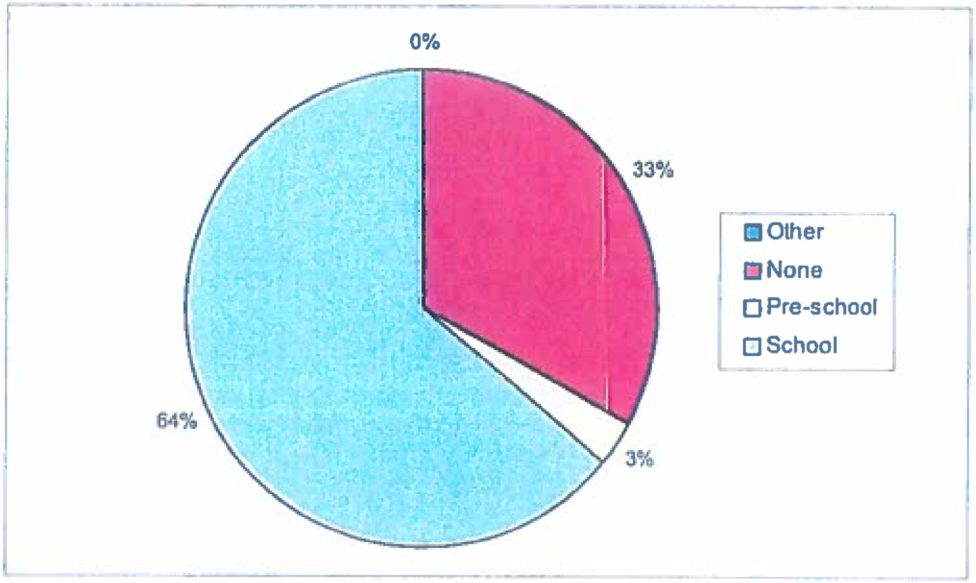

Figure 2-59: Tsantsabane education institutions being attended by 5 to 24 year olds

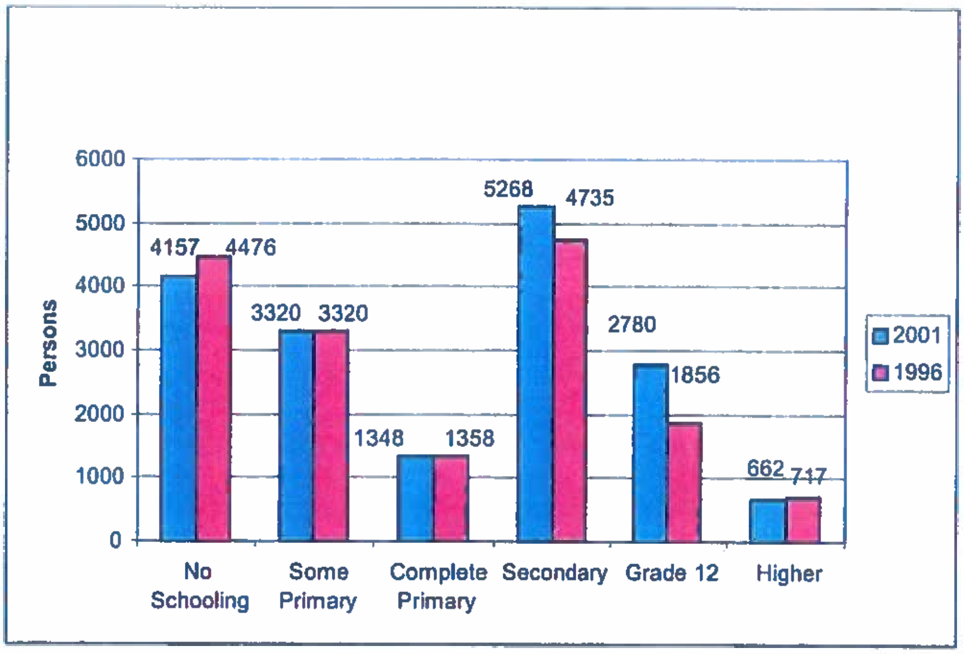

Figure 2-60: Tsantsabane highest education level attained by over 20 year olds

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2.16.2.5 Employment

Poverty is widespread throughout the Siyanda district, and is especially problematic in rural areas. The mining and agriculture sectors provide some employment but the socio-economic profile of the district indicates a 42 % unemployment rate, leaving 30 % of households with no income. This represents a significant increase in unemployment since 1996, when 33 % of the labour force was unemployed. This high unemployment rate in the area contributes to poverty and crime in the area.

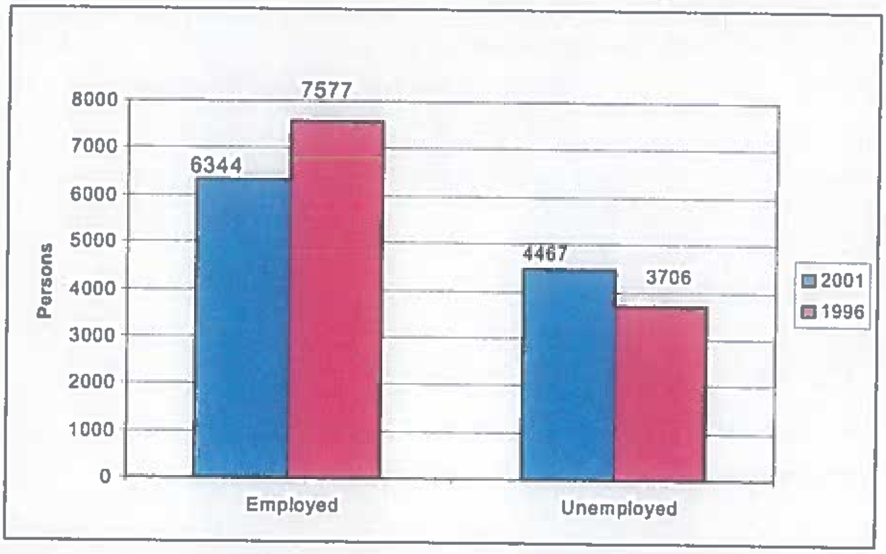

Figure 2-61: Tsantsabane employment rate (Mawatsan, 2004)

Of those persons who are employed, 29 % are employed in elementary (unskilled) occupations.

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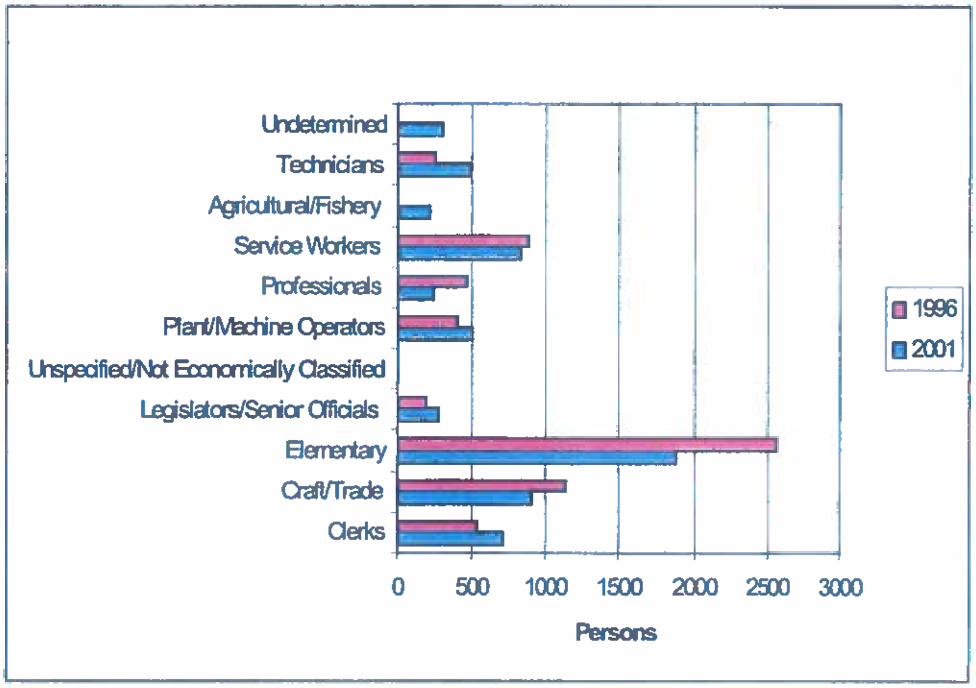

Figure 2-62: Tsantsabane occupations (Mawatsan, 2004)

Fourteen % are employed in craft- or trade-related occupations, and 13 % as service workers (Mawatsan, 2004).

2.16.2.6 Income

The greatest social problems in the Siyanda district are illiteracy and poverty. According to the last socio-economic survey in 1997, approximately 68 % of the inhabitants have a monthly household income of between R 0 to R 800. In 2001, 45 % of residents of the Tsantsabane Local municipal area were reported to have a monthly income of less than R 800. The individual and annual household income distributions o the Tsantsabane population are given in the diagrams below (Mawatsan, 2004).

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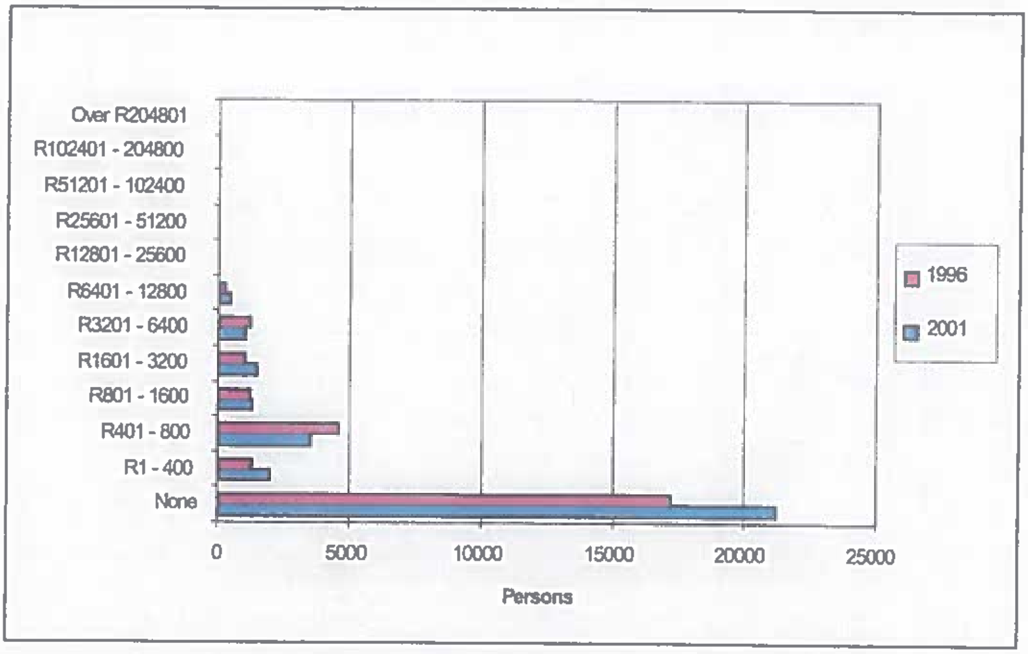

Figure 2-63: Tsantsabane individual monthly income (Mawatsan, 2004)

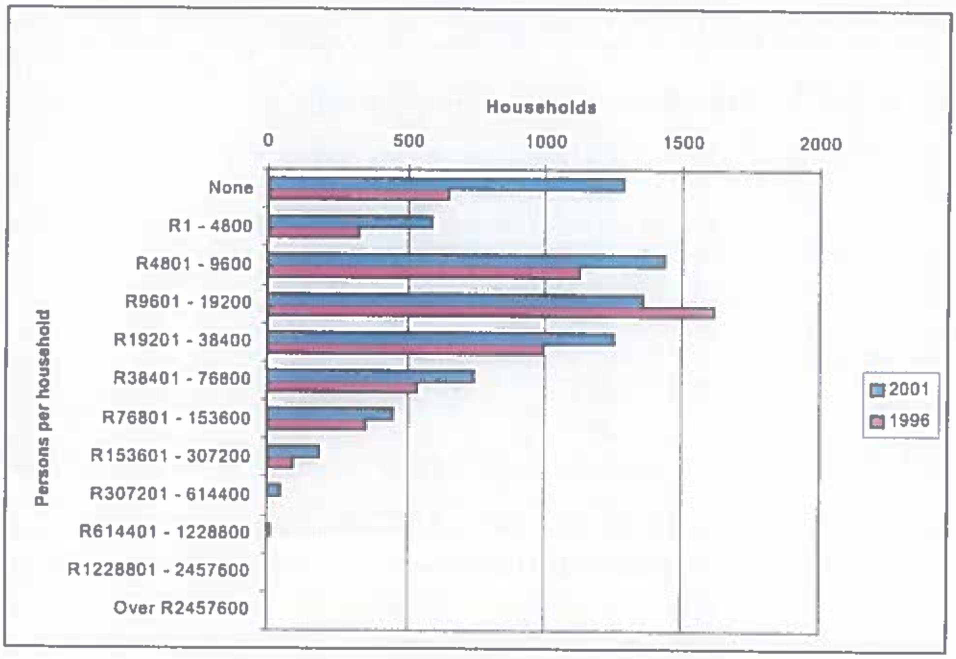

Figure 2-64: Tsantsabane annual household income

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2.16.2.7 Housing

Eighty-one % of the population live in formal housing, and 16 % in informal settlements. Thirty-seven % of households have more than four people, while 37 % have fewer than four rooms. The average household size is just under four persons per household (Mawatsan, 2004).

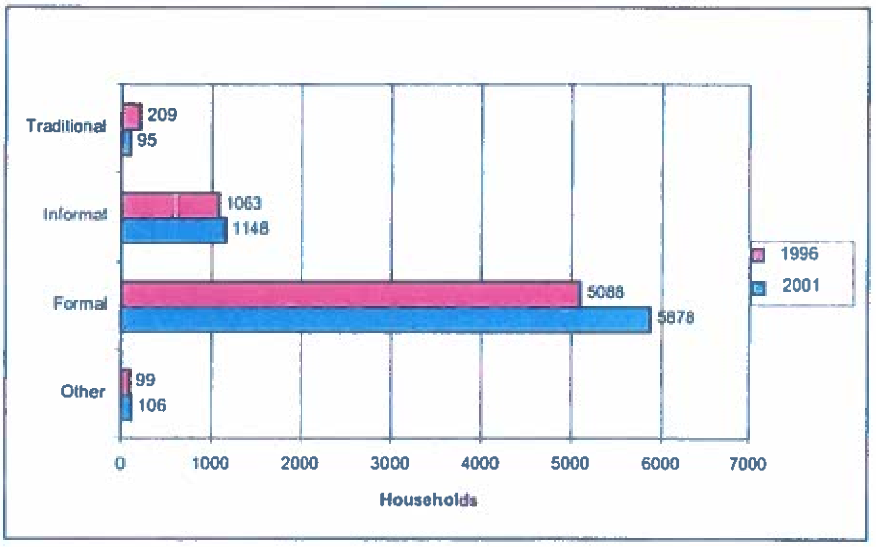

Figure 2-65: Tsantsabane dwellings (Mawatsan, 2004)

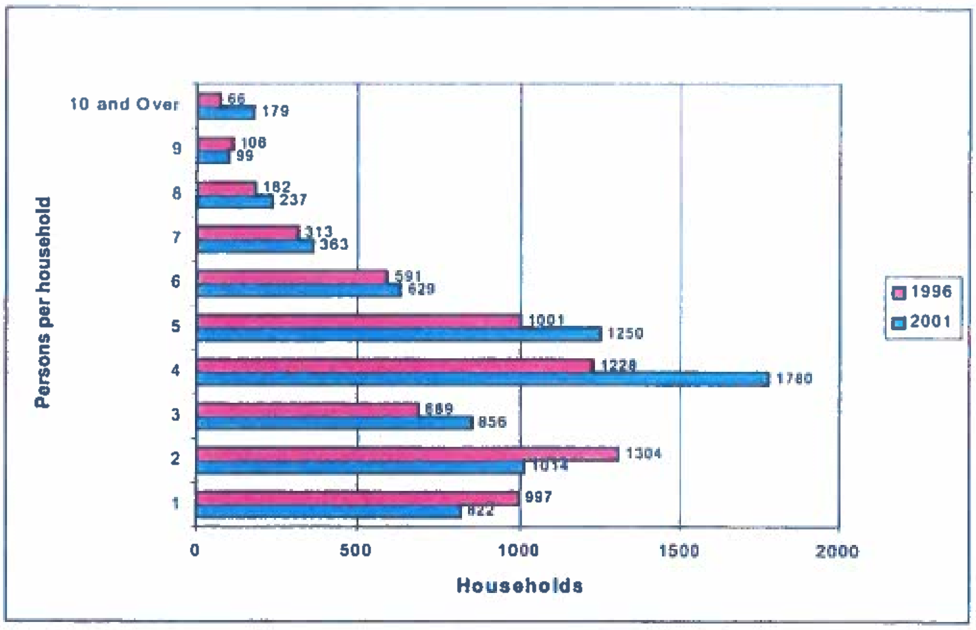

Figure 2-66: Tsantsabane number of rooms per household (Mawatsan, 2004)

2.16.2.8 Land Use

Cattle and livestock farming

The dominant land use in the area, prior to mining, involved cattle and small livestock farming. The average carrying capacity of the veldt is rated to be low. Low-density cattle farming remains common, with emphasis on meat production and some dairy farming. Livestock husbandry occurs mainly on large farms where farming is extensive. Because of the low rainfall and the shallow soil conditions, the area is not suitable for arable agriculture. The large majority of these farms are in private hands.

Agriculture

Agricultural activities in the Siyanda District are limited by the lack of water. Farms tend to be very large and grazing is limited to 1 large animal per 20 hectares. Cattle, sheep, goats and game are the most common animals found on farms. Farms are not labour intensive and are often inhabited by only a couple of families.

Game farms

Farming activities in the Siyanda District are limited. A large variety of game, situated on both private and conservation areas, forms an important base for the well-established game industry in the region. More than 1 000 game farmers in the Siyanda District have been registered with the Department of Nature Conservation and that is also an indication of the extent of the industry in the region.

Land claims

A substantial number of people are claiming land back in the region. Over 3 680 households, most of whom are presently based in the North West Province are involved in land claims. Assuming that there are 5 people per household, up to 18 412 people may move back into the region. This will represent a 20 % increase for the area.

No land claims have been lodged against the BKM Mine area.

2.16.2.9 Economic activities

The major economical activities involved are shown in Figure 2-67 (page 2-123). The largest provider of employment in Tsantsabane is the Community / Social / Personal Services sector (25 %), followed by Wholesale / Retail (13 %) and Mining (11 %) (Mawatsan, 2004).

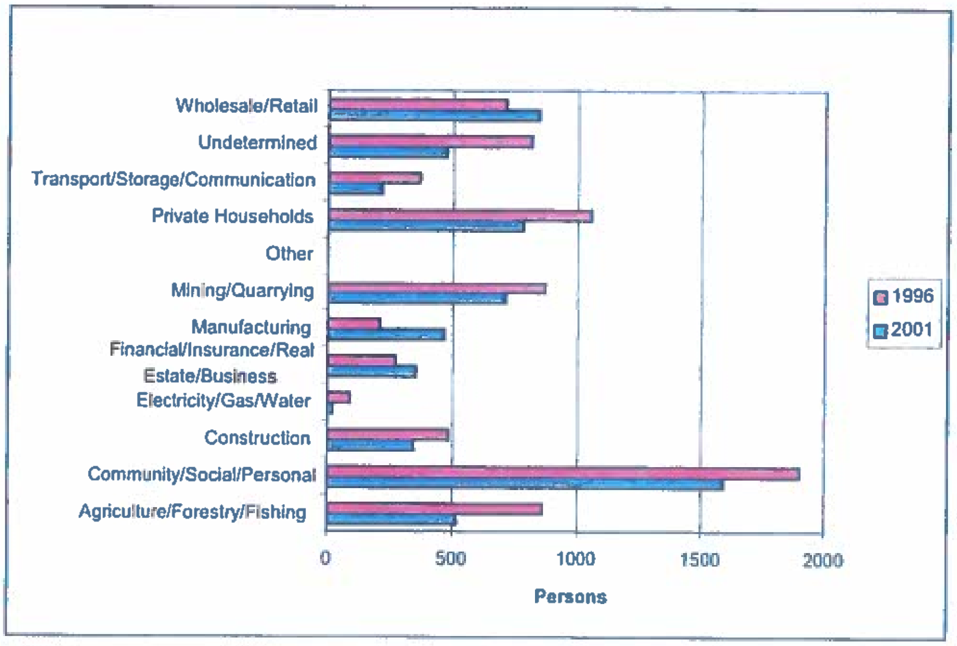

Figure 2-67: Tsantsabane economic activities (Mawatsan, 2004)

2.16.2.10 Services

Transport and road infrastructure

The N14, which extends from Springbok to Johannesburg, passes through the towns of Kakamas, Keimoes and Olifantshoek.

The dominant modes of transport are pedestrian and buses (Mawatsan, 2004).

Sanitation and waste removal

As most of the properties within the boundaries of the Siyanda District Municipality are private farms, which are very dispersed, the Council cannot provide an effective sanitation system. All the farms in the district are self sufficient in this respect. Most of the farms make use of a French Drain System. Some formal settlements have a so-called VIP sanitation system.

Sixty-seven % of households in the Tsantsabane Local Municipality have flush toilets, 85 % have access to electricity, and 82 % have weekly refuse removal (Mawatsan, 2004).

Health and Welfare

Postmasburg Hospital has 40 authorised beds and Olifantshoek Hospital has 12 beds. All mining towns have day clinics run by the respective mines. Other services include Mobile Clinics, and three emergency services.

Tourism is one of the most important economic sectors in the Northern Cape and within the Siyanda District Municipality boundaries. The district has priceless natural resources, which have the potential to make tourism in the area flourish. The development of the tourism industry in the area will give impetus to increased job creation. At the present rate of growth; the local tourism industry should become one of the most important economic activities in the area within the next 10 years (Mawatsan, 2004).

2.16.2.11 Crime

Due to poverty and the high unemployment rate, the area is subjected to a high crime rate. Violence against women and children is higher in the Northern Cape Province than in any other province of South Africa, with 165,2 rapes and 42,4 cases of child abuse recorded per 100 000 residents during 2003. Many of these crimes are suspected to be alcohol-related. Stock theft is also more common than in any other province (Mawatsan, 2004).

2.16.3 Gamagara Local Municipality

2.16.3.1 Background

The largest part of the BKM Project is situated under the jurisdiction of the Gamagara Local Municipality. The inclusion of this municipality, in the North West Province, together with Ga-Segonyana, and a District Management Area (Vanzylsrus and surrounds) in the Northern Cape, resulted in the cross-border status of the Kgalagadi Districts Municipality.

The geographical area of the municipality is 467,92005 km2 of semi desert, straddling both the north-eastern section of the Northern Cape and the western area of the North West Province. The nearest town is Kathu, surrounded by Dingleton and Sesheng. Kathu lies approximtely15 km north of the centre of the planned mine.

Sishen Iron Ore Mine, is located directly to the west of the planned BKM Project. Dingleton, Kathu and Sesheng emerged as a result of the mining activities at Sishen, which began in the early 1950s. The towns are dependant on Sishen Mine, which provides potable water and variety additional services, including a fire station, housing for employees and training facilities. With a workforce of more than 3 000 people and 1 500 contract workers, the mine is also a significant source of local employment (Mawatsan, 2004).

2.16.3.2 Population Statistics

The total population of the Kgalagadi Districts Municipaltiy is 176 909 on a sparsely populated area, making the population density low. In 1994, the density had increased to an average densityof 1,27 persons per inhabitable km2.

Forty-eight % of the population of Gamagara is African, while 25 % are Coloured and 27 % White. Most common languages spoken are Afrikaans (54 %) and Setswana (39 %). In relation to the Tsantsabane Local Municipality, the %age Africans in Gamagara is 47 % higher, while Coloured population is 25 % lower and White population is 27 % higher. The higher white population is because of the mines near Kathu (Mawatsan, 2004).

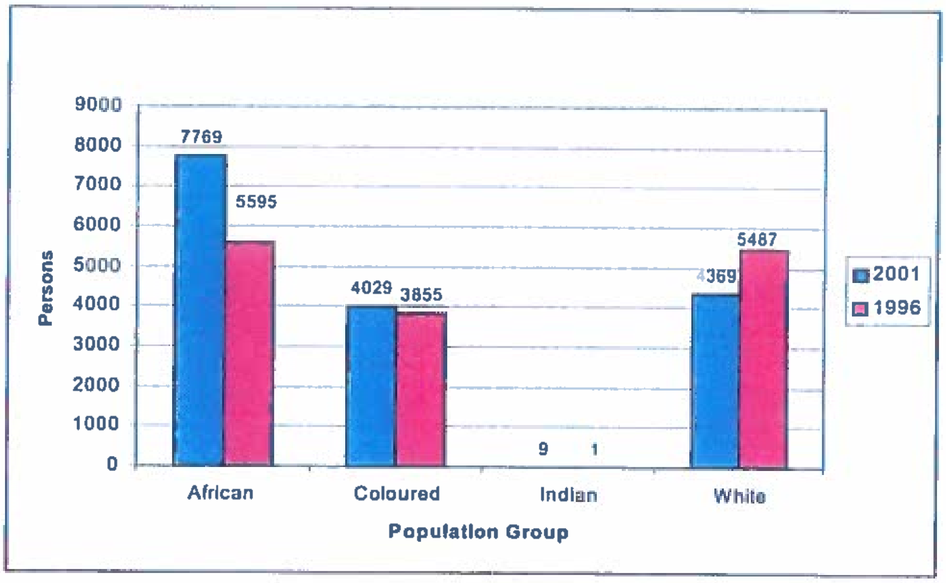

Figure 2-68: Gamagara population groups (Mawatsan, 2004)

2.16.3.3 Age and Gender Structure

Fifty-two % of the population is male, and forty-eight is female. Twenty-eight % of the population is under 14 years of age, while 33 % is over 35 (Mawatsan, 2004).

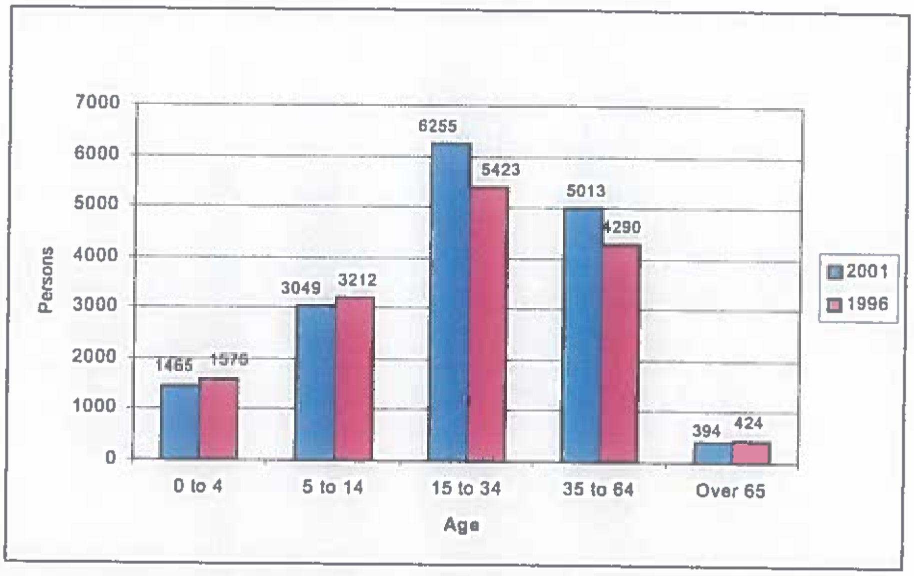

Figure 2-69: Gamagara age distribution (Mawatsan, 2004)

2.16.3.4 Education

Fifty-six % of the population in the 5 to 24 year age group attend school. Sixteen % of the population has not had any schooling (Mawatsan, 2004).

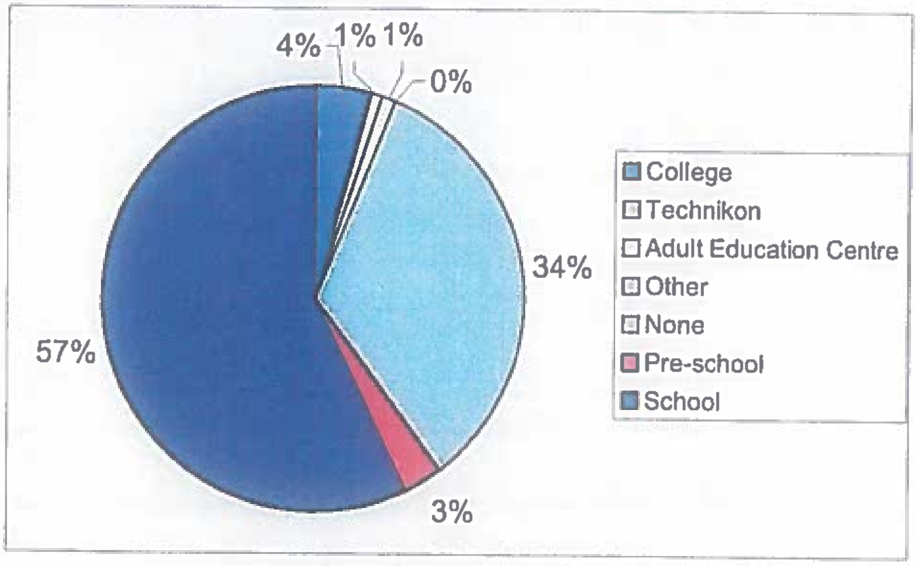

Figure 2-70: Gamagara education institutions being attended by 5 to 24 year olds (Mawatsan, 2004)

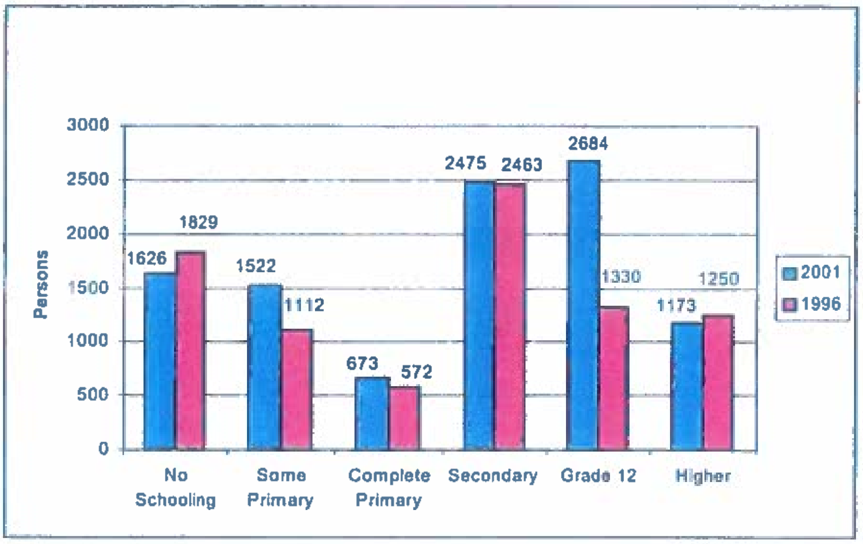

Figure 2-71: Gamagara highest education levels attained by over 20 year olds (Mawatsan, 2004)

2.16.3.5 Employment

Unemployment levels in the Kgalagadi District are high, with 65 to 70 % of the economically active population out of work. Poverty is especially problematic in rural areas. Given the extreme lack of service provision, economic and educational opportunities, the Kgalagadi District has been named a presidential poverty node.

Twenty % of the labour force is unemployed. This represents a slight increase in unemployment since 1996, when 16 % of the labour force was unemployed (Mawatsan, 2004).

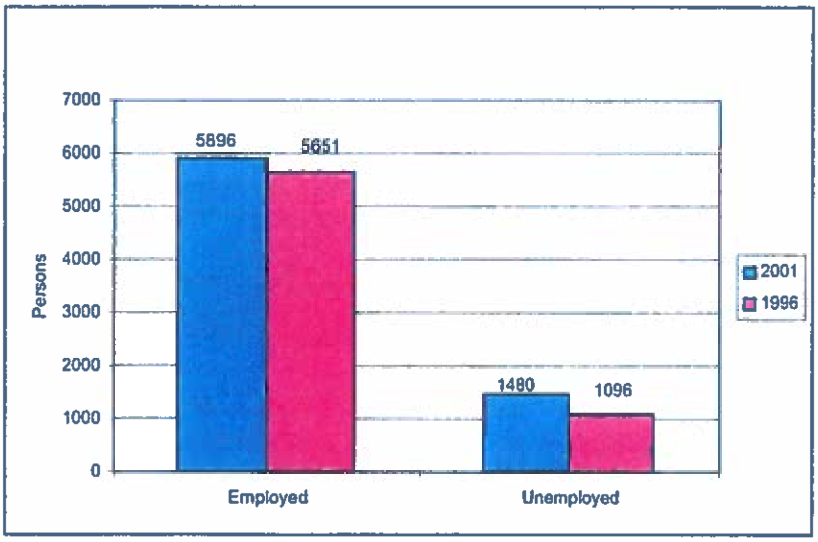

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Figure 2-72: Gamagara employment rates (Mawatsan, 2004)

Of those persons employed, 28 % are employed in elementary (unskilled) occupations. Twenty-five % are employed in craft- and trade-related occupations, and 11 % as clerks (Mawatsan, 2004).

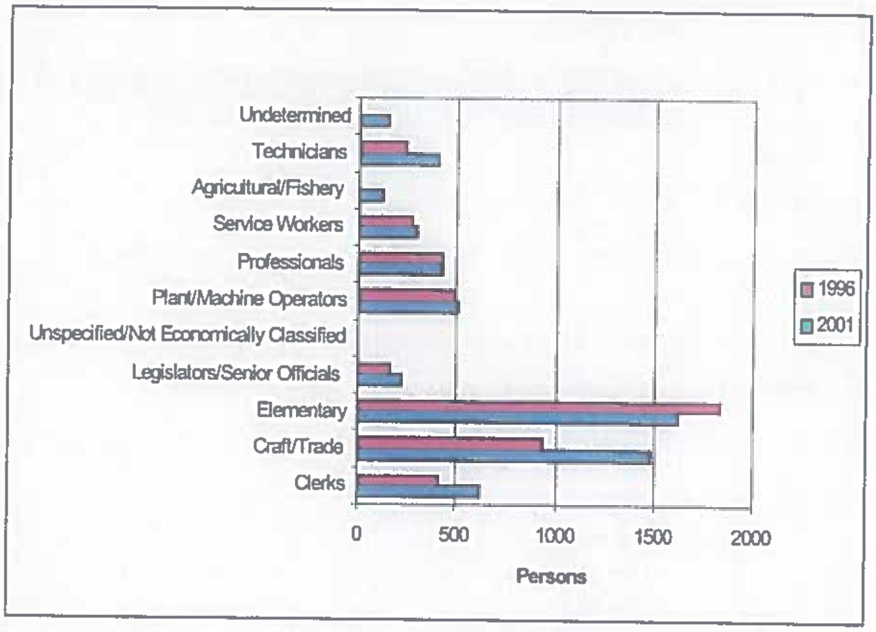

Figure 2-73: Gamagara occupations (Mawatsan, 2004)

2.16.3.6 Housing

Eighty-three % of the population live in formal housing, and 16 % in informal settlements. Twenty-nine % of households have more than four people, while 41 % have fewer than 4 rooms. The average household size is just over 3.6 persons / household (Mawatsan, 2004).

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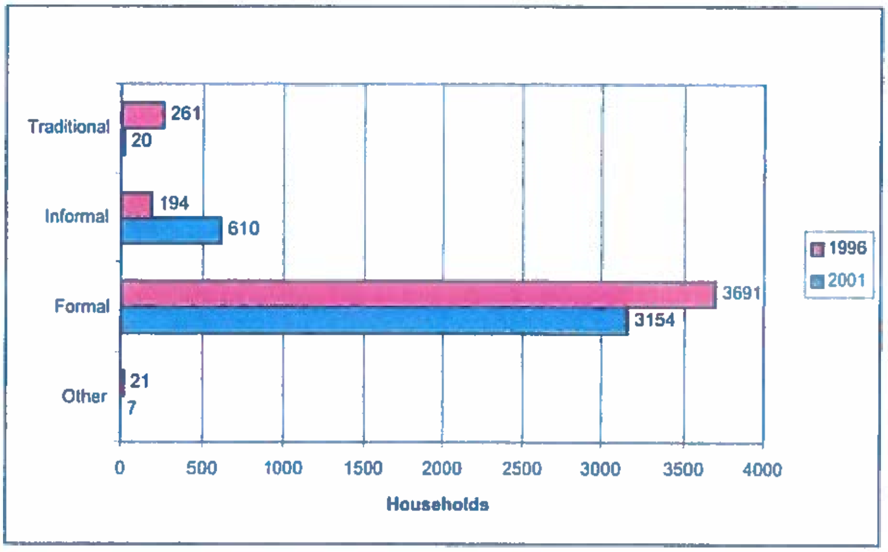

Figure 2-74: Gamagara dwelling types (Mawatsan, 2004)

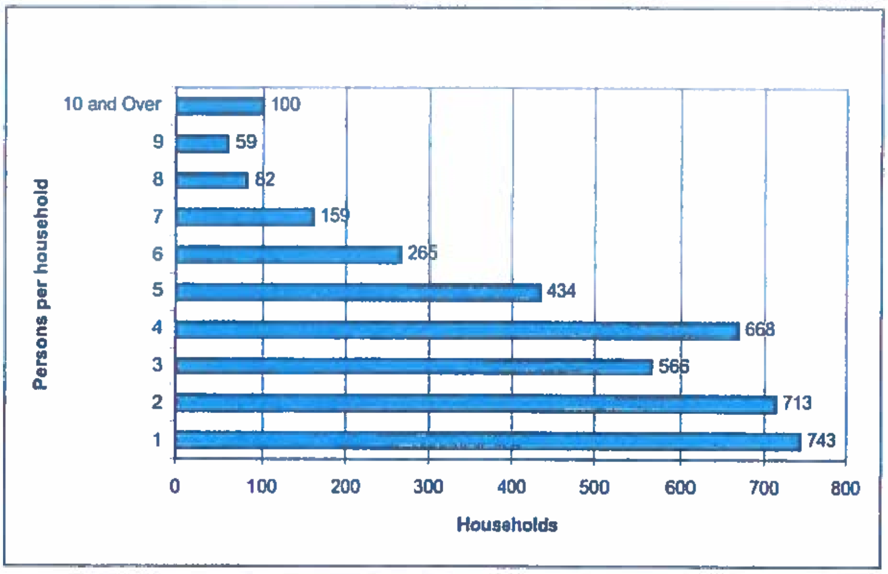

Figure 2-75: Gamagara household size (Mawatsan, 2004)

2.16.3.7 Land Use

Cattle and livestock farming

Prior to mining the foremost land use in the area involved cattle and small livestock farming. The carrying ability of the veldt is rated to be low. Low-density cattle farming remains the norm, with emphasis on meat production and on dairy farming. Because of the low precipitation, the area is not suitable for agriculture. Livestock and game are the most common animals found on farms. Farms are not labour intensive and are seldom inhabited by many families.

Agriculture

Agricultural activities in the district are limited by the need for water. Farms are usually large and grazing is restricted to one large animal per 20 hectares.

Land claims

There have not been any land claims on the farms Bruce, King or Parson. The expected land claims of the immediate affected area are the farm McCarthy to the south of the BKM Project (Mawatsan, 2004).

2.16.3.8 Economic Activities

The largest provider of employment in the Gamagara is the Mining sector (34 %), followed by Community / Social / Personal Services (13 %) and Manufacturing (10 %). More than 85 % of the population of Kathu and Dingleton is associated with Sishen Mine and related activities (such as employment in support services and trades). The local municipality employs a large %age of the remaining 15 %.

The light industrial area of Kathu houses more than 70 established businesses with 29 business stands for the development of secondary industries (Mawatsan, 2004).

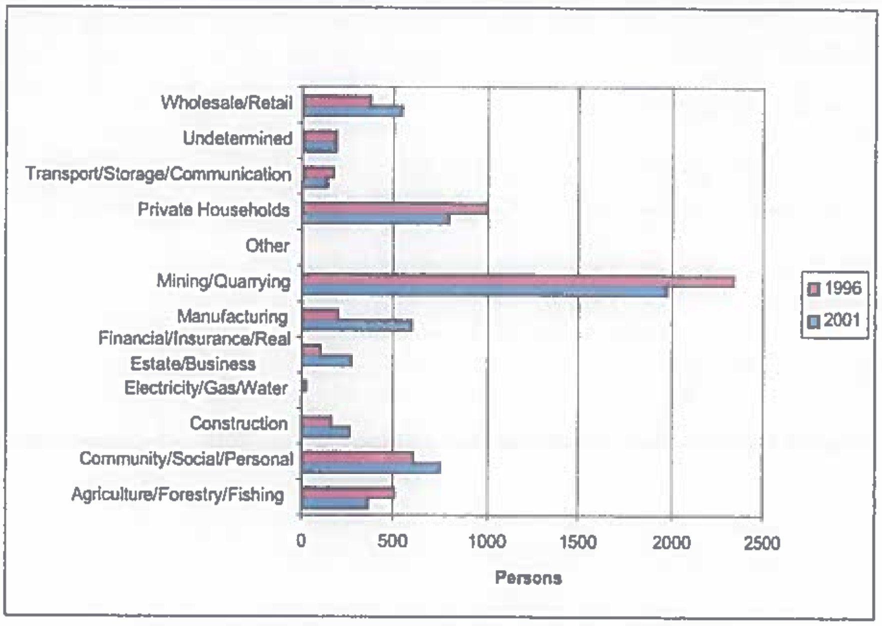

Figure 2-76: Gamagara economic activities (Mawatsan, 2004)

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2.16.3.9 Services

Transport and road infrastructure

The N14 road passes by the town of Kathu. Other roads linking nearby towns include:

- Tarred road between Kuruman and Postmaburg,
- Tarred road past Kathu toward Debeng, and
- Tarred road between Dingleton and Lylyveld.

There is a tarred road junction from Dingleton South to the Postmasburg road (R325), but generally the roads are in bad condition.

Railway lines include:

- Railway from Postmasbrg to Hotazel via Sishen,
- Connecting line between Sishen and Saldanha (OREX line), and
- Postmasburg-Hotazel railway line across the southern part of the farm Bruce (Mawatsan, 2004).

Sanitation and waste removal

With regard to water and sanitation provision, 14 % of the population does not have access to potable water supplies and 60 % do not have access to adequate sanitation services. Ninety-two % of households have access to electricity, 87 % have weekly refuse removal, and 69 % have flush toilets.

Health and welfare

HIV / AIDS related diseases are one of the main contributors to mortality in the Kgalagadi area. Asbestos related diseases in the area are also high (Mawatsan, 2004).

2.16.3.10 Crime

Low capacity for police services and a low income feeds the high rate of crime. Violent crime against women and children, as well as stock theft, are higher than any other province.

2.16.4 Local Town (Kathu)

2.16.4.1 Background

Kathu is the town closest to the proposed BKM Project, approximately 15 km north of the centre of the proposed project. The town falls within Ward 4 of the Gamagara Local Municipality.

2.16.4.2 Population Statistics

Approximately 22 % of the population are dependent children under the age of 14, whereas 2 % are pensioners. Approximately 92 % of the population falls within the economically active and employed, whereas 7 % is unemployed.

The three main languages in the Kathu area are Afrikaans (74 %), Setswana (22 %) and English (2 %).

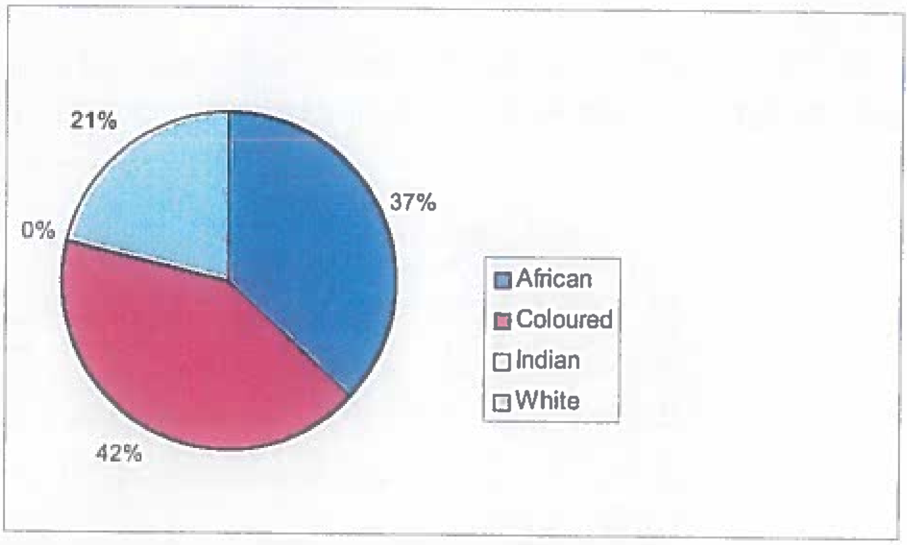

Figure 2-77: Ward 4 (Kathu) population breakdown

2.16.4.3 Age and Gender Structure

Fifty-one % of the population is male, and 49 % is female. Twenty-six % of the population is under 14 years of age, while another 26 % is over the age of 35.

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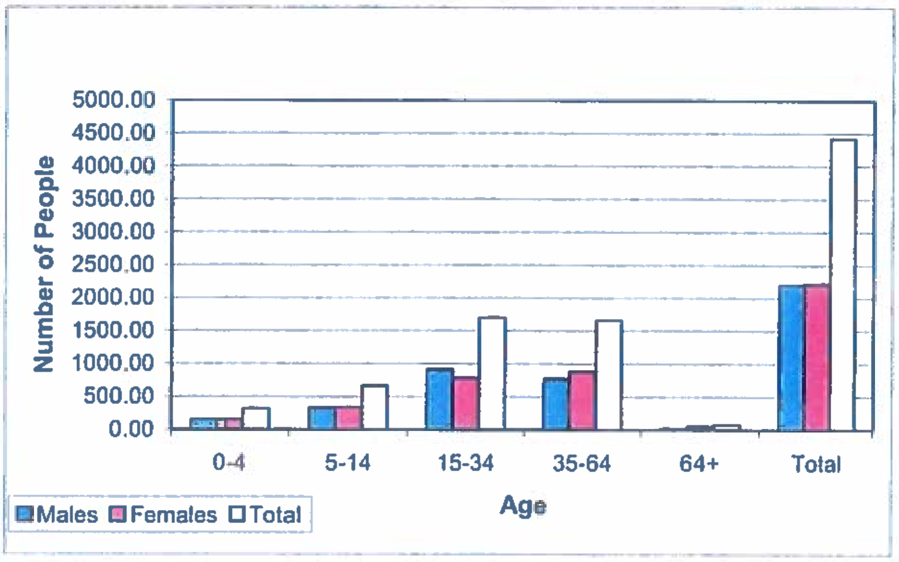

Figure 2-78 Ward 4 (Kathu) age and gender structure

2.16.4.4 Education

Seventy-seven % of the population group attend school. Eleven % of the population undertook tertiary education after schooling. Twelve % of the population has not had any schooling.

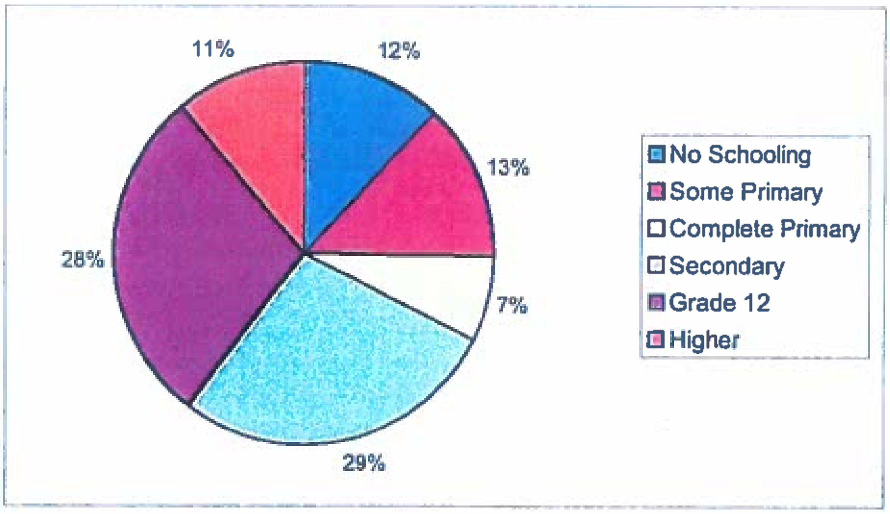

Figure 2-79: Ward 4 (Kathu) education levels

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2.16.4.5 Employment

Approximately 65 % of the population in Ward 4 is employed, whereas only 5 % is classified as unemployed. Approximately 30 % of the population in this area is classified as not economically active.

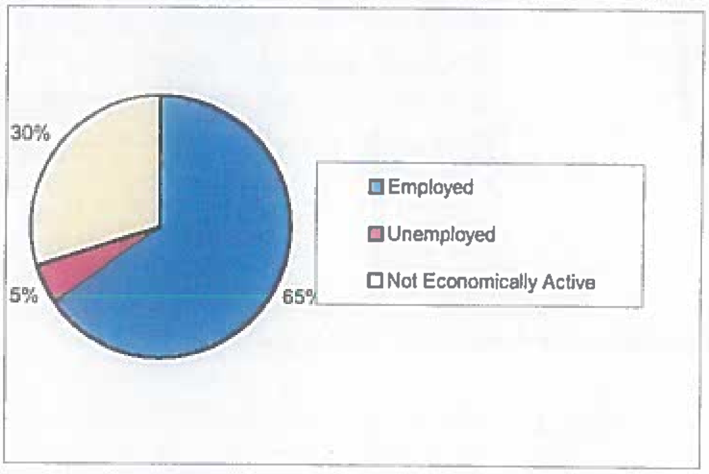

Figure 2-80 Ward 4 (Kathu) economically active status

2.16.4.6 Housing

Ninety-nine % of the population live in formal housing, and one % in informal settlements.

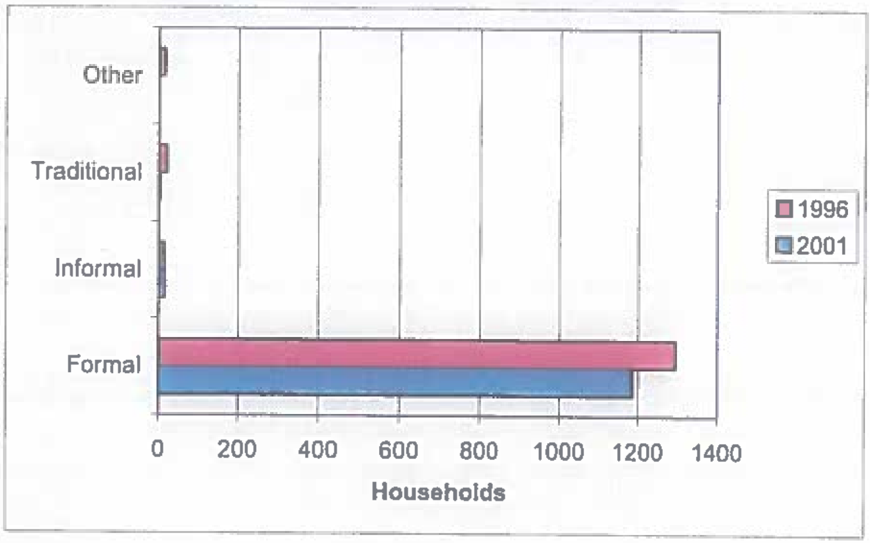

Figure 2-81: Ward 4 (Kathu) dwelling types

Thirty % of households have more than four people, while 39 % have fewer than four rooms.

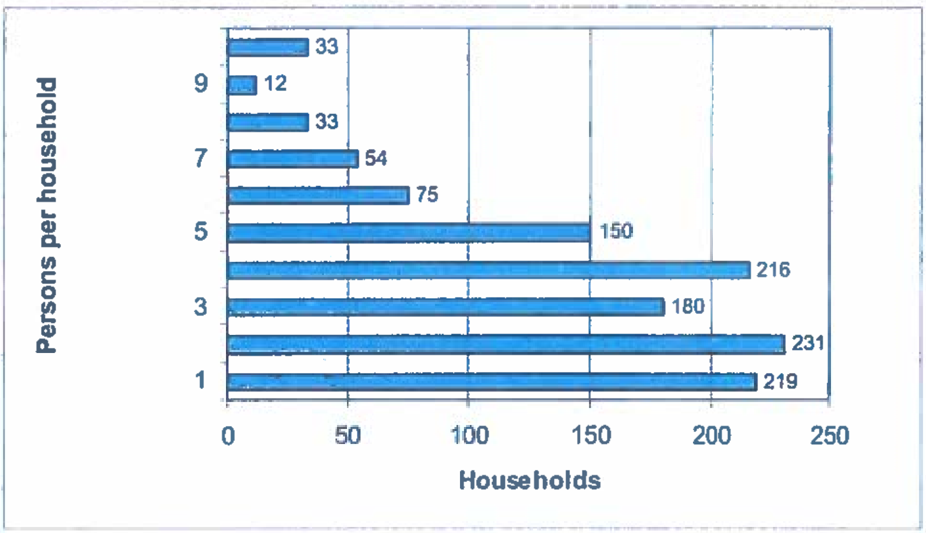

Figure 2-82: Ward 4 (Kathu) household size

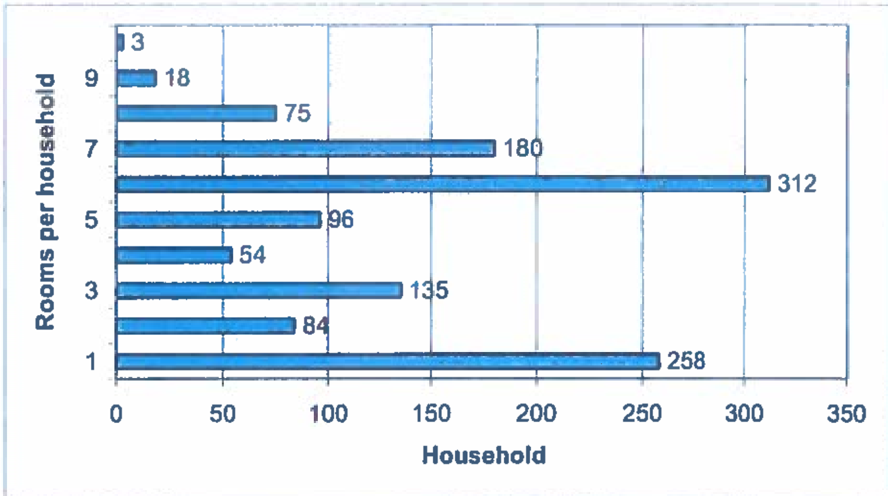

Figure 2-83: Ward 4 (Kathu) Number of rooms per household

2.16.4.7 Economic Activities

Mining contributes about 43 % of employment in the Kathu area, followed by people economically active in private households (16 %) and within the community / social / personal sector (14 %). Agriculture however only employs 0.7 % of the formally employed in the Kathu area.

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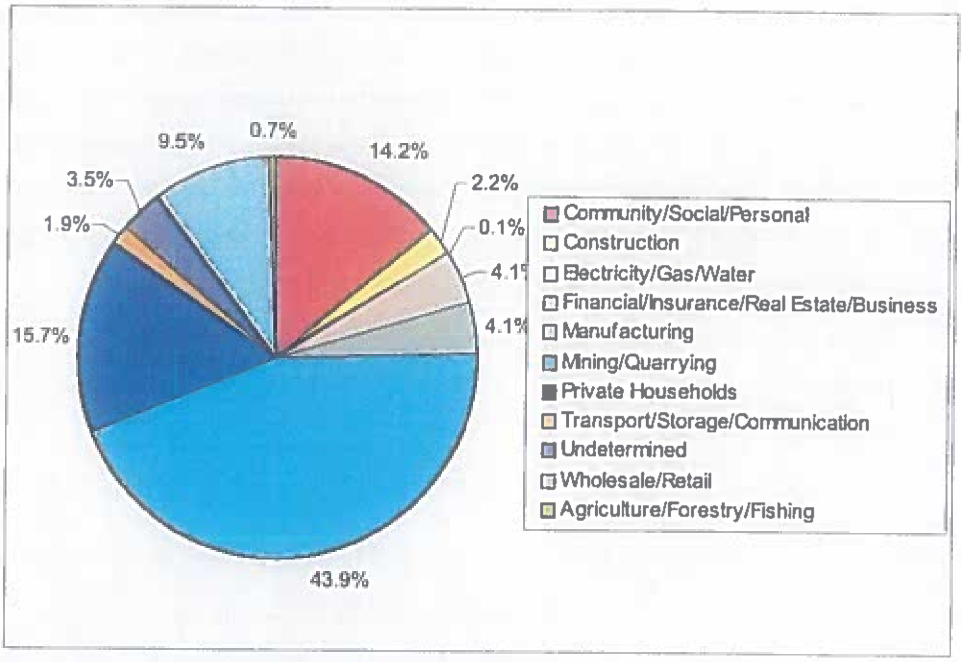

Figure 2-84: Ward 4 (Kathu) economic activities

2.16.4.8 Services

The following information relates to the services supplied in the Kathu area - 99.8 % of the people in the Kathu area are supplied with electricity, whereas only 0.2 % of households are dependent on candles; 98 % of the people have access to flush toilets and 1.2 % have no access to toilet facilities; 84 % of people have access to a telephone, cellular phone or both; 98 % of people are supplied with water in dwellings.

2.17 Crack Survey

2.17.1 Aim

A crack survey was carried out to determine the potential impact on surrounding houses, which could result due to blasting activities undertaken by the proposed BKM Mine.

2.17.2 Methodology

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As no existing infrastructure will be established or is currently situated within the legislated 500 m blasting radius, it was agreed with Ivuzi that various radii of impacts be established to determine potential impacts on surrounding farm houses. Information specific to the BKM Mine were assessed in accordance with a Peak Particle Velocity (PPV) impact table in order to determine the various radii of impact specific to the proposed BKM Mine operations. The study determined different radii in which high, medium, low and no impacts could occur as a result of the BKM Mine blasting procedures. Radii of 600 m (high impact), 1 000 m (medium impact), 3 000 m (low impact) and greater that 3 000 m (no impact) were established around the BKM Mining area to provide a framework for the investigation.

The mass of explosives per delay (kg), and constant PPV values were included into the equation to determine distances associated with various PPV's, specific to the BKM Mine blasting procedure.

$$PPV = 1143\ (D / \sqrt{E})^{-1.6}$$

Where:

D = Distance to property of concern (m)

E = Mass of explosives per delay (kg)

PPV = Peak Particle Velocity (mm/s)

This method was used as an estimate only; since it assumes site constants, which would differ on various sites, rock types, etc.

It was decided that all houses situated within the low, medium or high impact zones will be assessed during a crack census.

Although the town Dingleton is situated approximately 2 km from the BKM northern opencast operations, and within the low impact radius of blasting activities by the BKM Mine, it is not regarded as an area that will be significantly impacted on by the blasting activities. The reason being that Dingleton will be relocated in the nearby future, due to the expansion of mining activities by Sishen. A current seismic station of Sishen is implemented within the Dingleton town.

2.17.3 Proposed blasting procedures

The BKM Mine will be mined to an average final depth of about 116 m, with the deepest pit being 240 m and the shallowest pit, 30 m. The closest opencast operation will be located at an approximate distance of 1 200 m from the nearest farmhouse on Mokaning Portion 1, of which the surface and mineral rights belong to Assmang Limited.

The Mining Consultant supplied the following summary of the blasting procedures for the BKM Mine opencast operations. The data should be regarded as indicative as no blasting has been undertaken yet, and the blasting schedule has not been finalized.

- Number of blasts per day: Estimated 1 blast per day
- Time of day when blasting will occur: Between 12h00 and 16h00
- Charge weight: 200 kg per hole
- Explosives type: Emulsion Blend
- Number of rows: 3 in ore and 3 in waste
- Distance apart: 4 m in ore; 4.5 m in waste
- Panel size: 103 holes in ore;154 holes in waste
- Size of holes: 165 mm diameter
- Depth of holes: 10 m bench + 1.3 m sub-drill = 11.3 m
- Delay between charges: in excess of 500 ms in and 42 ms between holes.

2.17.4 Surrounding activities inducing vibrations

The possible role of blast-induced and other vibrations during the course of nearby mining operations and other activities must also be raised. There are various activities in close proximity to the BKM Mine, which could lead to an increase in vibrations detected by the various farm owners. These include the following:

- Trains

Two major railway lines transect the BKM Mine property, i.e. the Orex line to Saldanha and the Postmasburg line to Port Elizabeth.

The presence of the trains in the vicinity of the surrounding farm properties, will increase the amount of measurable vibrations as per seismic stations, but will not have significant impact on the potential cracking of houses.

- Surrounding Mining Activities

The BKM Mine area is not undermined; the nearest operating mine is some 6.8 km from the nearest farmhouse on the farm Dingle.

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Blasting data from Sishen, investigating blasting impacts on the nearby town Dingleton (within 1 km from the Sishen mining activities), indicated that blasting activities fall well within the USBM Limits for particle velocity vs. frequency.

Given the blasting protocols followed by the Sishen Mine, the distance of the mine from the properties under investigation, and the data indicating the particle velocity vs. frequency, it is concluded that the mine is much too far removed for vibrations transmitted through rock and soil to be considered as a possible cause of any cracking on the farms to the south and east of the BKM Mine property.

- N14 and R325 roads

The N14 national highway and the R325 run through the BKM Mine properties.

The presence of the roads in the vicinity of the surrounding farm properties, will increase the amount of measurable vibrations as per seismic stations, but will not have significant impact on the potential cracking of houses.

- Other factors

Other factors, including geology, soils and building constraints are discussed in more detail within the following Section.

2.17.5 Cracking factors

The previous section indicated the various activities that could induce the measurable vibrations levels as detected by a seismic station, but are not necessarily a contributing factor to cracking of infrastructure. It should be noted that more than one factor may be involved in the development of cracks in a mine area. The sections following will detail these.

2.17.5.1 Geology

Due to the presence of dolomites in the area (Refer to Section 2.1 for a detailed geological description), the possibility for the development of sinkholes and associated cracks exists. Sinkholes have been reported in the area. However, due to the surrounding mining operations, which have been in operation for over 50 years, the proposed BKM Mining area has been dewatered. The proposed mine will therefore not, or if so, to a limited degree, dewater from the opencast pits, as the inflow of groundwater into the mining operations is not foreseen.

The potential for impacting the underlying geological structure and the associated impact on the groundwater, which has a direct impact on karstification, ground instability and sinkhole development, is therefore not envisaged for the new mining development.

The result of cracking due to the underlying geological structure does exist. It is, however not foreseen that the new mining development will contribute to this issue.

2.17.5.2 Soils

A high clay (i.e. smectite) content in soils will impart to them a fissured and slickensided structure which emanates from local movements within the soil mass. Movements can be extremely damaging to houses founded upon soils with high clay content without the use of specially designed foundations and superstructures. The clay content in the soils of the BKM Mine area is however very low. The soils are therefore not subject to heave and shrinkage with changes in moisture content. Refer to Section 2.4 for a detailed description on the soil conditions associated with the BKM Mine.

The topsoil depth is generally between 0,30 and 0,50 m thick, except in the areas underlain by Mispah Form soils and rock outcrop, where topsoil is less than 0,10 m thick. The total soil depth is highly variable. In the areas of Mispah and Augrabies soils and outcrop, soil depth is between 0,0 and 1,0 m, averaging about 0,50 m. In the areas of Hutton and Plooysburg Form soils, soil depth ranges between 0,3 and greater than 2,0 m. It is generally in the order of 0,4 to 1,0 m. In general, soil depth is less than 0,50 m with frequent scattered cobbles and boulders on surface. Due to the shallow soil conditions, the collapse potential of the soils is very low.

Cracking due to soil conditions is therefore not anticipated due to the low clay content and the shallow soil conditions.

2.17.5.3 Building conditions / construction

Building conditions / construction methods could play an integral role in the development of cracks. According to a report by Dr. Partridge, 2004 the construction methods, which can contribute to cracking of the infrastructure could be summarized as follows:

- Casting of corrugated iron roofing sheets and supporting beams into the upper courses of peripheral walls of the house. This could cause strain from the expansion and contraction of the iron sheets as a result of diurnal solar heating and nocturnal cooling.
- Inadequate lintels above door and window openings, or, in some cases, failure to use a lintel of any kind. The strength of the lintels (usually a function of their composition and thickness) in relation to the span of the opening, and insufficient extension of lintels into the adjoining walls, are problems, which can lead to structural failure, with associated cracking above doors and windows.

- Poor bonding between walls. This is frequently a result of the later addition of walls without providing interlock along the abutments by bridging into openings created in the old wall in alternate brick or block courses.
- The use of poor quality building materials. These include bricks or blocks of poor strength, poor quality cement (or, sometimes, a lime-mud mix) between brick/block courses.
- Failure to provide adequate foundations for the house superstructure. If no concrete strip footings have been provided, and brickwork or blockwork has been laid directly on the soil
- Omission of any damp proof course. This permits rising damp to weaken the lower walls.
- The occasional placement of heavy tiled roofs on walls that are of inadequate strength as a result of the use of poor construction techniques or materials.

The farmhouses visited during the crack census were in a very bad condition as most of the properties have been neglected due to selling agreements. Hence a crack survey has not been undertaken on properties which will be purchased or belonging to Assmang, as these will be used as mine offices (security etc.) and will be fixed where necessary.

The house on the farm Sishen, just north of the farm Police Camp, could be utilized for contractor accommodation. The property owner is planning to establish a construction camp on the property. The main house is in good condition, however the outside buildings have been neglected and consists of various cracks.

The Burk Mine Offices are situated in the low impact zone. The building has various cracks, as this is an old building, which has been, renovated by the mine. The only concern for the mining personnel was the weighbridge, which is situated, in the medium impact zone along with the plant operations. The weighbridge is a small building, which is in good conditions although associated with some crack along the outside foundations. No further permanent building exists on the property.

Section 5 will detail the findings of the crack survey. Refer to Appendix 10 for the detailed crack survey.

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2.18 Consultation Process

This section of the report documents the process, which was followed with respect to consultation of the interested and affected parties (I&AP's) and the Government Authorities.

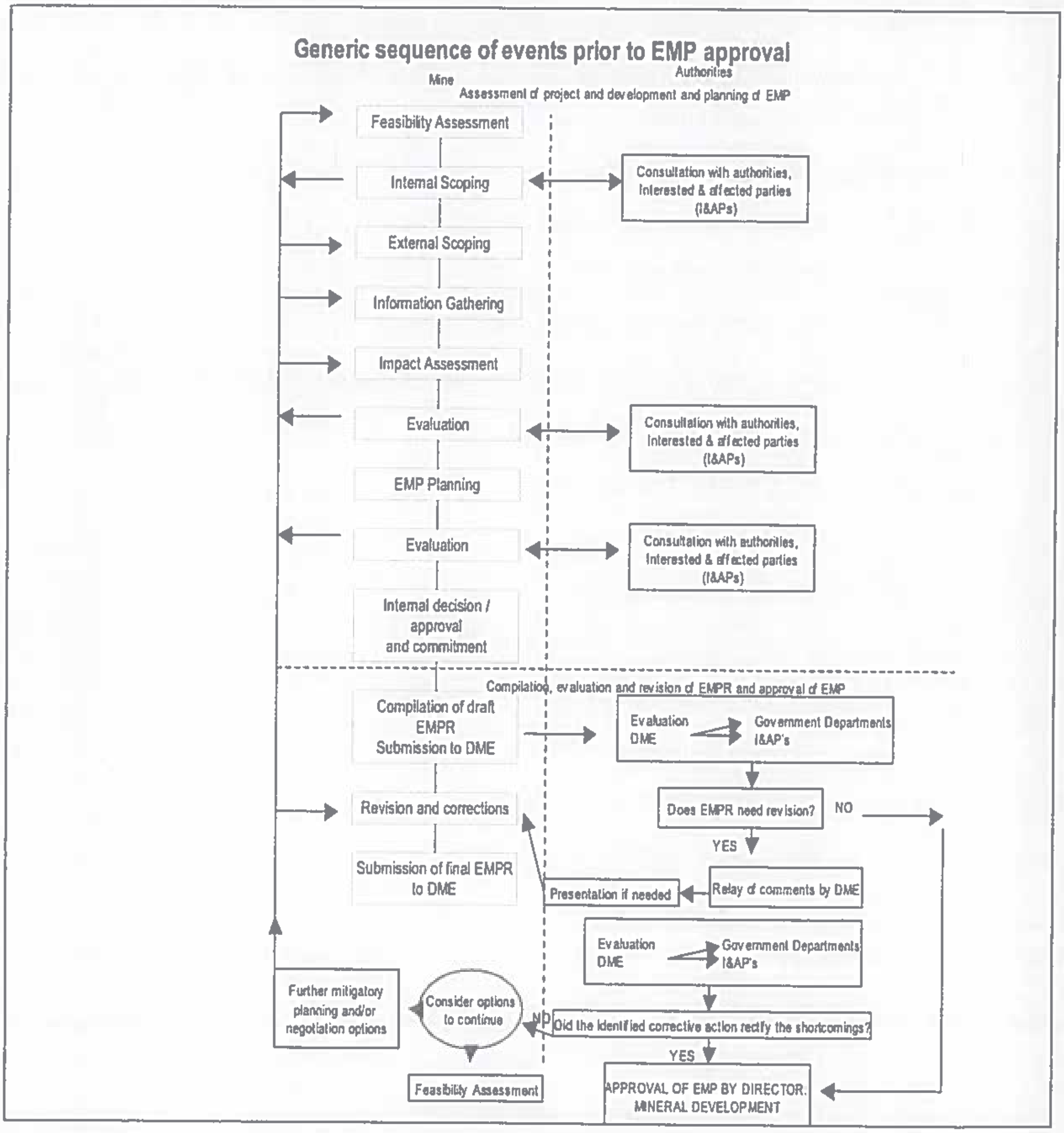

Figure 2-85: Generic sequence of events for EIA / EMP

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2.18.1 Government Authorities

2.18.1.1 Identifying the Government Authorities

Authorities were identified by Ivuzi and DME, during the initial Authorities Introductory Meeting (refer to Table 2-16) and throughout the scoping phase.

The following Authorities have been identified and were invited to become involved in the BKM Mine environmental process:

National Government Authorities:

- Department of Minerals and Energy (DME);
- Department of Water Affairs and Forestry (DWAF);
- National Department of Agriculture (NDA);
- Department of Tourism, Environment and Conservation (DTEC / DACE);
- Department of Land Affairs (DLA);
- Department of Transport; and
- National Roads Agency.

Provincial Government Authorities:

- Department of Housing and Local Government;
- Department of Transport, Roads and Public Works;
- Provincial Administration Northern Cape;
- Department of Economic Affairs;
- Department of Agriculture; and
- Department of Health.

Other Authorities:

- Spoornet;
- Eskom; and
- South African Heritage Resources Agency (SAHRA).

Table 2-16: Identified authorities

Name of Department	Authority	Position	Postal Address	Contact Details	Email
National Government Authorities					
DWAF	Jurgen Streit Gawie van Dyk	Deputy Director	Private bag X6101 Kimberly 8300 Corner Knight and Stead Street Kimberly 8300	053 831 4125 (Phone) 053 831 4534 (Fax) 082 806 3400 (Cell)	streitj@dwaf.nk.gov.za 4na@dwaf.gov.za
DACE / DTEC	Dineo Moleko Abie Abrahams	Environmental Officer Director	Private bag X6012 Kimberly 8300 224 du Toitspan Rd Kimberley 8300	053 807 4800 (Phone) 053 831 3530 (Fax)	dmoleko@grand.ncape.gov.za aabrahams@grand.ncape.gov.za
National Department Agriculture	Harm Voster	Chief Resource Conservation Inspector	PO Box 2303 Kimberly 8300 Ou Munt Building Cannelworth road De beers Kimberly 8300	053 831 1793 (Phone) 053 832 3101 (Fax) 083 233 7730 (Cell)	jhen@iafrica.com
Department of Land Affairs	David Smit	Deputy Director	Private Bag X5007 Kimberley 8300	053 831 4090 (Phone) 053 831 4095 (Fax) 082 822 5102 (Cell)	ddsmit@sghq.pwv.gov.za
Commission on Restitution of Land Rights	Maxwell Jansen		Private Bag X5007 Kimberley 8300	053 807 5700 (Phone) 053 831 6501 (Fax)	macjansen@dla.gov.za

DME	Roelien Oosthuizen Rudzani Mudau Hennie van Rensburg		PO Box 6093 Kimberly 8300 43 Chapel Street Kimberly 8300	053 830 0800 (Recept) 053 830 0808 (Phone) 053 832 5631 (Fax) 082 454 5824 (Cell) 053 830 0801	roelien.oosthuizen@dme.gov.za
Department of Transport	Albert Meyring	Districts engineer east.	Private bag X 5064 Kimberly 8300 45 Smitdrift weg Kimberly 8300	053 861 9600 (Phone Kimberly) 053 861 9626 (Fax Kimberly) 053 353 2054 (Phone Prieska) 053 353 2135 (Fax Prieska) 082 825 9122 (Cell)	ameyring@de.ncape.gov.za (Prieska) ameyring@dre.ncape.gov.za (Kimberly)
Provincial Government Authorities					
Department of Labour	D Abile		46 Main Street Postmasburg 8420	082 346 9470 (Cell) 053 313 1569 (Fax)	None
Provincial Administration Northern Cape	Paul Fanner			053 839 2165 (Phone) 053 861 9600 (Phone) 083 231 6119 (Cell) 059 861 9626 (Fax)	pfanner@wil.ncape.gov.za
Department of Housing and Local Government	Mr S Kies	Waarnemende Director of infrastructure and development	Private bag X5005 Kimberly 8301	053 830 9427 (Pieterse) 053 830 9430 (Kies) 053 830 9462 (Assegaai) 053 831 8718 (Fax)	jwest@sjp.ncape.gov.za
Transport, Roads and Public Works	Deputy Director	Mr Selemela	PO Box 3132 Kimberly 8300	053 839 2100 (Phone) 053 831 3973 (Fax)	selemela@wil.ncape.gov.za

Economic Affairs	Mr Darius Babuseng Mr Makweya	Director MEC	Private Bag X6108 Kimberly 8300	053 839 4000 Phone) 053 831 3668 (Fax) 053 831 4136 (Phone) 053 832 9464 (Fax) 082 556 9936 (Cell)	dbabuseng@met.ncape.gov.za tmakweya@met.ncape.gov.za
Agriculture	Mr WVD Mothibi	Chief Director	Private Bag X5018 Kimberly 8300	053 838 9102 (Phone) 053 831 3635 (Fax)	stoffar@grand.ncape.gov.za
Health	Dr Magyo	Head of Department	Private Bag X 5049 Kimberly 8300	053 830 2102 (Phone) 053 833 4394 (Fax)	amatthews@kbhsp.ncape.gov.za
Other Authorities					
Spoornet	Willie Maritz Bill Garden Piet du Plessis	Area Manager Environmental Manager Infrastructure	P O Box 620 Kimberly 8301 Corner Roper and Quinn Street Kimberly 8301 PO Box 2189 Joubertpark 2044 Kamer 712 Smit Street 222 Braamfontein 2017	053 838 2420 (Phone) 053 838 2725 (Fax) 011 773 8881 (Phone) 011 773 7127 (Fax) 083 283 6442 (Cell) 083 461 7161 (Cell)	maritzw@spoornet.co.za billg@spoornet.co.za
Eskom	Jan Peyper Piet Ferreira	Design Engineer		083 301 7991 082 857 3352	peyperjf@eskom.co.za Pieter.Ferreira@eskom.co.za

National Monuments Council (SAHRA)	Andrew Timothy	Acting Provincial Manager	PO Box 1930 Kimberly 8300 27 D-Arcy Street Kimberly 8300	053 831 2537 (Phone) 053 833 1435 (Fax) 083 329 5791 (Cell)	sahranc2@iafrica.com

2.18.2 Informing and Contacting Authorities

Two main meetings (an Introductory Meeting and a Scoping Meeting) were held with authorities regarding the BKM Mine.

Ivuzi invited the relevant Authorities to an initial introductory meeting via telephone, e-mail and / or fax. The objective of the meeting was to:

- Inform the Authorities of the proposed BKM project,
- Inform and discuss the projected timeframes of the project,
- Determining the technical issues associated to the project and the requirements of the New Minerals and Petroleum Resources Development Act of 2002,
- Understand the concerns of the Authorities,
- Highlight the importance of the Authorities input in the EIA / EMP process.

The meeting was held on two separate dates (25 and 26 May 2004) to accommodate all authorities wanting to attend.

Representatives from those department listed under 2.17.1.1 were further invited to attend the Scoping Meeting on 29 June 2004 at the Beeshoek Ammosal Club Conference Room at Beeshoek Mine. The Authorities include those from the initial introductory meeting, as well as authorities identified throughout the scoping process. The objective of the meeting was to:

- Provide detailed information regarding the proposed project,
- Finalize the technical issues associated to the project, and the New Minerals and Petroleum Resources Development Act of 2002,
- Insure that all the concerns of the Authorities are understood,
- Define the scope of work for the compilation of the EIA / EMP
- Finalize the timeframe for the proposed EIA / EMP process.

Copies of the Authority Meeting presentation, attendance register and minutes were forwarded to all the government departments.

Refer to Appendix 11 (a) for minutes of the meetings.

The Environmental Impact Assessment and Environmental Programme Report will be presented to the Authorities on 25 February 2005 during a meeting in which the documents will be discusses and submitted for comments.

2.18.3 Interested and Affected Parties (I&AP's)

2.18.3.1 Identifying I&AP's

The existing comprehensive list of I&AP's from the Beeshoek Mine, have been expanded upon by Ivuzi through a process of networking, press advertisements and poster notices. Beeshoek has established a database consisting of contact persons and various forums. These included:

- Non Governmental Organizations,
- Tsantsabane Forum of Communication, Transport and Finance,
- Tsantsabane Forum of Health and Welfare,
- Tsantsabane Forum of Entrepreneurial,
- Tsantsabane Forum of Tourism and Environment,
- Tsantsabane Forum of Protection Services,
- Tsantsabane Forum of Education and Training,
- Tsantsabane Forum of Agriculture and Water,
- Other contact persons.

The Chairperson and Secretary (where available) from each forum were contacted personally. Background Information Documents (BID) were provided to the Forums for distribution. Landowners were personally contacted by Ivuzi and provided with BID's. Refer to Appendix 11 (b) for a list of Stakeholders utilised for this project.

Beeshoek Mine conducted a forum meeting on 23 June 2004, where the BID of the BKM mine was discussed. Issues and concerns were gathered and forwarded to Ivuzi in order for it to be addressed in the specialist investigations and environmental reporting.

2.18.3.2 Informing Stakeholders

<u>Advertisements</u>

Advertisements regarding the project background, the assessment process being followed and the details and purpose of the Public Meeting were placed in the following newspapers:

- The Volksblad on 1 June 2004

- The Kuruman Bulletin on 4 June 2004
- The Gemsbok on 4 June 2004.

Notices

Notices were place in the following places:

- Gasegonyana Municipality, Kuruman,
- Kgalagadi District Council, Kuruman,
- Kgatelopele, Danielskuil,
- Gamagara Municipality, Kathu,
- Gamagara, Deben,
- Tsantsabane Municipality, Postmasburg,
- Groenwater Village, Postmasburg,
- Postdene, Postmasburg,
- Boichoko, Postmasburg,
- Welgelee, Olifantshoek,
- Postmasburg Schools, Tsantsabane Municipality,
- Newtown Community, Tsantsabane Municipality.

In addition, notices in Afrikaans, English and Setswana were distributed by the Human Resources Department of Beeshoek to all the Beeshoek workers and mine unions. Refer to Appendix 11 (c) for a copy of the advertisement and notices.

Background Information Document

Ivuzi forwarded a Background Information Document or BID (Refer to Appendix 11 (c) to all I&AP's / stakeholders via e-mail, fax and/or post. The BID was made available in Afrikaans, Setswana and English. Copies of the BID were distributed to the surrounding communities by the Social Community Investor of Beeshoek mine. The BID included details of the proposed project as well as the EIA / EMP purpose, requirements and process. It also included relevant contact details and a comment / registration sheet. I&AP's were invited to register and send responses by fax, telephone or e-mail to Ivuzi.

The BID was also distributed via intranet to all Beeshoek mine users.

2.18.3.3 Identifying I&AP's Views and Concerns

Key Stakeholder Meeting

Ivuzi distributed invitations to all those I&AP's / stakeholders on the database included in Appendix 11 (b) to attend a Stakeholders meeting on 3 July 2004. Mawatsan, who is undertaking the Social and Labour Plan for the BKM mine, was invited to act as the mediator during the stakeholder meeting. The background to the project, as well as the environmental approach, was explained and copies of the minutes of the meeting were forwarded to all attendees.

The attendees were encouraged to raise issues, concerns, questions and views. All of these were documented during the discussion session. A list of meeting attendees and the proceedings of the meeting are included in Appendix 11 (d). The issues / comments were consolidated into Sections 5 and 6.

Property Owners Focus Meeting

The property owners of the surrounding BKM Mine area requested a focus meeting in which issues regarding the proposed BKM Mine could be discussed. Representatives from Ivuzi, Mawatsan and ARM / Assmang attended the meeting.

Various issues were discussed during the meeting. The farmers were given the opportunity to raise concerns, which were minuted and are noted within this Scoping Report and will be investigated for the EIA and EMP. The Minutes are included in Appendix 11 (d).

Telephonic, Fax and Electronic Mail Communication

Throughout the Scoping Process the I&AP's / stakeholders were invited and encouraged to communicate their concerns / views on the proposed project to Ivuzi via telephone, fax or email.

2.18.4 Additional Public Participation

An Environmental Impact Assessment, according to the Environmental Conservation Act of 1989 is being undertaken for the BKM Mine in parallel to the BKM Mine EIA / EMP.

All registered I&AP's / Stakeholders were personally informed by Ivuzi (via fax, e-mail or phone) of the additional environmental studies being undertaken. Advertisements, notifying the public of the EIA process were placed in the following newspapers:

- Gemsbok;

- Volksblad; and
- Kuruman Bulletin.

Notices were placed in various venues in the Olifantshoek, Postmasburg, Kuruman, Danielskuil and Kathu areas. An on-site notice was also placed at the farm King. BIDs were made available to the registered I&AP's / Stakeholders.

2.18.5 Issues Raised During The I&AP Consultation

This section of the report documents the concerns, comments, viewpoints and questions (collectively referred to as 'issues') raised by the Authorities, Key Stakeholders, I&AP's and Ivuzi during the consultation process. In addition, Ivuzi, Assmang and Mawatsan have compiled detailed responses to each, either detailing the way forward (i.e. how these issues will be dealt with in the subsequent phase of the project) or providing explanations where required.

Table 2-17: Issues identified and raised during public consultation

Impact	Issue	Issue raised by…
Geology	Sinkhole development	J Z Olivier Farm Owner
Topography	None were raised	
Soils	None were raised	
Land use and Land capability	None were raised	
Fauna and Flora	None were raised	
Surface Water	Impact of BKM Mine on water in the BKM area.	D Jansen van Rensburg Farm Owner
	Has the storage of water been investigated?	Nick de At Farm Owner
Groundwater	Impact of BKM Mine on groundwater levels in the BKM area.	D Jansen van Rensburg Farm Owner
		J Z Olivier Farm Owner
	The potential for groundwater pollution	D v Rensburg Farm Owner
	Where will water be extracted?	K Loots Farm Owner
	The impact of dewatering on the groundwater levels. Impact on groundwater levels Impact on Groundwater	K van Coppenhagen Farm Owner
		K & S Cornelissen Farm Owner
		MW Von Wieligh Kumba

Impact	Issue	Issue raised by...
Visual	Impact of lights on the game farms / light pollution	J Z Olivier Farm Owner / Secretary of the Farmers Association: Lomoteng Farmers Association K Venter Kgalagadi Districts Municipality
Air pollution	Increase of dust in the area The management of dust pollution in the BKM area.	D Jansen van Rensburg Farm Owner K van Coppenhagen Farm Owner MW Von Wieligh Kumba
		J Z Olivier Farm Owner
Noise	Impact of noise on the environment.	MW Von Wieligh Kumba K van Coppenhagen Farm Owner
Archaeology	None were raised	
Sensitive landscapes	None were raised	
Mining operations	The depth of the pits at the BKM Mine.	J Z Olivier Farm Owner
	Establishment of refining process as it creates a lot of job opportunities	Constant Fourie Farm Owner

Impact	Issue	Issue raised by...
Socio-Economic Impacts	How many people will be affected by the new developments?	C Joachim Interested and Affected Party
Local Employment	Involvement of youth and local community in the new BKM Mine How will the issue regarding unemployment and local employment be handled? Will local entrepreneurs be used in the construction of infrastructure? The benefits of the project to the community at large in the Tsantsabane Municipality (i.e. create work and fight poverty). Involvement of local contractors in the production process. Build the refining markets in our provinces. Privatize our people by employing them in the mining field Employment to a number of unemployed residents in the Postmasburg District, in particular the youth who end up in the world of crime.	Mbuyiselo Ashley Mpetsheni Involved in a youth company 8 km from Beeshoek. IC Nkadimang Interested and Affected Party Donald Ingwane Tsantsabane Forum Entrepreneurial H Mothibi Postmasburg Employment H Mothibi Postmasburg Employment N E Hendrick Kuruman T V Phepheng Tsantsabane Health and Welfare
	How many people will be employed at the BKM Mine?	E Croucamp Farm Owner and businesses in Kathu
	What skills will be required for the construction of the plant at the BKM Mine?	Tshilidzi Doreen Molwagae Interested and Affected Party
	Will Beeshoek Mine Employees have to re-apply for their positions at the new BKM Mine? How long will it be before the staffing-model for the BKM Mine is in place?	Corne le Roux Assmang: HR department

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Impact	Issue	Issue raised by...
	Will contractors working for Beeshoek Mine have preferred supplier status or could this be negotiated? This will ensure the sustainability of the Postmasburg business community.	
Sishen Operations	Mining Interruptions during the Bruce Blasting Safety Periods Damage to Sishen infrastructure i.e. culverts, pipelines, and power lines Impact on Slope Stability along Sishen / Bruce Pit Blasting perimeter Impact on railway line in the event of tailings dam failure Impact of a downtime on the Sishen – Saldanha rail line during construction activities	MW Von Wieligh Kumba
Business potential in surrounding area (i.e. Kathu)	Is there business potential for the Kathu businesses? How will Assmang contribute to the development of small businesses and what will happen to the current small businesses in the surrounding area? Will Assmang still focus on the Beeshoek area once Beeshoek Mine is decommissioned?	E Croucamp Farm Owner and businesses in Kathu Donald Ingwane Tsantsabane Forum Entrepreneurial
Education facilities	Impact of the BKM Mine on the education facilities in the surrounding area.	A Ramonye Education Department
Safety	Police Service Requirements Fences	I Styles GPF Chair Person J Z Olivier Farm Owner
Transport	Where will the new railway line be established, if the present railway line should be relocated?	A Markram Farm Owner
	Impact of the BKM Mine on the railways and the impact of the realignment.	D Jansen van Rensburg Farm Owner J Z Olivier Farm Owner

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Impact	Issue	Issue raised by…
	Impact of the BKM Mine on the roads and transport on the current N14 (R325)	J Z Olivier Farm Owner D Jansen van Rensburg Farm Owner K van Coppenhagen Farm Owner
	Will BKM Mine provide transportation for their employees?	Johan Peens Assmang
Power Supply	The impact of the BKM Mine on the power lines	J Z Olivier Farm Owner D Jansen van Rensburg Farm Owner
Housing	Where will mine employees by housed / accommodated	J Z Olivier Farm Owner E Croucamp Farm Owner
	What will the impact be on housing (i.e. unoccupied houses) in the Postmasburg area if the mine relocates all the people to the BKM Mine What will be done regarding the new Project in order for it not to impact negatively on houses in Postmasburg? What is the planning for alternatives in regard to housing?	M Swart Tax Payers Association Johan Peens Assmang M Swart Tax Payers Association
Properties	The impact of the BKM Mine on the farm located directly west of King Farm. The impact of the BKM Mine on the farms surrounding the BKM area.	A Markram Farm Owner

Impact	Issue	Issue raised by…
		K Loots Farm Owner J P Croucamp Farm Owner D J Croucamp Farm Owner
	The impact of BKM mine of property value. The impact of the BKM Mine on Bona-Fide Farmers, whose farms are their residences as well as financial provision and how this will impact the farmers' future dreams.	J Z Olivier Farm Owner D Jansen van Rensburg Farm Owner J Z Olivier Farm Owner
Blasting	The effect of blasting activities on the surrounding farms	D Jansen van Rensburg Farm Owner
Waste disposal	Where will waste be disposed?	K Loots Farm Owner
Land Claims	61 000 ha of land has been claimed and should be investigated. If land claims are present the BKM Mine can not commence construction Have studies made provision for the investigation into land claims?	I Tathelo Siyanda Municipality A Ramonye Education Department
Information	Municipalities require statistics, localities and frameworks in order for them to make provision for the various organizations and people in the area.	J Walker Gamagara Municipality
Shares and BEE	How will local people from Kgalagadi benefit from the BKM Mine - will directorship and shares be made available to local people?	K Mmoiemang Kgalagadi Districts Municipality