PART 4: ENVIRONMENTAL DESCRIPTION

Since the commencement of mining operations more than a century ago at the De Beers Kimberley Mines, the environment has already been impacted upon and conditions are generally no longer pristine. This part of the document describes the biophysical environment relevant to the De Beers Kimberley Mines, so that the impacts of the mining activities can be assessed and the best practical environmental options can be identified.

The mining environment has been described in this part of the EMP[1] in terms of each component that makes up the environment, for ease of understanding.

The following terminology has been used throughout this document to describe the relevant surface areas that apply to this EMP (**Table 4.1**).

Table 4.1: Terminology

Area	Definition	Size (in ha)
De Beers Kimberley Mines mining area	Actual mining area as defined in terms of the mining authorisation.	3097
Study area	The areas relevant to this project and investigations depending on the relevant environmental component. The extent of these areas is determined by the area of influence of the different environmental components relevant to each specialist investigation and each environmental component description. The study area referred to in the text thus applies to the specific environmental component under description. The extent of the study area is therefore not influenced by the mine boundary, but rather by the specific activity relative to the environmental component.	Dependant on relevant environmental component
Land use area	The whole area where the land use and land capability has been changed, temporarily or permanently, due to the existing activities. This includes the total area where the income generated per hectare of land will change due to a change in land use.	2270
Area of surface disturbance	This refers to the area where the soil and vegetation has been and will be physically disturbed due to existing activities, as well as infrastructure, i.e. the infrastructure associated with the Treatment Plants, etc.	2270
Phase 1+2 purchase agreement	This area includes the area associated with the Phase 2 purchase agreement. De Beers Kimberley Mines Ltd. sold 717 ha of their Surface Rights and Mineral Rights off to Crown Resources (Pty) Ltd.: Kimberley Underground Mines Joint Venture as part of the Phase 2 purchase agreement.	717

[1] EMP: Environmental Management Programme.

Area	Definition	Size (in ha)

4.1 GEOLOGY

4.1.1 GENERAL

The area of investigation is located on a flat Plateau with an average altitude of just over 1 200 m above mean sea level. The area around De Beers Kimberley Mines is therefore relatively flat due to the nature of the underlying strata. The surface drainage is south towards a number of pans, namely the Dutoitspan, Paardebergvlei and the Benfonteinpan.

The basement rocks consist of Andesitic Ventersdorp lavas and related pyroclastics overlying the Witwatersrand Strata. These lavas are covered by younger shale of the Ecca group of the Karoo Supergroup. A thin layer of less than 5 m of red soils and calcrete is present on the immediate surface.

Refer also to Annexure 9a and 9b of the approved EMPR[2], dated October 1999 Vol. III, extracts of which are attached hereto in **Appendix G** for an indication of the general geology of the Kimberley area.

4.1.2 SITE SPECIFIC

The De Beers Kimberley Mines area is underlain by rocks of the Karoo Supergroup, with a sequence comprising of a sedimentary succession of mainly Karoo shales and dolerite. These successions vary between 10 – 125 m. The sedimentary succession overlies a sequence of Ventersdorp lavas and quartzites, which vary in thickness from ± 900 m below surface at Wesselton Mine to ± 500 m below surface at Joint Shaft and De Beers Mine. The Ventersdorp rock overlies the basement granite gneisses with amphibolites and schists in varying amounts.

Kimberlite tailings resources are located in many locations over the mining property and are likely to influence water quality due to the high sodium and sulphate content and the high silt load contained in the runoff water. An assessment on groundwater impacts was conducted by Golder Associates Africa (Pty) Ltd. The results of this assessment were documented in the report titled "*De Beers Kimberley Mines, Assessment of groundwater impacts from tailings storage facilities and proposed backfilling of open pits – Phase 1 – situation assessment – Rev 1*", dated July 2007, with Report No. 8785/9449/1/G.

4.1.3 KIMBERLITE PIPES

[2] EMPR: Environmental Management Programme Report.

Diamonds were carried to the surface by molten magma forcing channels, or pipes, upward through the earth's crust and bursting through the surface during volcanic eruptions. When the magma eventually cooled in the pipes, diamonds became trapped in the relatively soft rock, which is known as Kimberlite.

As mentioned in previously, several stages of intrusions have resulted in the presence of separate columns of Kimberlite and Kimberlite breccias within the pipes in the Kimberley area. The Kimberlite pipes are approximately circular or oval in shape and are deeply eroded volcanic necks. The volcanic necks, at present, range from 230 m to 500 m in diameter at the surface and the pipes decrease in area with depth. The average dip of the contacts is 80 degrees

4.1.4 PRESENCE OF DYKES, SILLS AND FAULTS THAT EXTEND BEYOND THE PROPERTY BOUNDARY

Several dykes and faults occur beyond the property boundary of De Beers Kimberley Mines. Refer to **Appendix A**, for a satellite image of the Kimberley area with lineations.

4.2 CLIMATE

4.2.1 REGIONAL CLIMATE

The Town of Kimberley is located in an arid climatic region and is characterised by relatively low rainfall. In addition, rainfall in the Kimberley area is highly unpredictable, both temporally and spatially. However, precipitation is seasonal with the majority of rain falling between December and February. Conditions can be extreme with temperature ranges between summer and winter. The maximum historical recorded temperature is 40°C, measured in the months of December, January and February. The prevailing wind direction for the region is pre-dominantly north-westerly and the average monthly wind speeds range between 1.1 and 4.8 ms^{-1}.

4.2.2 MEAN MONTHLY AND ANNUAL RAINFALL

As mentioned previously, rainfall in the Kimberley area is highly unpredictable and generally low (average of 415 mm per annum). The mean monthly rainfall and number of days per month with measurable precipitation are indicated in **Table 4.2**, below.

Table 4.2: Minimum, average and maximum monthly rainfall (mm) and average number of days per month with measurable precipitation for the Kimberley area

Month	Minimum	Average	Maximum	Days with rain
January	1	61	213	9.1
February	2	67	190	9.0
March	2	72	222	9.8
April	0	42	160	6.9
May	0	19	74	4.3
June	0	9	105	2.0
July	0	9	58	1.7

Month	Minimum	Average	Maximum	Days with rain
August	0	10	120	1.8
September	0	12	145	2.4
October	0	28	172	5.2
November	0	42	144	7.1
December	2	51	214	7.4

Refer to **Table 4.3**, below for the monthly precipitation averages for the 30-year period from 1961 – 1990 according to the South African Weather Service.

Table 4.3: Average monthly precipitation (mm), highest 24 hour rainfall (mm), as well as the average number of days per month with precipitation more than 1 mm for the Kimberley area (1961 –1990)

Month	Average monthly (mm)	Average number of days with > = 1 mm	Highest 24 hour rainfall (mm)
January	57	10	45
February	76	10	88
March	65	10	54
April	49	8	51
May	16	3	55
June	7	3	18
July	7	2	22
August	7	2	26
September	12	3	44
October	30	6	35
November	42	8	60
December	46	8	60
Year	414	71	88

4.2.3 MAXIMUM RAINFALL INTENSITIES

Rainfall in the Kimberley area is derived mainly from thunderstorms and the majority of rainfall events results in less than 30 mm of rain. Recent years (2005 -2012) have shown increased intensity of some rainfall events. The maximum-recorded rainfall in 24 hours is 110 mm and per hour is 48mm. Refer also to **Table 4.4** key Climate data for Kimberley, South African Weather Servic.

Table 4.4: Key Climate Data for Kimberley, South African Weather Service (March 2010)

Month	Record High °C	Average High °C	Average Low °C	Record Low °C	Precipitation mm	Average. Precipitation Days
Jan	40	33	18	7	57	10

Feb	40	31	17	6	76	10
Mar	36	29	15	2	65	10
Apr	35	25	11	0	49	8
May	31	21	7	-6	16	3
Jun	27	18	3	-7	7	3
Jul	27	19	3	-8	7	2
Aug	31	21	5	-7	7	2
Sep	36	26	9	-6	12	3
Oct	38	28	12	-1	30	6
Nov	39	30	15	3	42	8
Dec	40	32	17	5	46	8
Year	**40**	**26**	**11**	**-8**	**414**	**73**

Table 4.5: Mean precipitation data for the Joint Shaft as well as mean precipitation data for Kimberley (1877-1990) in mm

Month	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
January	92.0	32.0	151.0	93.5	65.5	67.0	92.0	61.0	177.2	60.0
February	76.0	107.0	94.0	12.0	101.7	39.0	76.0	14.0	85	67.4
March	95.0	14.0	39.0	88.5	9.5	203.0	95.0	24.0	113.5	73.6
April	26.0	18.0	4.0	0	66.0	46.0	26.0	10	26.4	40.0
May	0	6.0	3.0	35.0	0	70.0	0	75.5	0	18.3
June	0	0	0	0	0.1	5.0	0	0	0	7.4
July	0	0	2.5	0	26.1	10.0	5	0	0	7.3
August	0	5.5	0	0	10.0	4.0	5	0	1.5	8.6
September	0	0	0	0	5.0	2.0	10	0	53.2	15.2
October	34.0	116.5	0	56.0	16.0	19.0	26.5	73.5	17.5	28.1
November	50.0	41.0	7.0	82.0	172.5	7.5	83.0	11.6	35.4	41.9
December	17.0	99.0	28.0	66.5	83.0	9.0	13.0	159.0	102.4	52.4
Total	**390**	**439**	**328.5**	**433.5**	**555.4**	**481.5**	**431.5**	**428.6**	**612.1**	**420.2**

4.2.4 MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES

The mean monthly temperatures vary from 25 °C in January to approximately 11 °C in June. In mid-summer, daily temperatures can rise to 35 °C, and may even rise above 40 °C. Frost generally occurs in the Kimberley area when the temperature falls below -5°C during the winter months.

Refer to **Table 4.6** below for the minimum, average and maximum monthly temperatures (ºC) for the Kimberley area. The time period for the data indicated in this table however, was unknown during the compilation of this document.

Table 4.6: Minimum, average and maximum temperatures (°C) for Kimberley

Month	Temperatures		
	Minimum	Average	Maximum
January	6	25	40
February	7	24	39
March	2	22	36
April	- 2	18	35
May	- 5	14	31
June	- 6	11	28
July	- 8	11	27
August	- 6	13	32
September	- 5	17	36
October	- 1	20	37
November	3	23	38
December	5	24	40

Table 4.7 indicate the highest recorded, average daily maximum and minimum, as well as the lowest recorded temperatures (ºC) for the Kimberley area for the period 1961 – 1990, as recorded by the South African Weather Service.

Table 4.7: Highest recorded, average daily maximum and minimum, as well as the lowest recorded temperature (ºC) for the Kimberley area (1961 – 1990)

Month	Highest recorded (ºC)	Average daily maximum (ºC)	Average daily minimum (ºC)	Lowest recorded temperature (ºC)
January	40	33	18	7
February	40	31	17	6
March	36	29	15	2
April	35	25	11	0
May	31	21	7	-6
June	27	18	3	-7
July	27	19	3	-8
August	31	21	5	-7
September	36	26	9	-6
October	38	28	12	-1
November	39	30	15	3
December	40	32	17	5
Year	40	26	11	-8

4.2.5 MEAN MONTHLY WIND DIRECTION AND SPEED

The average monthly wind speed ranges between 1.1 and 4.8 ms^{-1} which may influence on the extent of the dust and noise impact zone associated with the mining operations. The prevailing wind direction is pre-dominantly to the northwest. Refer to **Table 4.8** below for an indication of the average monthly wind speed for the period 1996 – 1998.

Table 4.8: Average monthly wind speed (m/s) in the Kimberley area (1996 – 1998)

Year	Wind speed (m/s)											
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1996	-	-	-	-	-	3.6	3.2	3.8	3.7	3.8	4.5	2.9
1997	2.1	1.1	2.8	3.2	3.6	3.5	3.5	3.6	3.9	4.8	4.3	4.2
1998	4.6	4.4	3.2	3.7	3.5	-	-	-	-	-	-	-
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**

4.2.6 MEAN MONTHLY EVAPORATION

The mean evaporation for the wettest six months period for the last 30 years was between 321.8 and 556.3 mm, whilst the total A - pan evaporation was between 1 208.4 and 1 873 mm. Refer to **Table 4.9**, below for an indication of the mean evaporation for the wettest six months period over the last 30 years.

Table 4.9: Mean evaporation for the wettest six months period over the last 30 years

Period	Total rainfall for 6 months (mm)	Total A-pan evaporation for 6 months (mm)	Water balance
1975 / 76	556.3	1 208.4	- 289.68
1961 / 62	480.3	1 725.1	- 726.57
1973 / 74	455.5	1 308.7	- 460.58
1974 / 75	423.3	1 537.2	- 652.74
1966 / 67	361.3	1 684.8	- 818.06
1959 / 60	359.5	1 873.2	- 951.74
1981 / 82	349.1	1 813.4	- 920.28
1971 / 72	326.2	1 607.0	- 798.7
1980 / 81	321.8	1 753.7	- 905.79
1979 / 80	299.5	1 524.0	- 767.3

4.2.7 INCIDENCE OF EXTREME WEATHER CONDITIONS

Although thunderstorms occur regularly in summer and hail incidents are infrequent, drought occurs at regular intervals. High winds occur during early and late summer during the change in season. Frost generally occurs during the winter months.

Table 4.10 indicates the extreme weather conditions for the period 1961 – 1990, as recorded by the South African Weather Service.

Table 4.10: Mean number of days of extreme weather conditions

Months	Average number of days			
	Thunderstorm	Hail	Snow	Fog
January	9.0	0.3	0.0	0.0
February	8.3	0.5	0.0	0.0
March	7.2	0.2	0.0	0.3
April	4.9	0.3	0.0	0.1
May	2.1	0.2	0.0	0.3
June	0.7	0.1	0.0	0.3
July	0.9	0.1	0.1	0.4
August	1.3	0.1	0.1	0.3
September	2.3	0.2	0.0	0.0
October	5.5	0.3	0.0	0.1
November	5.9	0.6	0.0	0.0
December	8.4	0.4	0.0	0.1
Average	**56.5**	**3.3**	**0.2**	**1.9**

4.3 TOPOGRAPHY

Kimberley is located approximately 1 200m above sea level on a generally flat plain with low gradient slopes. Closer to the mine, the landscape is altered by the presence of man-made hills of tailing resource. These heaps in some places rise up to 80m above the original ground surface and are visible from the main public roads to Bloemfontein, Barkley West, Warrenton, Griekwastad, Magersfontein and Paardeburg passing alongside the mining areas. On the Kimberley / Modderrivier road, some tailings resources are visible at a distance.

Topographical disturbances due to the existing mining and related activities include the following:

- Tailings resources and deposits.
- Slimes dams.
- Tailings resource material stockpiles at the CTP[3].
- Water management measures such as trenches, pollution control dams etc.
- Infrastructure associated with the Plants, workshops, offices, haul roads, conveyors etc.

4.4 SOIL

The soils encountered in and around Kimberley fall into the following land types:

[3] CTP: Combined Treatment Plant.

- Ae15.
- Ae45.
- Fb1.

The Ae15 land type is comprised of topography with an A3 grading. This means that more than 80 % of the land type has a slope less than 8 % and the altitude difference between the highest and the lowest point ranges from 90 – 150 m. The soils are predominantly rocky and shallow on the higher lying areas (mainly dolerite outcrops) and moderately deep to deep in the lower lying areas (mainly derived from wind transported sands). Due to a relatively low rainfall the soils are mainly eutrophic with occasional occurrences of free lime and lime nodules in deeper soil horizons. The soils are not suited to intensive dryland agricultural practices mainly due to climatic constraints (rainfall).

The Ae45 land type is very similar to the Ae15 land type with the difference that the soils are generally shallower with a wider occurrence of lime containing soils in the lower lying areas. The shallow nature of the soils is linked mainly to the dominant geology – tillite, shale and mudstone partially covered by surface limestone and red wind-blown sands.

The Fb1 land type is comprised of topography with an A2 grading. This means that more than 80 % of the land type has a slope less than 8 % and the altitude difference between the highest and the lowest point ranges from 30 – 90 m. This land type is dominated by rock outcrops and rocky areas and with the occasional occurrence of moderately deep to deep soils that range from apedal to structured. Due to a relatively low rainfall the soils are mainly eutrophic with wide spread occurrences of free lime and lime nodules in deeper soil horizons. The soils are not suited to intensive dryland agricultural practices mainly due to climatic constraints (rainfall).

Due to human activities associated with diamond mining stretching back more than 100 years there is no baseline information on soils on impacted sites. All soil information regarding these sites has to be inferred from soil associations in surrounding areas.

The soil occurring in the study area has been characterised as being of the Mispah and Glenrosa soil forms. Refer to **Table 4.11** for more details regarding these soil types. Lime is rare or absent in upland soils but occurs regularly in one or more valley bottom soils. Rock weathering, the formation of orthic topsoil horizons and, clay illuviations giving rise typically to lithocutanic horizons, were the dominant soil forming processes.

Table 4.11: Soils occurring in the De Beers Kimberley Mines area

Soil Form	General soil description	Agricultural potential			Suitability for rehabilitation	
		Properties affecting potential	Irrigation potential	Dry-land potential	Upper soil	Lower soil
Glenrosa (Gs)	Dark reddish brown sandy clay loam with prominent mottles and clay cutans expressed as tongues (prominent colour variegations)	Topsoil is underlain by stone-line merging into weathering rock	Low	Low (grazing)	Often stony – difficult to strip	Unsuitable as a growth medium for rehabilitation purposes
Mispah (Ms)	A dark brown loamy sand to sandy clay loam overlies rock/stone at shallow depth	Soils wet following rains and extremely dry during dry periods	Low	Low (wilderness / grazing)	Sandy and infertile; suited for rehab	None

The topsoil layer in the natural veld is very shallow and on average estimated to be less than 200 mm deep. In addition, a thin layer of less than 5 m of red soils and calcrete is present on the immediate surface. A comprehensive pedological survey was carried out as part of the EMPR, 1999, over the mine boundary area to evaluate the vegetation growth and slope characteristics of Kimberlite deposits and slimes dams.

A soil analyses was undertaken as part of the mentioned pedological survey. This analysis indicates in most cases a very high sodium content which could inhibit the successful establishment of plant-life. In addition, almost all soil sampling locations indicate deficient quantities of phosphorus (which is an essential element for plant growth) or none at all.

Smectite is the most abundant clay mineral in the tailings resource material. The smectite has a significant influence on the physical stability of the tailings resources. The erodibility of all the materials is greatly increased by the presence of high percentages of smectite materials, combined with the high sodium content. These two factors, combined with the high silt and sand content result in extremely erodible material. Refer to **Tables 4.12** and **4.13** for the average percentage of silicate and clay minerals compiling Kimberlite in several of the tailings resources at De Beers Kimberley Mines.

Table 4.12: Average percentage silicate minerals present in the Kimberlite of several of the tailings resources at De Beers Kimberley Mines

Silicate mineral	Percentage (%)
Smectite	42.2
Mica	9
Quartz	22.8
Calcite	12.4
Koalinite	13
Feldspar	0.6

Table 4.13: Average percentage clay minerals present in the Kimberlite of several of the tailings resources at De Beers Kimberley Mines

Clay mineral	Percentage (%)
Smectite	61
Mica	7
Koalin	11.4
Chloritised minerals	12.6

The massive downward movement of particles on tailings resources, crust formation and dispersion of the clay minerals of the surface, impacts negatively on seed germination and plant establishment. The land in this area is not arable due to the shallow soils, relatively low rainfall and shortage of water for irrigation purposes.

Rainfall mainly infiltrates to the groundwater or runoff occurs as sheet flow over short distances, due to the low topographical incline of the study area. The study area is thus not naturally prone to erosion of soils.

4.5 LAND CAPABILITY

The De Beers Kimberley mining area was classified as having grazing potential (3981.1240 ha), prior to the establishment of the mining and related activities. A natural depression, the Dutoitspan, would under natural circumstances have been an ephemeral pan that only contained water during periods of high rainfall. The Dutoitspan contains runoff from following areas:

- The Kimberley town area.
- The Beaconsfield industrial area.
- Mine affected stormwater run-off.
- Mine affected run-off from Petra Operations.
- Treated effluent water from the Homevale WWTW[4].
- Treated effluent from the Greenpoint WWTW.
- Kamfers Dam.

[4] WWTW: Wastewater Treatment Works.

4.6 LAND USE

4.6.1 PRE-MINING LAND USE

According to historical information, the area was natural rangeland prior to 1870. Indigenous herbivores roamed this area before mining activities commenced. The area currently affected by mining was largely used for grazing.

4.6.2. EVIDENCE OF MISUSE

No information on the misuse of land is available since De Beers Kimberley Mines is more than 100 years old.

4.6.3 EXISTING STRUCTURES

No information is available on structures prior to mining. However, with the establishment of the mining activities, the existing De Beers Kimberley Mines property is marked by the presence of a number of existing structures, which include amongst other: the offices, the Treatment Plants and related infrastructure, explosive magazines, gravel access roads as well as power lines.

4.6.4 WETLANDS

Dutoitspan and Paardebergvlei occur within the De Beers Kimberley Mines property. These wetland areas are not under statutory protection. The ecological importance of the Dutoitspan and Paardebergvlei will be determined as part of a biodiversity and Wetland Delineation studies that are currently being conducted for the mine.

4.7 VEGETATION

A major portion of the mining area is disturbed due to historical mining activities, such as the depositing of tailings and slimes. Thus no site specific information, prior to the establishment of the industry, is available for the study area. However, according to existing information, Kimberley is characterised by a grassy ground layer and a distinct upper layer of woody plants, which is also known as the Savanna Biome. The grass layer is dominated by C_4-type grasses, which are at an advantage when the growing season is characterised with high temperatures. In areas of the Biome where rainfall has a stronger winter component, C_3-type grasses dominate.

The vegetation type occurring in the Kimberley area was previously classified by Acocks (1998) as the Kalahari Thornveld (A16) invaded by Karoo. However, this area was re-classified as the Kimberley Thorn Bushveld (32) by Low and Rebelo (1998).

4.7.1 DOMINANT SPECIES

4.7.1.1 General species

Various plant communities are found within the direct vicinity of the De Beers Kimberley Mines site. The natural vegetation is dominated by an open savanna (Low and Rebelo, 1998). The dominant tree species are Umbrella Thorn (*Acacia tortilis*) and Camel Thorn (A. *erioloba*), while scattered individuals of Shepherd's Tree (*Boscia albitrunca*) and Sweet Thorn (*Acacia karroo*) also occur within the Kimberley area.

According to Low and Rebelo (1998), the shrub layer is poorly to moderately developed in places. Individuals of Camphor Tree (*Tarchonanthus camphorates*), Spike-flowered Black Thorn (*Acacia mellifera*), Wild Raisin (*Grewia flava*) and (*Lycium hirsutum*) occur widely scattered. The grass layer is fairly well developed and grasses such as Redgrass (*Themeda triandra)*, Common Nine-awn Grass (*Enneapogon cenchroides)*, Lehmann's Lovegrass (*Eragrostis lehmanniana), Elionurus muticus* and *Cymbopogon plurinodis* are prominent.

4.7.1.2 Site specific species

Portions of the mining area were disturbed due to historical mining activities, such as the dumping of tailings and slimes. **Table 4.14** indicates the dominant plant species occurring within the De Beers Kimberley Mines property.

Woody species occurring within the study area include *A. hebeclada, A. karroo, Diospyros lyceoides, Ehretia rigida, Grewia flava, Lyceum spp., Tarchonanthus camphoratus* and *Ziziphus mucronata.*

Other shrubs present in the area include *Berkheya pinnatifida*, *Blumea gariepina*, *Eriocephalus ericoides*, *Gnidia polycephala*, *Protasparagus* sp., *Psilocaulon absimile*, *Pterothrix spinescens* and *Walafrida saxatilus*.

Under grazing, the latter is replaced by *Schmidtia pappophoroides* and *Stipagrostis* spp. Short grasses such as *Enneapogon desvauxsii* are common on shallow soils overlaying calcrete. Other common grasses occurring in the area includes various *Aristida* spp.*, Cynodon dactylon, Enneapogon scoparius, Eragrostis trichopora, Fingerhuthia africana, Heteropogon contortus, Panicum coloratum and Sporobolus rangei.*

Table 4.14: Dominant plant species within the De Beers Kimberley Mines property (Anderson, 1992)

Vegetation type	Species	Common name	Occurrence
Trees	*Acacia tortilis*	Umbrella Thorn	Turf soils
	Acacia erioloba	Camel Thorn	Deeper sands
	Acacia mellifera	Spike-flowered Black Thorn	Turf soils
	Acacia hebeclada	Candle Thorn	
	Acacia karroo	Sweet-thorn	
Woody species	*Diospyros lycioides*	Bloubos	
	Ehretia rigida	Puzzle-bush	
	Grewia flava	Raisin bush	
	Lyceum spp.	-	
	Tarchonanthus camphorates	Camhor Bush	
	Ziziphus mucronata	Buffalo-thorn	
Shrubs	*Berkheya pinnatifida*	Lobed African Thistle	

Vegetation type	Species	Common name	Occurrence
	Blumea gariepina	-	
	Eriocephalus ericoides	-	
	Gnidia polycephala	-	
	Protasparagus sp.	E.g. Wild asparagus, Asparagus fern, etc.	Abandoned disturbed places, amongst other.
	Psilocaulon absimile	-	
	Pterothrix spinescens	Voêltjie Kanniesit	
	Walafrida saxatilus	-	
Grass	*Themeda triandra*	Redgrass	Undisturbed areas / deeper red soil
	Eragrostis lehmanniana	Lehmann's Lovegrass	Deeper red soil
	Cymbopogon plurinodis	Narrow leaved Turpentine grass	Undisturbed areas
	Schmidtia pappophoroides	-	Replace *Themeda triandra* and *Cymbopogon plurinodis* when under grazing / red sandy soil
	Stipagrostis spp.	Silky bushman grass	
	Enneapogon desvauxii	Spike Pappus grass	Shallow soils overlaying calcrete
	Aristida spp.	Three Awn grass	Common grasses in area
	Cynodon dactylon	Couch grass	
	Enneapogon scoparius	Bottlebrush grass	
	Eragrostis trichopora	-	
	Fingerhuthia africana	Thimble grass	
	Heteropogon contortus	Spear grass	
	Panicum coloratum	Small / White buffalo grass	
	Sporobolus rangei	-	

4.7.1.3 Endangered species

Two Red Data surveys have been conducted for the De Beers Kimberley Mines mining area in the past (Anon 1992, Anderson 1992). No endangered plant species as defined in Schedule 3 of the Nature and Environmental Conservation Ordinance, 1974, were identified during these surveys. In addition, no endangered plant species are anticipated to occur, mainly due to existing disturbances in terms of the existing land use.

Two cycads *Encephalartos natalensis* (Permit No. 007/99) were, however, kept in pots at Wesselton Mine. *Dodonea viscose* has been classified as rare in the Red Data list for plants (Hilton – Taylor, 1996). Unidentified *Aloe, Senecio* and *Stoebe* species that could occur in the IUCN Red Data list (2004), also occur within the De Beers Kimberley Mines property. In addition, *Acacia erioloba* is classified as a protected tree in terms of the Forest Act (Act 122 of 1984). This tree can therefore not be cut or destroyed without the necessary authorisations.

4.7.1.4 Exotic and declared invaders

The disturbed mining areas are severely invaded by alien species such as *Prosopis chilensis* (Mesquite), *Schinus molle* (Pepper tree), *Blackiela inflate*, *Attriplex semibaccata* and *Salsola kali*.

The results of a survey of the genera, as well as on the extent of alien and invasive plants and / or weeds occurring within the mine boundary area of De Beers Kimberley Mines, were documented in the report, titled "*The Distribution and Extent of Declared Weeds and Invader Plants on De Beers Mining Property with Management Recommendations*", dated January 2004, and compiled by CHEMC[5]. Refer to **Appendix H** attached hereto for a copy of the Invader Plant Survey Report, dated January 2004.

According to the Invader Plant Survey Report, dated January 2004, 24 genera of invader plants were identified. These genera were divided into the following categories:

- 12 Category 1 weeds (i.e. prohibited weeds that must be controlled).
- 6 Category 2 weeds (i.e. commercially used and may be grown in demarcated areas provided that there is a permit and steps taken to prevent their spread).
- 2 Category 3 weeds (i.e. ornamental plants that may no longer be planted. Existing plants may remain, but all reasonable steps must be taken to prevent their spread).

The invader plant species divided according to the above-mentioned categories occur within areas disturbed by mining and related activities. Refer to the Invader Plant Survey Report, dated January 2004, attached hereto as **Appendix H** for more detail pertaining to the mentioned weed categories, including the proposed management thereof.

In addition to the invader plant species mentioned above, *Pennisetum* (tufted grass) also occur on the slopes of rock dumps and tailings dams, while the road verges support a range of broad leaved weeds (CHEMC, 2004).

Table 4.15 lists the weeds and invader plant species that were recorded during the Plant Survey and tabulated in the Plant Survey Report, dated January 2004.

[5] CHEMC: Conrad Herbst Environmental Management Consultants.

Table 4.15: List of the weeds and invader plants recorded during the survey

Scientific Name	Common name	Category	General comments
Arundo donax	Spanish reed	1	Restricted to Isolated clumps
1. *Pennisetum sp*	Fountain grass	1	Occurs extensively on slopes of rock dumps on De Beers Mine and along road verges
2. *Argemone sp*	Mexican poppy	1	Numerous sites, primarily on road verges and disturbed sites on all properties
3. *Datura sp*	Thorn apples	1	Restricted to a few disturbed sites where their density is high and along road and fence lines
4. *Salsola kali*	Russian tumbleweed	1	Along roadsides and other disturbed sites
5. *Solanum sp*	Bitter apple	1	Along roadsides and fence lines
6. *Xanthium sp*	Cocklebur	1	Along roadsides and fence lines
7. *Atriplex sp*	Saltbush	2	Isolated individuals occur on all properties
8. *Lepidium draba*	Hoary cardaria	1	Occurs along roadsides
9. *Agave americana*	American agave	1	Occurs in large clumps on most of the properties
10. *Agave sisalana*	Sisal	2	Occurs in a few isolated localities
11. *Opunita sp*	Various cacti	1	A number of different species occur on all the properties
12. *Casuarina equisetifolia*	Horsetail tree	2	A single specimen was seen
13. *Pinus sp*	Pine trees	2	Numerous pines occur along road verges for example to Wesselton mine
14. *Tamarix sp*	Tamarisk	1	Occurs occasionally
15. *Prosopis sp*	Mesquite	2	Two species occur on the property and form extensive stands on both slimes and rock dumps
16. *Populus sp*	Poplar	2	Occurs in office gardens
17. *Morus alba*	Mulberry	3	Single specimen observed in drainage line
18. *Eucalyptus sp*	Gum	2	Occurs along roads, gardens and watercourses
19. *Nerium oleander*	Oleander	1	Occurs in gardens
20. *Nicotiana glauca*	Wild tobacco	1	Individuals occur at a number of sites along roadsides and on rock dumps
21. *Schinus molle*	Pepper tree	3	Occurs on all properties
22. *Sesbania punicea*	Red sesbania	1	A single specimen observed in drainage line
23. *Melia azedarach*	Seringa	3	Individuals occur on some of the properties, not widespread

Refer to Figure 1 of **Appendix H** for a map indicating the sites where weed composition and / or photographs were taken. Refer also to Figures 2 and 3 of **Appendix H** for an indication of the approximate density of *Prosopis* (dominant weed at De Beers Kimberley Mines), as well as the distribution thereof.

4.8 ANIMAL LIFE

4.8.1 COMMONLY OCCURRING SPECIES

Species such as aardvark, springhare, steenbok and duiker have been sighted throughout mining the area in the past.

Numerous species of water birds, such as Yellowbilled Duck, South African Shelduck and Redknobbed Coot, have been seen at Dutoitspan. Smaller birds such as the Ant-eating Chat, Kalahari Robin and Bokmakierie have also been sighted on the De Beers Kimberley Mines property, while larger raptors such as Martial Eagles have also previously been observed. A list of bird species (Table 2 of Annexure 15 attached hereto in **Appendix G**) naturally occurring on De Beers Kimberley Mines property, as well as the adjacent farms, are attached hereto in **Appendix G**.

4.8.2 ENDANGERED OR RARE SPECIES

No endangered wild animals listed in Schedule 1 of the Nature and Environmental Conservation Ordinance, 1974, is known to occur on the De Beers Kimberley Mines property. However, several animal species occurring within the De Beers Kimberley Mines property are listed in the South African Red Data List and are indicated in **Table 4.16**, below.

Table 4.16: Animal species listed in the South African Red Data List occurring on the De Beers Kimberley Mines property

Species	Common name	Status
Bird species (Barnes in prep.)		
Gyps coprotheres	Cape Vulture	Vulnerable
Gyps africanus	Whitebacked Vulture	
Torgos tracheliotus	Lappetfaced Vulture	
Aquila rapax	Tawney Eagle	
Polemaetus bellicosus	Martial Eagle	
Ardeotis kori	Kori Bustard	
Leptoptilos crumeniferus	Marabou Stork	Near-threatened
Sagittarius serpentarius	Secretary Bird	
Falco biarmicus	Lanner Falcon	
Mammal species (Smithers 1986)		
Mystromys albicaudatus	White-tailed mouse	Vulnerable
Felis lybica	African wild cat	
Manis temminckii	Pangolin	
Orycteropus afer	Antbear	

Species	Common name	Status
Atelerix frontalis	South African hedgehog	Rare species.
Poecilogale albinucha	African striped weasel	
Proteles cristatus	Aardwolf	
Felis nigripes	Small spotted cat	

No amphibian and reptile species that are listed in the South African Red Data Book for reptiles and amphibians (Branch 1988), are occurring within the De Beers Kimberley Mines property.

4.9 SURFACE WATER

The surface water at De Beers Kimberley Mines was described in detail in the IWULA[6], dated October 2006, amongst other, and has been summarised in this part of the EMP.

4.9.1 SURFACE WATER QUANTITY

4.9.1.1 Catchment boundaries

The mine and its operations fall within the quaternary drainage region C52L of the Lower Vaal Water Management Area, Northern Cape, including the quaternary drainage regions C51L and C91E of the Lower Vaal Water Management Area, respectively. The Lower Vaal Water Management area lies in the north-western part of South Africa, and borders on Botswana in the north. Stream flow characteristics are distinctly different for the three sub-areas within the overall area. Flow in the Vaal River is perennial, fed mainly from high rainfall and regulation upstream. The Harts River is characterized by highly intermittent runoff, while the Molopo and Kuruman Rivers are endoreic and typically cease to flow after some distance due to infiltration and evaporation. Iron ore, diamonds and manganese are mostly mined in the water management area of these catchments. Farming activities range from extensive livestock production and dry land cultivation to intensive irrigation enterprises at Vaalharts. Kimberley, which straddles the divide between the Lower Vaal and Upper Orange water management areas, is the largest urban centre in the water management area.

The area surrounding Kimberley is characterised as being arid to semi-arid and subsequently receives low rainfall. As a result of these conditions there are very few perennial pans occurring within the regional study area. Major rivers within the area include the Vaal River, Riet River and Modder River. Major wetlands or dams occurring in the area include the Kamfers Dam, Dutoitspan Pan, Paardebergvlei Pan and the Benfontein Pan. All of these pans are associated with mining activities and this is one of the major reasons why they retain such large quantities of water in such a harsh environment.

[6] IWULA: Integrated Water Use Licence Application.

Refer to **Figure 1.3.6** in **Appendix A** for an indication of the relevant catchment boundaries of De Beers Kimberley Mines.

The characteristics of the relevant catchments are presented in **Table 4.17** below.

Table 4.17: Catchment characteristics of the C51L, C52L and C91E quaternary catchments as defined by the DWAF (WRC, 1994)

Catchment	C51L	C52L	C91E
Gross Area (km^2)	2032	2406	1509
Net area (km^2)	540	435	1066
Forest area (km^2)	0	0	0
Irrigation area (km^2)	12.7	1.2	13.2
Evaporation Zone	19B	19B	9B
MAE (mm)	2140	2000	2140
Rain Zone	C5E	C5E	C9B
MAP (mm)	350	377	371
MAR (mm)	2.5	3.3	2.3
MAP-MAR Resp	7	7	7
NET MAR ($10^6 m^3$)	1.3	1.4	2.4
Gross MAR ($10^6 m^3$)	5.0	7.9	3.5
CV	3.049	2.947	3.771
Hydro zone	M	M	M

The Vaal River lies approximately 30 km to the north west of Kimberley, with the Modder River approximately 35 km to the south of Kimberley. De Beers Kimberley Mines forms part of a local endoreic area adjacent and to the north of the Modder River system. This local endoreic area stretches ± 25 km west of Kimberley to ± 30 km east of Kimberley with a north-south width of 7 - 10 km. Due to its flat topography, about zero runoff from this local drainage region contributes to the Modder River running ± 10 km south of the site.

No other drainage lines are present in the study area. A few storm water furrows / channels were constructed in the past to allow interception of runoff and thereby allowing drainage of the region and containment of water for re-use since no natural watercourses traverse the De Beers Kimberley Mines site. These furrows traverse the study area and discharge towards a few local pans or dams like the Dutoitspan, located to the south of the De Beers Kimberley Mines mining operations.

4.9.1.2 Mean Annual Runoff (MAR)

According to the WRC Report Nr. 298/2.1/94 the mean annual runoff for the relevant quaternary catchments is included in **Table 4.17** above.

Rain water from the mining and surrounding areas is diverted by storm water trenches into the Dutoitspan and Kamfersdam which are located southeast and north of Kimberley. In addition, treated effluent from the Homevale- and Greenpoint WWTW site areas, water with a high silt load from the tailings resources and mining areas, as well as mine affected water pumped from various mine pits within the mining property are diverted to the Dutoitspan. The Dutoitspan is regarded as a dirty water system by the De Beers Kimberley Mines, Crown Resources (Pty) Ltd.: Kimberley Underground Mines Joint Venture as well as the municipality. Dutoitspan overflows via the Paardebergvlei, which in turn has the potential to overflow into the Benfontein Pan.

4.9.1.3 Average dry weather flow

No natural drainage lines are present on the property of De Beers Kimberley Mines. According to historical information, Dutoitspan was once a seasonal system. Due to contaminated water that is being diverted to the Dutoitspan via storm water channels, this pan is currently perennial. Both the Benfontein Pan and the Paardebergvlei are seasonal pans and usually dry, except for one or two months of the year during the rainy season.

4.9.1.4 Flood peaks and volumes

During exceptionally high rainfall seasons, Dutoitspan is able to overflow into the Benfontein Pan via the Paardebergvlei. Borrow pits below the FRD are also utilised as an emergency storage facility for affected storm water runoff from the CTP and Petra slimes dams. In addition to the mentioned borrow pit, Paardebergvlei is currently near dry and the vlei walls have been repaired with the expectation therefore that no additional flow of contaminated water to the Benfontein is anticipated to occur.

4.9.1.5 Flood lines

No data on the 1:50 year flood-line is available since no clearly defined natural watercourses are present on the property of De Beers Kimberley Mines. Due to the local area’s flat topography almost no runoff from this local drainage region contributes to the Modder River.

4.9.1.6 Watercourse alterations

Since no natural drainage lines are present within the property of De Beers Kimberley Mines, no alterations to natural drainage lines have occurred at De Beers Kimberley Mines. However, wetlands are defined in the NWA[7] (1998) as watercourses, and since Dutoitspan and Paardebergvlei are wetlands, the changes in water quality as well as seasonality constitutes an alteration to a watercourse.

---

[7] NWA: National Water Act, Act 36 of 1998.

4.9.2 SURFACE WATER QUALITY

A monitoring programme is currently implemented at De Beers Kimberley Mines for the purpose of acquiring accurate and reliable data that can be used for a wide variety of reasons. According to the DWA Best Practice Guideline G3: "*Water Monitoring Systems*", dated July 2007, this includes the development of environmental and water management plans, identification of sources of pollution and the assessment of compliance with set standards, amongst other.

De Beers Kimberley Mines appointed Clean Stream Scientific Services to conduct the surface water monitoring at the mine. Refer to the document titled *"De Beers Kimberley Diamond Mine Annual Water Quality Monitoring Report, May 2011 – April 2012"*, dated 2012, with reference number DBK/AR1/2010/DE and compiled by Clean Stream Environmental Services, for the latest surface water quality results. This report will hereafter be referred to as the Annual Water Quality Report, dated 2012 and is attached hereto as **Appendix I**.

According to the De Beers Kimberley Mines IWULA, dated October 2006, the mine has no direct impact on the surface water of any of the natural watercourses of the Kimberley area (i.e. Vaal River and Modder River) due to the flat topography, highly permeable sands and the absence of any surface water drainage courses on site. .

There is currently no separation of clean and dirty water runoff in the study area due to the fact that the entire mining area is managed as a dirty water system. As mentioned previously, runoff from the Plants, tailings resource areas, Kimberley town as well as the Beaconsfield industrial area, amongst other, is diverted to the Dutoitspan by means of storm water trenches. Dutoitspan is therefore regarded as part of the dirty water management system.

According to the Annual Water Quality Report, dated 2012, Dutoitspan and Paardebergvlei are considered to be sensitive landscapes. The water quality at De Beers Kimberley Mines is compared with the TWQGR[8] for aquatic ecosystems as specified by DWAF[9] since numerous bird species occur on the De Beers Kimberley Mines property. Since Dutoitspan is also being used for recreational purposes, the water quality of this pan is assessed with the TWQGR for Domestic Use (tolerated).

4.9.2.1 The monitoring localities

A description of the surface water monitoring localities present on the property of De Beers Kimberley Mines, including an indication of the frequency of sampling at each monitoring locality during the period May 2011 to April 2012, is included in the Annual Water Quality Report, dated 2012 which is attached hereto in **Appendix I**.

Refer to **Table 4.18** for a list of the surface water monitoring localities occurring within the De Beers Kimberley Mines property. A short description of the surface water

[8] TWQR: Target Water Quality Guideline Ranges.
[9] DWAF: Department of Water Affairs and Forestry.

quality monitoring results taken from the above-mentioned Annual Water Quality Report for the mentioned period is included within this part of this EMP (incl. EIA) document. Refer also to Part 5.2 of the Annual Water Quality Report, dated 2012 (attached hereto as **Appendix I**) for more detail pertaining to the statistical water quality results of the surface water monitoring results, including compliance to the TWQGR of each monitoring locality.

Table 4.18: Surface water monitoring localities at De Beers Kimberley Mines

Locality number	Locality name
DBK – S01	NTP – Upstream
DBK – S02	NTP – Downstream
DBK – S03	CTP – Trench upstream of NTP
DBK – S04	CTP effluent
DBK – S05	Dutoitspan inlet
DBK – S06	Dutoitspan at pumping station
DBK – S07	Joint Shaft: Venters dam
DBK – S08	Joint Shaft: Downstream
DBK – S09	Homevale WWTW
DBK – S10	Hill Reservoir
DBK – S11	Greenpoint WWTW
DBK – S12	Joint Shaft: Municipal Inflow I
DBK – S13	Joint Shaft: Municipal Inflow II
DBK – S14	Joint Shaft: Side canal
DBK – S15	Shaft 1B trench
DBK – S16	Geology / Wesselton trench
DBK – S17	Paardebergvlei – inflow canal
DBK – S18	Paardebergvlei
DBK – S19	Borrow Pit
DBK – S20	Canal from Dutoitspan into Paardebergvlei
DBK – S21	Kamfers Dam – flow to pumphouse

According to the Annual Water Quality Report, dated 2012, monitoring localities DBK – S13 and DBK – S15 were recorded as dry for the mentioned period of May 2011 to April 2012.

Most of the monitoring localities within the property of De Beers Kimberley Mines were mostly neutral (pH = 6.0 to 8.5) for the period sampled. The range of averaged pH values extended from pH 7.62 at DBK S11 to 8.94 at DBK S21. All surface monitoring localities complied with the TWQGR for domestic use and aquatic ecosystems.

The average TDS[10] and associated average EC[11] values exceeded the TWQGR guidelines for domestic use at most of the localities. The average EC values recorded from May 2009 to April 2010 at the De Beers surface water localities ranged from 79.68 mS/m (DBK-S16) to 1172.80 mS/m (DBK-S21). The average TDS values extended from 734 mg/l at DBK S11 to 8484 mg/l at DBK S21. Water is sampled at DBK S08, DBK 05 and DBK 01 before entering the Dutoitspan (DBK S06) where it is sampled again. It can be noticed that the averaged EC and TDS values at these three localities all exceed the TWQGR guidelines for domestic use and can thus be assumed to be contributing to the salt loading in the Dutoitspan, which also has excessive EC and TDS average values. Water in the Kamfers dam (DBK S21), which collects in the Dutoitspan via DBK S10 and DBK S20, has extremely elevated salt concentrations. It can be seen that the EC at most of the surface water monitoring localities exceeded the TWQGR for domestic use (150 mS/m).

Out of the 21 monitoring localities, five localities (DBK S04, DBK S07, DBK S11, DBK S12 and DBK S16) were the only localities in which the average natrium concentration did not exceed the DWA TWQGR guidelines for domestic use during this annual period. With Natruim concentrations exceeding 200 mg/l; the incidence of health risks increase, as the concentration increases.

The target concentration for Chloride is that of 0 – 100 mg/l. However, Cl concentrations exceeded the tolerated domestic guidelines for May 2009 to April 2010 at localities DBK S08, DBK S14, DBK S18, with aquatic guidelines being exceeded at DBK S01, DBK S02, DBK S03, DBK S05, DBK S06, DBK S09, DBK S10, DBK S17, DBK S19, DBK S20 and DBK S21.

Average Sulphate (SO_4) concentrations revealed that the highest SO_4 concentrations greater than 1000 mg/l, were recorded at DBK S02, DBK S03, DBK S05, DBK S06, DBK S10, DBK S19, DBK S20 and DBK S21.

Total Hardness is described as the total sum of Calcium and Magnesium concentrations in a water body, and is expressed as mg/l Calcium Carbonate. All localities were found to exceed the tolerated domestic use guidelines, except that of DBK S04 and DBK S12 for the year May 2009 to April 2010.

All localities exceeded the average Phosphate (PO_4) concentrations according to the DWA Target Water Quality domestic guidelines, except for localities DBK S06, DBK 07, DBK S17 and DBK S19.

All average concentrations for Nitrates (NO_3) for all the localities were found to be within the Target Water Quality guidelines during the period of May 2009 to June 2010.

---

[10] TDS: Total Dissolved Solids.

[11] EC: Electrical Conductivity.

The average concentrations for Ammonia (NH_3) were found to be within the DWA Target Water Quality domestic guidelines except for the following localities; DBK S09, DBK S10, DBK S11, DBK S12 and DBK S14.

It can be seen that localities DBK S09 (Homevale WWTW) and DBK S11 (Greenpoint WWTW) are the two main localities that are responsible for the nutrient enrichment of water bodies at the De Beers Kimberley Mines. It can also be seen that the continuous influx of treated waste water to the receiving water body, may lead to nutrient loading. This nutrient loading is in return responsible for the eutriphication, and associated harmful algal blooms of the receiving water bodies and can result in the death of aquatic life.

During the sampling period, two localities were found to have high annual average concentrations of Iron (Fe). These sampling points were that of DBK-S04 (CTP Effluent) and DBK-S16 (Geology/Wesselton Trench). Iron can be found to be a very important micro-nutrient, however in high concentrations can be dangerous and cause poisoning.

It was found, during the test period, that monitoring localities DBK S04 and DBK S16 exceeded the aquatic and domestic guidelines in terms of the average manganese (Mn) concentrations. It is found that iron is often associated with manganese and is toxic at high concentrations. The concentrations found at the above mentioned localities are a health risk to sensitive users.

4.9.2.2 The receiving environment localities

As mentioned previously, Dutoitspan is regarded as part of the dirty water management system since it receives contaminated water from various mining areas. Dutoitspan used to overflow into the Paardebergvlei which in turn had the potential to overflow into the Benfonteinpan. Paardebergvlei was previously classified as a wetland and has until recently been regarded as a contingency measure should the Dutoitspan overflow.

Due to the dry conditions experienced at the monitoring locality DBK S19 (Borrow Pit), during May 2009 to August 2009 and January 2010 sampling of water were limited. The average water quality was found to be improved when compared to that of the previous annual period.

It was found that the water quality composition at DBK S20 (inflow into Paardebergvlei from Dutoitspan) remained relatively stable for most months. However, October 2009 showed deterioration in the quality of water. This water flows into the Paardebergvlei from the Dutoitspan and could have a considerable impact on the quality of the water from the Paardebergvlei.

4.9.2.3 Bacteriological Monitoring

According to the Annual Water Quality Report, dated 2010, seven monitoring localities are subjected to monthly bacteriological monitoring. These monitoring localities include; DBK S06 (Dutoitspan), DBK S09 (Homevale WWTW), DBK S10 (Hill reservoir), DBK S11 (Greenpoint WWTW), DBK S18 (Paardebergvlei), DBK S20

(Canal from Dutoits pan to Paardebergvlei) and DBK S21 (Kamfers Dam water pumped to mine).

Refer to Table 5.4-1 of the Annual Water Quality Report, dated 2010, attached hereto as **Appendix I** for an indication of the bacteriological data recorded for the above-mentioned monitoring localities during May 2009 to April 2010.

It was found that the counts of total coliforms for all seven of the monitoring localities were all detected to unacceptable. These high levels of coliforms may cause sevre health effects and lead to an increase in clinical infections.

It was also found that the Total Viable Count bacteriological water quality data for all seven localities were above detection limits.

4.9.3 SURFACE WATER USE

De Beers Kimberley Mines is the only user of water from Dutoitspan. A Yacht Club and Fishing Club at Dutoitspan were also established by De Beers Kimberley Mines.

Affected water from underground sources as well as treated effluent from the WWTW's and contaminated storm water from a portion of Kimberley area, is pumped to the Dutoitspan. The Dutoitspan is therefore used as a return water dam and the use of Dutoitspan as a return water dam was discussed within the De Beers Kimberley Mines IWULA, dated October 2006. This supplies water to the CTP.

A water balance was developed for De Beers Kimberley Mines in 2003 and has since been updated. Refer to **Appendix J** attached hereto for a copy of this water balance. Refer also to **Appendix J** attached hereto for a diagrammatic representation of the previous water management system at De Beers Kimberley Mines. The current water balance for De Beers Kimberley Mines will therefore differs significantly from the water balance described within the mentioned report and will be updated to represent the current state of water flow at the mine.

However, according to the above-mentioned report, the total amount of process water required by the CTP is 220 000 m^3 / month. 80 000 m^3 / month is clean water (water with a low number of dissolved salts, a pH value close to neutral and very few suspended solids).

In addition, small mining operations at De Beers Pit use an average of 0.45 m^3 water per ton of ground, following the installation of a thickener that reduces the water requirements.

According to the Standard Procedure KM-EM-PR-29 '*Environmental Water Quality Monitoring and Measurement Procedure'*, dated February 2010 (attached as **Appendix F**), the water usage of De Beers Kimberley Mines is monitored on a monthly basis. Water usage monitoring is conducted by the Engineering Department which is also responsible for maintaining the relevant records.

4.9.4 WATER AUTHORITY

The water authority responsible for the study area is the Department of Water Affairs: Northern Cape Region. Kimberley Municipality is indirectly responsible for the potable water supply.

4.9.5 WETLANDS

As mentioned previously, Dutoitspan and Paardebergvlei occur within the De Beers Kimberley Mines boundary area. Suitable habitat for such species is, however, provided throughout the year due to water being pumped to the pan. The ecological importance of the pans at De Beers Kimberley Mines will be determined as part of a biodiversity study currently underway.

4.10 GROUNDWATER

4.10.1 DEPTH OF GROUNDWATER LEVEL(S)

A hydrological impact investigation has been conducted specifically for the backfilling of the Bultfontein Mine. The results of this study was documented in the report, titled "*De Beers Consolidated Mines Limited: De Beers Kimberley Mines, Investigation of the hydrologic impact of the backfilling of the Bultfontein Mine*", dated December 2001, with Job No. 3040, and compiled by KLM Consulting Services (Pty) Ltd. Extracts from this report are attached hereto in **Appendix K**.

During the above-mentioned study, the groundwater level was measured in various boreholes within the mine boundary of De Beers Kimberley Mines. The depth of the measured groundwater levels ranged from 5 m to 60 m below ground level. According to the Hydrological investigation report, dated December 2001, the water levels within the Bultfontein Mine and Dutoitspan Mine are unknown since no observation boreholes were installed at these areas at the time of the investigation. Refer to Figure 4 in **Appendix K** for an indication of the groundwater contour map of the Dutoitspan Mine and Bultfontein Mine area.

According to the Phase 1 Groundwater Impact Assessment Report titled "*De Beers Kimberley Mines Assessment of groundwater impacts from tailings storage facilities and proposed backfilling of open pits – Phase 1 – Situation Assessment – Rev 1*", dated July 2007, and compiled by Golder Associates Africa (Pty) Ltd. (attached hereto as **Appendix K**), the highest groundwater levels (> 1 210 mamsl) occur at De Beers Pit, probably as a result of previous backfilling. However, the water levels at Wesselton Pit are the deepest (of approximately 1 130 mamsl). Due to the low aquifer transmissivity generating a steep dewatering drawdown cone, or possibly anisotropy generating different drawdown depths for different directions, large differences in water level occur between the boreholes. Refer to Figures 15, 16, 17 and 19 of **Appendix K** attached hereto for a copy of the hydrographs for four boreholes for each open pit. In general the groundwater level of De Beers Kimberley Mines is approximately 30 m below surface with a maximum of 50 to 60 m below surface. Refer also to Figure 20 of **Appendix K** attached hereto for an indication of the correlation between the topography and groundwater levels of the area. The hydraulic gradients, together with the permeability control the migration of contaminant plumes away from the area impacted upon by dewatering.

Furthermore, the water level in some of the geotechnical boreholes indicated minor oscillations throughout the hydrological year likely to be due to seasonal changes in recharge rates. However, this does not mean that there is no contaminant migration, but that it is only occurring at a slow rate. According to the Phase 1 Groundwater Impact Assessment Report, dated July 2007, this is compatible with the low hydraulic gradients with characterise the area and the apparent low permeability of the weathered aquifer.

According to the hydrological investigation report, dated December 2001, both the Dutoitspan Mine and Bultfontein Mine are partially encircled by several water tunnels ranging in depth from 25 m to 70 m. The main purpose of these water tunnels was to intersect groundwater in the weathered zone and geological contacts prior to entering the Dutoitspan Pit and Bultfontein Pit. The water tunnels do not cover the entire area of De Beers Kimberley Mines, however a number of boreholes and a collection trench (referred to as the Guest's Gully) were constructed to capture surface runoff prior to entering the mentioned pits. Refer to Figure 6 in **Appendix K** for an indication of the location of the mentioned water tunnels encircling both Dutoitspan Mine and Bultfontein Mine, as well as an indication of the mentioned collection trench, including storm water trenches.

According to the approved EMPR, dated October 1999, the general groundwater table of De Beers Kimberley Mines has dropped by approximately 20 m from natural groundwater level due to the development of the above-mentioned water tunnels around the Dutoitspan Mine and the Bultfontein Mine. According to the Hydrological impact investigation report, dated December 2001, the abstraction volumes of the water tunnels should be monitored on a weekly basis.

According to the De Beers Kimberley Mines IWULA, dated October 2006, two distinct groundwater zones or aquifers can be identified in the Kimberley area namely a shallow aquifer and a much deeper aquifer. A short description of the mentioned aquifers is given below.

4.10.1.1 Shallow aquifer

The outcropping rocks in the area, namely the Ecca shales and dolerite sills are not known to be a favorable aquifer due to the shale layer being impermeable and the distinctly bad quality of the water normally found in these shales (saline). However, water is found in the shales in areas of deeper weathering where surface recharge takes place, and where water is in contact with shallow concordant dolerite sills. According to the Phase 1 Groundwater Impact Assessment Report, dated July 2007, water levels in this aquifer range from 0 to 30 mblg with a low borehole yield of < 2 l/s.

Since the shales as well as any dolerite sill will promote the lateral rather than vertical movement of water, a pollution plume will not be induced through the near surface system. This is further indicated by the close correspondence between topographic and groundwater level contours that implies negligible vertical leakage between the shallow and the deeper aquifer system.

The movement of water in the shallow aquifer will therefore follow the surface topography to such an extent that the water table will become shallower towards areas occupied by pans and watercourses. Pollution plumes in the shallow aquifer will thus follow the surface water drainage direction.

4.10.1.2 Deeper aquifer

A much deeper aquifer can be found below the Ecca shales and is estimated to be between 30 to 100 mbgl[12]. Where Kimberlite or dolerite dykes and fissures intrude into the shales, substantial yields can be found on the contact zones of the country rock caused by contact mesomorphism. The presence of such contact zones is known to locally enhance the hydraulic characteristics of the formation, with groundwater moving preferentially through interconnected networks of cooling fractures. Some of the fissures may also act as barriers to underground flow of water. This can cause water to dam up behind the feature, creating a seepage zone at surface. According to the Phase 1 Groundwater Impact Assessment Report, dated July 2007, the groundwater levels range from 30 to 60 mbgl. Although yields could be substantial in these secondary aquifers (up to 10 l/s), it will only be substantial in this area at depths below 80 m. Although it is not known whether a very shallow (< 5 – 10 m) perched aquifer is present, these aquifers frequently become heavily contaminated and plumes migrate in this perched zone. The underlying low permeability horizon acts as a banner to downward percolation of contamination.

The flow of water in the deeper aquifer will be more dependent on geological structures, with flow concentrated in and following faults, fractures and intrusive contact zones. As a result, some underground working areas in the mine will remain relatively dry compared to others that intersect water-bearing structures.

4.10.2 PRESENCE AND ESTIMATED YIELDS OF WATER BOREHOLES AND SPRINGS

A geohydrological impact assessment was performed around the De Beers Geology Services Division site (situated to the west of the De Beers Kimberley Mines area) as part of the IWULA process. Results of the mentioned assessment was discussed within the report, titled "*De Beers SA Geological Services Division: Report on Geohydrological Investigation as part of the Integrated Water Use License Application*", dated September 2004 and compiled by Clean Stream Groundwater Services. Extracts from the mentioned report are attached hereto in **Appendix L**. This part of this EMP (incl. EIA) document contains information taken from the mentioned report.

According to the above-mentioned report, a hydrocensus to the east of the De Beers GSD[13] site was conducted by the DWA in 2003 and monitoring was also conducted to the west at Wesselton Mine. Much of the required data was therefore already

---

[12] MBGL: Metres Below Ground Level.

[13] GSD: Geological Services Division.

available. Follow up sampling and measurements were however taken during the geohydrological impact assessment to update and verify previous measurements.

The radius of influence depends strongly on geological structures such as faults and dykes (preferred groundwater flow paths), groundwater gradients, nearby mining operations and the presence of other groundwater production boreholes in the area. From preliminary data assessments, the impact of dewatering of the Wesselton Pit (and others) on the regional groundwater level does not seem to extend further than 1 km from the Wesselton Pit. Since monitoring data has not previously been interpreted in a holistic manner, the hydrocensus data was considered for a radius of more than 3 km around the De Beers Geology site.

Different types of groundwater information within 3 km of the GSD site were obtained for a total of approximately 150 boreholes during the hydrocensus survey undertaken during June 2004. The macro element inorganic qualities of water supply sources of nearby users, as well as the qualities of monitoring boreholes on site were interpreted. The yields of the hydrocensus boreholes varied between 150 - 24 000 l/h with a mean of around 2 000 l/h.

As mentioned previously, the natural trend for the groundwater level or piezometric head is to follow the surface topography. However, the water level in the study area is the closest to surface in the topographically low-lying areas. Although it would be anticipated that springs will mostly occur in these areas, or at least on the slopes of hills, no springs were found or reported in the vicinity of the GSD site. In perched and confined aquifers however, groundwater or piezometric levels may also be high in topographical higher lying areas with subsequent spring formation. As mentioned previously, the topography the mining area is very flat with no perennial streams occurring at or near the GSD site.

According to the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**, the groundwater monitoring boreholes on the De Beers Kimberley Mines site have been situated downstream of known or suspected sources of groundwater contamination such as the NTP slimes dams and the Dutoitspan, for example.

According to the De Beers Kimberley Mines IWULA, dated October 2006, five abstraction boreholes exist on the farm Rooifontein. Groundwater is abstracted from these boreholes for the purpose of watering of game as well as for domestic purposes. The abstraction volumes for these boreholes are indicated in **Table 4.19** as indicated within the mentioned IWULA.

Table 4.19: Abstraction boreholes in the De Beers Kimberley Mines area

Borehole	Volume (Average l / month)
Lister engine borehole	20 000
Deutch engine borehole	250 000
Boma borehole	20 000

Borehole	Volume (Average l / month)
Windmill 1 (near Olifantsfontein Hotel)	30 000
Windmill 2 (next to Geology road)	30 000
Estimated monthly total	**350 000 l**

According to the approved EMPR, dated October 1999 Vol. I, groundwater is also abstracted from water tunnels in the shale layer around the open pits to capture water seepage. **Table 4.20** indicates the yield of each open pit.

Table 4.20: Yield of open pits at De Beers Kimberley Mines due to seepage

Description	Yield (m^3 / month)
Wesselton Mine	37. 112 000
Joint Shaft	38. 50 000
De Beers Mine	49 900
Kimberley Mine	12 400

In addition to the boreholes abstracting water for amongst other domestic purposes, a number of dewatering boreholes are in place around the underground mining areas (Pulles Howard and De Lange Incorporated, 2006). These boreholes used to facilitate the dewatering of the underground workings for the continuation of mining in a safe manner. However, since no underground mining activities are currently taking place at De Beers Kimberley Mines, these boreholes are only utilised to capture water seepage, as mentioned above.

According to the Hydrological impact investigation report, dated December 2001, the abstraction volumes of the water tunnels, boreholes and the groundwater level of the dewatering boreholes should be monitored on a weekly basis.

4.10.3 GROUNDWATER QUALITY

A Geochemical Assessment was undertaken on behalf of De Beers Kimberley Mines, the results of which are documented in the report, titled "*Assessment of the Geochemistry of the waste deposits at De Beers Kimberley Mines in order to establish the source of sulphates in the ground water environment*", dated July 2005, and compiled by Pulles Howard and De Lange Incorporated. This report is attached hereto in **Appendix M**.

The main objective of the Geochemistry Assessment was to establish the primary source of the high levels of sulphates found in the groundwater at De Beers Kimberley Mines. Refer to the Geochemistry Assessment Report, dated July 2005 attached hereto in **Appendix M** for detailed information on the procedures as well as the sample preparation and data programme followed during this mentioned assessment.

During the Geochemistry Assessment, it was indicated that sulphide containing minerals are present in the tailings residue facilities, as well as in the slimes dams. According to the Geochemistry Assessment Report, dated July 2005, conventional pyrite oxidation processes are responsible for the release of the sulphates into the groundwater. In addition, significant amounts of thenardite (Na_2SO_4) are present, which through simple dissolution processes, release sulphate. All the mentioned factors contribute to potentially high sulphate concentrations which can be released into seepage water. However, the tailings and slimes contained within the relevant holding facilities each contain a huge overabundance of neutralising minerals (between 80 and 200 times oversupply of neutralising potential compared to the available acid potential).

The neutralising minerals will ensure that seepage from the holding facilities will remain alkaline and will therefore not become acidic in future. This will in turn also reduce the possibility of long-term environmental problems associated with acidity. Long-term risks associated with other contaminants (e.g. sodium and neutral or alkaline soluble metals) that exist within the geology of the De Beers Kimberley Mines, will however still pose a long-term environmental risk.

According to the Phase 1 Groundwater Impact Assessment Report, dated July 2007, (attached hereto as **Appendix L**), TDS, sulphate, sodium, magnesium and chloride are the main constituents of concern in terms of contamination, considering the guideline values of the DWA. Manganese can be considered as a secondary constituent of concern, with slightly high concentrations in some monitoring points. Refer to Table 4 of **Appendix L** for a comparison between die DWA guidelines and maximum concentrations of the various constituents obtained from the groundwater monitoring conducted for February and December 2005, as well as for March, September and December 2006. Figure 28 to Figure 42 represents an overview of the groundwater quality obtained from the mentioned monitoring data, also indicating that groundwater quality is impacted as indicated by the elevated values of all the constituents depicted. Refer to the Phase 1 Groundwater Impact Assessment Report, dated July 2007 attached hereto as **Appendix L** for detailed information regarding the groundwater monitoring data obtained from groundwater monitoring for the above-mentioned period.

Refer also to the Annual Report on Groundwater Monitoring, titled "*De Beers Kimberley Mines: Annual Groundwater Assessment Report*", dated April 2010, and compiled by Ground Water Complete (hereafter referred to as the Annual Groundwater Assessment Report, dated April 2010), attached to the Annual Water Quality Report, dated 2010, which is attached hereto as **Appendix I**. This report contains detailed information regarding the groundwater quality of De Beers Kimberley Mines, as well as other contaminants, including the neutralising minerals. Information from the Annual Report on Groundwater Monitoring, dated June 2007, is summarised within this part of this EMP (incl. EIA) document.

Since groundwater seepage from the tailings dams is considered one of the most important impacts on the groundwater regime at De Beers Kimberley Mines, the monitoring boreholes within the study area were subdivided into three areas of groundwater impact or contamination source according to the conceptual groundwater seepage directions from the sources. The groundwater monitoring programme has been focused accordingly. The different areas are as follows:

- Tailings dams – northern seepage direction towards Wesselton Pit.
- Tailings dams – southern seepage direction towards the Paardebergvlei.
- Seepage from Dutoitspan westwards to the Bultfontein Mine.

The four chemical parameters chosen from the list of analytes as indicators of the specific type of contamination commonly occurring at De Beers Kimberley Mines are as follows:

- Electrical Conductivity (EC).
- Chloride (Cl).
- Calcium (Ca).
- Iron (Fe).

According to the Water Use and Waste Assessment Report, dated September 2004, the groundwater monitoring system currently implemented by De Beers Kimberley Mines is evaluated on a regular basis. This include a review of the existing monitoring programme as well as an interpretation of the available monitoring program.

4.10.3.1 Tailings dam area: Northern perimeter

The northern perimeter of the tailings dam complex is interpreted as situated on a groundwater divide which is partially caused by continuous seepage from the dams. Groundwater seeps in a northern direction towards the Wesselton Pit from the northern section of the dams.

The average TDS[14] values at the DBK-G07 and DBKG08 boreholes were 1 500 and 350 mg/l respectively. The average TDS values in the downgradient boreholes which are affected by mining operations varied between 810 and 5 900 mg/l. The maximum permissible concentration was exceeded by boreholes DBK-G03, G04, and G05, while the remainder of the downgradient boreholes displayed average concentrations within ideal and recommended ranges for domestic use. The groundwater contamination originating from the tailings dams towards the north is evident from the water quality results. Significant decreasing salinity trends were observed for boreholes DBK-G03 and DBK-G04, while no significant increasing or decreasing trends were observed for the remainder of the monitoring boreholes.

Upstream groundwater chloride concentrations vary between 200 and 440 mg/l, which are within the recommended ranges for domestic use. Downgradient chloride concentrations on the other hand exceed the maximum permissible concentration with averages varying between 640 and 1 740 mg/l. However, boreholes DBK-G03 and DBK-G04 displayed significant decreasing concentration trends, while the remainder of the monitoring boreholes indicated no significant increasing or decreasing trends. Refer to the Annual Groundwater Assessment Report, April 2010 (**Appendix I**).

---

[14] TDS: Total Dissolved Solids.

It was found that Iron (Fe) concentration were within the ideal range for domestic use. It was however noted that a significant concentration peak was observed for borehole DBK G04. It was concluded that this borehole should be monitored in order to determine if this trend persists.

Sulphate concentrations at three boreholes were found to exceed the maximum permissible concentrations. These boreholes are namely DBK-G03, G04 and G05, however a decrease was experienced at two of these boreholes (DBK-G03 and G04).

4.10.3.2 Tailings dam area: South perimeter

Groundwater monitoring to the southern seepage direction from tailings dams has been considered important with the placement of 10 monitoring boreholes.

The boreholes in this area that display ambient groundwater qualities are DBK-G15, DBK-G17 and DBK-G18. These boreholes are situated more to the west of the southern seepage direction to the Paardebergvlei.

TDS concentrations remained within the recommended range throughout the test period with averages varying between 400 and 2 300 mg/l. Boreholes DBK-G12 and DBKG13 were however found to have average concentrations varying between 2 930 and 4 200 mg/l, thus exceeding the maximum permissible concentration. A significant increasing concentration was also detected in both the monitoring boreholes.

Groundwater chloride concentrations measured in boreholes DBK-G10, G11, G12, and G13 were found to exceed the maximum permissible concentration throughout the monitoring test period with averages varying between 700 and 950 mg/l.

Average groundwater iron (Fe) concentrations were found to be within the ranges for domestic use. However, Borehole DBK-G10 was found to have an average concentration of 4 mg/l, which exceeds the maximum permissible concentration. On the positive side, a significant decrease in concentration was observed for borehole DBK-G10.

4.10.3.3 The Dutoitspan boreholes

Groundwater monitoring in the Dutoitspan area is conducted in three boreholes to the west and south-west of the pan. As mentioned previously, Dutoitspan is no longer a natural wetland since it contains contaminated water and serves as a return water dam as part as the dirty water management system at De Beers Kimberley Mines. Water quality in Dutoitspan is therefore expected due to discharge of different process water and effluent type(s) into the pan and the evaporation thereof, resulting in the concentration of pollutants within the pan. However pollutants are also diluted again by rainfall run-off into the pan.

TDS concentrations at boreholes DBK-G22 and DBK-G23 were found to exceed the maximum permissible concentration throughout the monitoring test period with averages varying between 3 410 and 3 490 mg/l. Borehole DBK-G21 was however found to be unaffected by contamination with an average concentration of 340 mg/l, which is within the ideal ranges for domestic use.

Sulphate concentrations measured in the two downgradient boreholes were found to exceed the maximum permissible concentration throughout the monitoring test period with averages between 1 060 and 1 080 mg/l. Borehole DBK-G21 was however found to be unaffected with an average concentration of 110 mg/l, which is well within the ideal ranges. Groundwater magnesium concentrations display the same trends with boreholes DBK-G22 and DBK-G23 exceeding the maximum permissible concentration with averages varying between 260 and 320 mg/l.

The chloride time-series behavior is similar to the TDS. Chloride concentrations are especially high in DBK-G22 and DBK-G23 and exceed the maximum permissible limits for potable water with averages varying between 920 and 970 mg/l. However, borehole DBK-G21 seemed to be unaffected with an average concentration of 100 mg/l (within the ideal ranges for domestic use). It was found that the average calcium concentrations are within the ideal ranges for domestic use and vary between 30 and 140 mg/l.

4.10.4 GROUNDWATER USE

It follows from the GSD hydrocensus (report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**), that groundwater from boreholes is used mainly for domestic supply, watering of gardens, livestock and game watering. Since CTP is currently the only Treatment Plant that is operational, groundwater inflow into the pits at De Beers Kimberley Mines is used in the washing and screening processes taking place at this Treatment Plant.

As mentioned previously, the water usage of De Beers Kimberley Mines is monitored on a monthly basis by the Engineering Department of the mine. According to the Standard Procedure on Environmental Monitoring and Measurement, dated July 2006, attached hereto in Appendix **F**, the Engineering Department is also responsible for maintaining the relevant records and a monthly report will be issued to the OPCO.

Affected water from underground workings or subsurface water sources is abstracted from water tunnels in the shale layer around the open holes to capture water seepage. This water is used as process water.

Table 4.21 indicates detail pertaining to the areas and yields of these underground workings or subsurface water sources.

Table 4.21: Details on underground dewatering sources

Area	Yield (m^3 / month)
De Beers Mine	100 000
Kimberley Mine	20 000

In addition, groundwater is also abstracted from boreholes situated on the farm Rooifontein No.211. This water is used for the watering of animals as well as for domestic purposes.

4.10.5 GROUNDWATER ZONE

A secondary fractured aquifer is developed in most areas on the mining property. This aquifer is the result of dolerite intruding into the surrounding shale, situated on top of the Ventersdorp lava. The shale is usually between 80 and 140 m deep. As mentioned previously, the main path of water movement is usually on the contact between the intruded dolerite and shale. The aquifer extends from a depth of 20 m to a depth of 60 m. Isolated fractures could occur in dolerite at depths more than 60 m. In addition, an aquifer could form near the surface (0 – 20 m) in areas where weathered dolerite occurs as water accumulates in these areas.

4.10.5.1 Physical characteristics of the aquifers

As mentioned previously, two distinct groundwater zones or aquifers can be identified in the Kimberley area namely a shallow aquifer and a much deeper aquifer.

4.10.5.2 Unsaturated zone

According to the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**, the unsaturated zone is composed of sandy soil of mostly quaternary age, as well as of fresh or weathered calcrete based on the geological profile descriptions. The soil layer is usually not very deep and is underlain by solid calcrete, weathered / fresh shale or dolerite.

The unsaturated zone impacts on the aquifer in terms of both groundwater quality and quantity. The permeability and thickness of the unsaturated zone amongst other, determine the infiltration rate, the amount of runoff and consequently the effective recharge percentage of rainfall to the aquifer. The mass transport of surface contamination to the underlying aquifer(s) can be influenced by the type of material forming the unsaturated zone as well as the permeability and texture of this material. In addition, factors like ion exchange, retardation, bio-degradation and dispersion all play a role in the unsaturated zone.

During the hydrocencus, the thickness of the unsaturated zone was determined by subtracting the static water levels in the study area from the topography. According to the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**, the unsaturated zone varies between approximately 3.3 and 20 metres below ground level. Although deeper static water levels were measured during the hydrocensus, some water levels had to be excluded. This included all the levels taken from boreholes that were impacted upon by mine dewatering (around Wesselton) and pumping.

4.10.5.3 Aquifer delineation

Aquifer delineation is conducted to show which part of the aquifer was used or considered during simulation exercises (numerical modelling). Because the main aquifer is a fractured rock type and fractures could assume any geometry and orientation, the physical boundary or 'end' of the aquifer is very difficult to specify or quantify.

The aquifer delineation of the property of De Beers Kimberley Mines has been discussed within the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**, and are briefly described in this part of this EMP (incl. EIA) document. According to this report, aquifer boundaries in a model can usually be divided in the following:

- No-flow boundaries are groundwater divides (high or low areas / lines) across which no groundwater flow is possible.
- Constant head boundaries are positions in the model where the groundwater level is fixed at a certain elevation and cannot change.

No-flow as well as constant head boundaries were used as model boundaries in the numerical model constructed for the De Beers Geology area. Instead of inserting constant head boundaries as constant head nodes in the mode, river nodes were employed on the same elevations and positions where the streams occur near the mining area. Constant head boundaries were only used for the Dutoitspan surface area. Water levels in the aquifer are fixed at these points and the river nodes in the model will add water to or remove water from the model 'aquifer' if the surrounding model water levels decrease below or rise above the assigned elevation of the nodes.

Since most of the De Beers Geology area has poor distribution of drainage streams, most parts of the model area acted as no-flow boundaries. A no-flow boundary in a numerical model is usually represented by the end / edge of the active cells of the model grid. Refer to Figure 2.2.2.4 of the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**, for an indication of the De Beers Geology model area showing no-flow boundaries and river nodes, as well as the deep pits that act as groundwater sink areas.

4.10.5.4 Aquifer thickness

According to the Report on Geohydrological Investigation, dated September 2004, most of the boreholes where drilling and construction information, as well as where yield testing was conducted, intersected water-yielding fractures. The fractures were intersected at depths varying from approximately 5 m to a maximum depth of more than 40 m. The average water strike depths occur at approximately 10 to 12 meters below surface. It is therefore considered more accurate or appropriate to calculate the aquifer thickness from the static piezometric water level to the deepest water yielding fractures in the study area. Taking this into consideration, the main aquifer thickness of the De Beers Kimberley Mines boundary area varies between 0 and approximately 20 meters.

4.10.5.5 Aquifer transmissivity and storativity

According to the Report on Geohydrological Investigation, dated September 2004, aquifer transmissivity is defined as "*a measure of the amount of water that could be transmitted horizontally through a unit width of aquifer 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)*".

According to literature values as well as calibrated numerical model parameters, the average transmissivity of the aquifer host rocks in the geology was fixed between 0.4 (consolidated kimberlite rock matrix) and 1.5 m^2 / day (Karoo and other rocks and weathered zone aquifer). During the hydrocencus, it was evident from the higher borehole yields that zones of higher transmissivity are certainly present in the area.

According to the Report on Geohydrological Investigation, dated September 2004, storativity is defined as "*the storitivity or the storage coefficient is the volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in piezometric head*". Storativity (a dimensionless parameter) cannot be measured with a high degree of accuracy in slug tests or even in conventional pumping tests. It has however, been calculated by numerous different methods with the results published widely. A value of 0.001 - 0.05 is taken as representative for the Karoo Supergroup sediments.

4.10.5.6 Aquifer recharge and discharge rates

The aquifer recharge and discharge rates of the area of De Beers Kimberley Mines has been discussed within the Report on Geohydrological Investigation, dated September 2004 and are briefly described in this part of this EMP (incl. EIA) document.

According to the mentioned report, effective recharge in the area covered by Karoo sediments is estimated at between 1 to 3 % of MAP. The effective recharge percentage could however, be slightly higher (2 to 5%) where sand and calcrete cover occurs. Based on this estimate, the average recharge to the modelled area (covered mostly by Karoo sediments) is approximately 1 140 m^3 / day (416 000 m^3 / year). Rainfall on the open pit void itself will basically report directly to the aquifer as 100 % recharge. If 100 % recharge is applied to the area where drainage occurs into the Wesselton and Dutoitspan pits, a total of approximately 1 840 m^3 / day (670 000 m^3 / year) report to the aquifers as recharge over the modelled area. Refer to Figure 2.2.2.4 attached hereto in **Appendix L** for an indication of the modelled area.

The discharge of an aquifer may be impacted upon significantly due to mining and processing operations. The natural aquifer discharge, for instance, will decrease by the volume of groundwater removed by dewatering. Although compacted surfaces, haul roads and concrete surfaces increase the surface runoff, it also prevent infiltration to the aquifer and therefore decrease groundwater discharge. However, given the size of the site, the compacted areas and areas covered by concrete or roofs are very small. The impact on the regional groundwater and surface water domain will therefore be negligible. In contrast, aquifer discharge may also increase due to leakage of water to the subsurface with the use of a return water dam, tailings dams, etc. No natural groundwater discharge areas are known to exist in the modelled area.

The average discharge from the Wesselton pit is in the order of 1 000 m^3 / day (365 000 m^3 / year), indicating that a large portion of the recharge to the area is pumped from the mine. According to the Report on Geohydrological Investigation, dated September 2004, the bigger part of this total recharge is not totally lost but remains in the system where it circulates in the environment e.g. the slimes dams, Dutoitspan and the Paardebergvlei. Only water that evaporates is totally lost from the resource in the area.

4.10.5.7 General conceptual model

A conceptual geohydrological model of the area within the mine boundary of De Beers Kimberley Mines was developed and discussed within the Report on Geohydrological Investigation, dated September 2004. The basis of such a model is the structural geological make-up of the study area.

According to the mentioned report, it is likely that the geohydrological regime in the study area is made up of two aquifer systems, namely the upper, semi-confined aquifer as well as the main aquifer.

- The upper, semi-confined aquifer.

  This aquifer would occur in the weathered zone and on pedological discontinuities (e.g. hardpan or calcrete formations). This aquifer is usually relatively poorly developed and only seepage moisture could be tapped from the aquifer through large diameter well in the calcrete and shale subsurface. In addition, the mentioned aquifer is also more dependent on seasonal fluctuations with higher yield during times of high rainfall (e.g. summer months).
- The main aquifer.

  This aquifer is associated with fractures, fissures and joints and other discontinuities within the consolidated bedrock (Karoo sediments and intrusives) underlying the site. The aquifer is therefore a secondary aquifer where primary porosity does not exist between grains but secondary porosity has developed through fracture or fissure formation in the consolidated rock. The aquifer occurs at depths of between 10 - 40 meters below surface in the study area.

Precipitation or artificial recharge will migrate vertically downwards until a more impervious layer, forming a perched aquifer, is encountered. Although temporarily retarded, the majority of recharge water will migrate downwards into the saturated zone. Recharge water from the saturated zone will migrate in the direction of the hydraulic gradient until it eventually enters surface water bodies (i.e. springs, rivers or pans) from where it will discharge as surface water.

According to the Report on Geohydrological Investigation, dated September 2004, the lateral rate of migration usually exceeds the vertical rate, especially in a sedimentary rock environment where the layers are more or less horizontal. Vertical leakage will be slow through especially the shales and Dwyka diamictites, with higher recharge rates where dolomites outcrop.

4.10.5.8 Direction and rate of groundwater movement in potentially impacted areas

A large number of artificial activities undertaken at De Beers Kimberley Mines could potentially impact on the groundwater regime, including the following aspects:

- The aquifer structure, flow paths and directions, as well as;
- Discharges and recharge.

Refer to Figure 2.3.1-2 of the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L**. The mentioned figure indicates the steady state groundwater level contours of the mine boundary area of De Beers Kimberley Mines. These contours represent steady state conditions without impacts from sources or actions other than natural conditions like rivers, natural spring discharges, pans or wetland recharge areas.

4.10.5.8.1 Aquifer structure, flow paths and directions

According to the Report on Geohydrological Investigation, dated September 2004, opencast followed by underground mining has been ongoing next to the site for nearly 100 years. Due to the previous and current mining activities taking place at De Beers Kimberley Mines, including the voids created by mining (open cast and underground), natural groundwater movement will and have been impacted upon.

Mine voids destroy the *in situ* aquifer structures and could be compared to areas of very high (even infinitely high) transmissivity and also high storativity. Since groundwater will follow the route of least resistance, groundwater will most likely move through the mined-out areas. Even after the mine has been closed and the mine voids have been backfilled, the transmissivity and storativity remain higher than the pre-mining natural aquifer(s). The extent of the impact depends mostly on the transmissivity of the *in situ* aquifer material. Since the Karoo rocks have relatively low transmissivity values, impacts on the natural flow pattern around the Wesselton and other pits are and will only be noticeable in the immediate vicinity of the operations.

Mounding of the water table due to recharge from the Dutoitspan also occurs in the Wesselton mining area. As mentioned previously, Dutoitspan was a natural pan depression that has evolved as a buffer storage facility for mine and process water management over the years. The constant head of water in the Dutoitspan will cause seepage to the underlying aquifer(s) and potential mounding of the water levels in the immediate vicinity of the pan with flow directions being radially outwards away from the pan.

4.10.5.8.2 Aquifer discharge

The discharge of an aquifer may be impacted upon due to mining and processing operations in different ways. The natural aquifer discharge for instance, will decrease by the volume of groundwater removed by dewatering. Although compacted surfaces, haul roads and concrete surfaces increase surface runoff, these factors prevent infiltration to the aquifer and therefore decrease groundwater discharge. Given the size of the De Beers Geology site, the compacted areas and areas covered by concrete or roofs are very small and the impact on the regional groundwater and surface water domain will therefore be negligible.

In contrast, aquifer discharge may also increase with the use of a return water dam, tailings dams, etc., due to leakage of water to the subsurface, especially if water is imported to the project from other sources.

4.10.5.8.3 Aquifer recharge

According to the Report on Geohydrological Investigation, dated September 2004, opencast mining usually causes an increase in aquifer recharge percentage, as well as surface water features like dams (tailings, slurry, process water, storm water, return water etc.), will usually increase the recharge to the aquifer. Compacted or concrete surfaces and roads will however decrease the recharge.

Refer to Figure 2.3.2 of the Report on Geohydrological Investigation, dated September 2004, extracts of which are attached hereto in **Appendix L** for an indication of the groundwater contours and flow lines in the mine boundary area of De Beers Kimberley Mines. The lengths of the red path lines are 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 could differ significantly.

Groundwater seepage rates will be higher on the relatively steeper sloping groundwater gradients, e.g. near the pit dewatering or constant head (Dutoitspan) areas. In contrast, seepage rates are much lower in the valley bottoms and flat-lying areas, e.g. in the wider surrounding area away from the pits. The impacts on groundwater flow lines of the mining areas are evident in spite of the relatively low transmissivities.

4.11 AIR QUALITY

Although there are various sources of dust pollution in the immediate area of De Beers Kimberley Mines, atmospheric pollution associated with diamond mining and the treatment process is relatively low compared to other opencast mining operations. The quartz content of Kimberlite ground is low and average air quality index figures obtained from mining and treatment operations over a two-year period range below the maximum level of 1 mg / m^3.

In addition to the low atmospheric pollution associated with diamond mining, dust pollution from the current and old slimes dams as well as the tailings resources within the property of De Beers Kimberley Mines is relatively low due to the following influences:

- The high coagulation quality of the clay minerals (kaolin etc.) in Kimberlite ground binds the ground particles and absorbs and retains water for long periods.
- The large particle size of tailings material.
- Natural vegetation.

Mining and related activities within the property of De Beers Kimberley Mines causing dust pollution includes the movement of heavy vehicles during the transporting of Kimberlite to the CTP. Although the small mining companies at De Beers Kimberley Mines are currently not operational, dust generation also occurs during transport of Kimberlite to the small contractors' Plants when operational. Traffic on the dirt roads to Rietpan, Petrusburg and Sumaria also contribute to dust generation. Furthermore, the Greenpoint Township has dirt roads and open areas with bare ground where dust is generated during wind storms.

Dust pollution arises from the following operational / land use areas within the mine boundary area:
- Haul and gravel access roads.
- Tailings resources and stockpiles.
- Crushing and screening.

Dust monitoring at De Beers Kimberley Mines is conducted on a monthly basis as stipulated in the Standard Procedures on Environmental Monitoring and Measurement, dated July 2006, attached hereto in Appendix **F**. Dust monitoring at De Beers Kimberley Mines is conducted by Gerry Kuhn, Environmental and Hygiene Engineering CC. Results of the dust monitoring are documented in a monthly dust monitoring report, referred to as the Dustwatch Report.

According to the Dustwatch Report, monthly dust monitoring at De Beers Kimberley Mines is conducted at the following units / locations:
- North on Dronsfield Farm.
- South on Benfontein.
- East near the airport.
- Greenside.
- HOH / CBD.
- Geology.
- West on Boshof road.
- Cassandra road.

Refer to the latest Dustwatch Reports attached hereto in **Appendix M** for the results from the latest dust monitoring conducted at the above-mentioned units / locations. These reports also give a brief indication of the dust on the filters for each mentioned location. Refer also to the graphs attached in the same appendix for a visual representation of the air quality for each unit / location over the relevant time periods of dust monitoring. Monthly air quality reports are also available from the Environmental Management Department of the mine on request.

According to the Standard Procedure on Environmental Monitoring and Measurement, dated July 2006, attached hereto in **Appendix F**, additional *ad hoc* samples will be collected by the mine at specific locations as and / or when requested. Furthermore, total particulates at the different mining operations are measured on an *ad hoc* basis by the OHD[15] for environmental purposes, as required.

The fall-out dust standard according to the SANS[16] (as documented in the Dustwatch Reports attached hereto in **Appendix M**) is indicated in **Table 4.22** below.

Table 4.22: Fall-out dust standards according to SANS 1929:2005)

Classification	Dust fall (mg / m^2 day) – averaged over 30 days	Permitted frequency of exceeding the levels
Target – long-term average	300	Long-term average (Annual).
Action - residential	600	Three within any year, no two sequential months.
Action - industrial	1 200	Three within any year, no two sequential months.
Alert threshold	2 400	None. First time exceeded, triggers remediation and reporting to authorities.

Refer to **Appendix N**, attached hereto, for a copy of the "*Annual Airborne Pollutants Personal Exposure Report Form 21.9(2)(a) in terms of Regulation 9.2(7), for 1 January 2006 – 31 December 2006*". These forms give an indication of the level of airborne pollutants associated with current mining and related activities undertaken at De Beers Kimberley Mines, to which the employees, including adjacent land owners and general public, are exposed to.

An Environmental Legal Compliance Audit was conducted by Gerry Kuhn, Environmental and Hygiene Engineering CC in March 2007, the results of which were documented within a first draft Environmental Legal Compliance Report, titled "*Environmental Legal Compliance Report*", dated May 2007. Refer to the mentioned report, attached hereto as **Appendix O**, for the results of the Environmental Legal Compliance Audit.

4.12 NOISE

The industrial area in Beaconsfield border De Beers Kimberley Mines where noise is generated by businesses such as the panel beater shop, the garage and Kimberley Roller Mills, amongst other. Noise from the recovery mining operations on surface mostly occurs in the built environment or disturbed natural environment within the mine boundary area.

Noise pollution due to the mining and related activities arises from:

- Movements of haul trucks.
- Conveyors.

---

[15] OHD: Occupational Hygiene Department.

[16] SANS: South African National Standards.

- Screening, Crushing and Washing Plant at CTP.

According to the Environmental Monitoring and Measurement, dated July 2006, annual monitoring is conducted on environmental perimeter nuisance noise by the OHD monitors. The results from the mentioned monitoring are recorded and filed at the OHD. Refer also to Part 8 of this EMP (incl. EIA) for more information on monitoring currently conducted at De Beers Kimberley Mines.

4.13 SENSITIVE LANDSCAPES

As mentioned previously, the Dutoitspan and Paardebergvlei are situated within the mine boundary area of De Beers Kimberley Mines. These wetlands are considered to be sensitive landscapes, however are not under statutory protection.

According to the De Beers Kimberley Mines IWULA, dated October 2006, the Dutoitspan has a depth of approximately 2.2 m with a capacity of approximately 174 500 m^3. As mentioned previously, although Dutoitspan was historically a seasonal pan, it is currently a perennial pan due to the pumping of water from the mines, The Dutoitspan is therefore regarded as a return water dam with very little control at individual sources in its catchment.

It is emphasised that the Dutoitspan was a natural pan and can still be considered to be a sensitive area. Unnatural inflows such as process water discharges, untreated or partially treated sewerage water or polluted runoff from industrial, residential, mine-related dams, tailings resources, quarries or Recovery Plants should only be allowed if in compliance with the requirements of the NWA (1998). This is evidently not the case and the entire water management system was developed in such a way that effluents, spills and affected runoff reach the pan.

In addition, Paardebergvlei used to be considered as a contingency measure should the Dutoitspan overflow. However, a burrow pit has been constructed downslope of the Dutoitspan and it is therefore not anticipated that overflow from Dutoitspan will flow to Paardebergvlei Since Paardebergvlei receives no overflow and is currently dry, no indirect overflow from Dutoitspan during extreme rainfall conditions is anticipated to end up in the Benfontein Pan. Both the Benfontein Pan and Paardebergvlei are usually dry, except for one or two months of the year during the rainy season.

4.14 VISUAL ASPECTS

The immediate topography is a flat landscape, characterised by spoil dumps and mining infrastructure. The area is also traversed by numerous power lines. The current tailings resource, the Boshoff road tailings resource, and the De Beers Mine residue deposit are visible from the Bloemfontein road. Although parts of the Stadium tailings resource have already been reclaimed, it is still visible within the town. The current tailings resource and the ODTP tailings resource are visible from the Kimberley town and the Paardeberg Road.

4.15 SITES OF ARCHAEOLOGICAL AND CULTURAL IMPORTANCE

A Heritage Risk and Impact Assessment concerning the decommissioning of the underground operations was undertaken for De Beers Consolidated Mines Limited Kimberley by African Heritage Consultants cc during August and September 2006, which mainly focused on the built environment and other man-made remains that were left over from 130 years of diamond mining operations. The results of this assessment were documented in the report titled "*Heritage risk and impact assessment for De Beers Consolidated Mines Limited Kimberley of the area known as Wesselton, Dutoitspan, Bultfontein, De Beers and Kimberley*", dated October 2006, which is attached hereto as **Appendix P**. Refer to this report for the methodology followed during the undertaking of this assessment. The Heritage Risk and Impact Assessment Report also includes information from the report titled "*Phase 1. Archaeological Impact Assessment Kimberley Mining Properties for De Beers Consolidated Mines Ltd.*", dated 2005, and compiled by David Morris.

The mining area within the property of De Beers Kimberley Mines has a relatively low value from a cultural interest point of view. As for sites of archaeological interest, two "horizons" in terms of archaeological deposits exists within the study area (Morris, 2005). The first horizon is characterised by the presence of a low density of Stone Age material known as Acheulen Fauresmith material, which is mainly found in the northern and eastern parts of the mining area, especially within undisturbed areas. The second horizon is characterised by archaeological debris consisting of the middens of early Kimberley, as well as some ruins of early buildings and historical gravesites. However, much of these ruins and remains have been destroyed by mining and related activities.

According to the Archaeological Impact Assessment Report, dated 2005, important gravesites situated within the mine boundary of De Beers Kimberley Mines were fenced off to provide some protection. Although the village known as 'Freetown' is clearly demarcated on the British Military Map of 1899 – 1900, no remains of the occupation of British forces during the South African War of 1899 to 1902 could be found during the study (Morris, 2005).

According to the above-mentioned Heritage Risk and Impact Assessment Report, dated October 2006, structures related to the mining operations of De Beers Consolidated Mines Limited may fall under the protection of the NHRA[17] (1999). Apart from historical mining equipment exhibited at the Kimberley Mine Museum, only a small quantity of earth moving and winding equipment (electrical winches and a steam hoist), which originate from early in the 1900's are available for reclamation.

4.16 REGIONAL SOCIO-ECONOMIC ASPECTS

A brief summary of the socio-economic structure at De Beers Kimberley Mines is described below.

[17] NHRA: Natural Heritage Resources Act, Act 25 of 1999.

4.16.1 POPULATION DENSITY, GROWTH AND LOCATION

4.16.1.1 Regional

The Northern Cape Province is the smallest province in population size being approximately 0.7 million people. However, the Northern Cape Province is the largest province concerning surface area, i.e. 361 830 km^2 (30 % of the country's land mass). This province borders the Atlantic Ocean, Namibia and Botswana, as well as the provinces of North-West, Free State, Eastern Cape and the Western Cape.

During the census in 2001, it was recorded that approximately 822 727 people lived in the Northern Cape (Statssa, 2001). The population density in the Northern Cape Prince is approximately 2 persons per square kilometre and most of the population (73 %) lives in small towns. An estimated average annual compound population growth rate for South Africa from 1970 to 1995 was estimated to be 2.4 %.

More than 50 % of the population of the Northern Cape is coloured, while Africans constitute the second largest group of people in the province (CSS, 1998). **Table 4.23** indicates the racial percentage of the population in the Northern Cape. Refer also to **Table 4.24** for an indication of the major languages in the province.

Table 4.23: Racial percentage of the population in the Northern Cape (2001)

Description	Percentage (%)
Coloured	51.6
Black	35.7
Caucasian	12.4
Asian	0.3

Table 4.24: Major languages spoken in the Northern Cape (2001)

Description	Percentage (%)
Afrikaans	70
Tswana	20
Xhosa	6.5

4.16.1.2 Kimberley population density, growth and location

Kimberley is the capital of the Northern Cape Province, including the largest city in the province. In 1999, 32 % of the population in Kimberley is older than 35 years. This tendency towards a growing age profile could be due to young people migrating from the region. Refer also to the age distribution of Kimberley citizens graph attached in Annexure 24 to the approved EMPR, dated October 1999 Vol. III, extracts of which are attached hereto in **Appendix G**. In addition, refer to **Table 4.25** below for an indication of the population of the Sol Plaatje Local Municipality in which Kimberley is located, recorded during the 2001 census (Statssa, 2001).

Table 4.25: The population of the Sol Plaatje Local Municipality by age, sex and ethnic origin (Statssa, 2001)

Age	Male				Female			
	Black African	Coloured	Indian/ Asian	White	Black African	Coloured	Indian/ Asian	White
0-9	10188	10454	6740	6607	149	141	1492	1459
10-15	11516	11775	7085	7137	147	160	2475	2267
20 - 29	10047	10689	5270	5848	118	142	1650	1699
30-39	8139	8952	4541	5102	129	107	1806	2001
40-49	5978	6805	3297	3846	95	114	1957	2094
50-59	3494	4054	1940	2337	76	78	1565	1588
60-69	1868	2629	1127	1492	45	57	972	1167
70-79	831	1395	407	704	16	26	558	869
80+	290	611	118	320	5	7	187	415
Totals	**39. 52351**	**40. 57364**	**41. 30525**	**42. 33393**	**43. 780**	**44. 832**	**45. 12662**	**46. 13559**
Grand total								**201466**

In 1999, the majority of the population in the Kimberley region had an average education level below matric. Refer also to the level of education graph attached in Annexure 24 to the approved EMPR, dated October 1999 Vol. III, extracts of which are attached hereto in **Appendix G**. Approximately 44 % of the population in Kimberley is economically active of which the non-active portion includes schooling children.

4.16.2 MAJOR ECONOMIC ACTIVITIES AND SOURCES OF EMPLOYMENT

4.16.2.1 Regional

According to the report compiled by CSS, dated 1998, 20 % of the main economic activities in the Northern Caped Province involve social and personal services, 15 % of trade, catering and accommodation and 4 % of manufacturing activity. However, the foremost contributor to the GGP[18] of the Northern Cape Province is mining and quarrying, compiling 25 % of the economic activities in this province.

4.16.2.2 Kimberley

According to the approved EMPR, dated October 1999 Vol. III, approximately 44 % of the population in Kimberley is economically active of which the non-active portion includes schooling children.

The mining industry accounts up to 24 % of the economic active population in the Kimberley region, however the downscaling thereof would result in a smaller contribution towards economic activity. Other than mining, community, social and personal services account to the majority of the economic active population in Kimberley. Refer also to the economic active graph attached as Annexure 24 to the approved EMPR, dated October 1999 Vol. III, extracts of which are attached hereto in **Appendix G**.

Table 4.26 below indicates the major economic activities (industries) taking place in the Sol Plaatje Local Municipality (including Kimberley) as was recorded during the 2001 census. These statistics also provide an indication of the different ethnic groups, as well as the gender mostly associated with each industry.

Table 4.26: Industries in the Sol Plaatje Local Municipality (Statssa, 2001)

Sector	Black African	Coloured	Indian/Asian	White
Males				
Agriculture; hunting; forestry and fishing	540	351	0	182
Mining and quarrying	1512	285	6	516
Manufacturing	869	606	31	515
Electricity; gas and water supply	186	69	3	97
Construction	1203	788	16	306
Wholesale and retail trade	1696	1128	139	1087

[18] GGP: Gross Geographic Product.

Sector	Black African	Coloured	Indian/Asian	White
Transport; storage and communication	848	637	17	677
Financial; insurance; real estate and business services	992	571	20	757
Community; social and personal services	3282	2320	75	1469
Other and not adequately defined	304	103	0	14
Private Households	3	0	0	3
Undetermined	913	513	25	397
Not Applicable	22518	12069	188	2922
Females				
Agriculture; hunting; forestry and fishing	186	92	3	46
Mining and quarrying	96	105	4	228
Manufacturing	447	385	13	236
Electricity; gas and water supply	24	12	0	24
Construction	214	58	0	64
Wholesale and retail trade	1183	1112	76	741
Transport; storage and communication	119	97	9	238
Financial; insurance; real estate and business services	596	467	32	922
Community; social and personal services	3121	2317	85	2088
Other and not adequately defined	2695	961	4	35
Private Households	3	0	0	0
Undetermined	558	315	14	317
Not Applicable	28995	15793	313	4348

4.16.3 UNEMPLOYMENT ESTIMATE FOR THE AREA

4.16.3.1 Regional

According to the report compiled by CSS, dated 1998, the total unemployment rate in the Northern Cape Province for 1994 was 32.5 %. Of the mentioned percentage, approximately 24.5 % comprises of males and 44.8 % of females.

Table 4.27 indicates the results of the Census, 2001, pertaining to the employment status of the Northern Cape Province as was recorded in 2001.

Table 4.27: Employment status of the Northern Cape Province (Statssa, 2001)

Status	Black African	Coloured	Indian/Asian	White
Males				
Employed	44 985	56 456	479	25 040
Unemployed	21 510	26 167	96	1 167
Not economically active	30 593	43 559	214	8 272
Female				

Employed	27 384	38 061	295	16 045
Unemployed	26 341	28 007	80	1 211
Not economically active	44 676	70 963	375	17 867

4.16.3.2 Kimberley

According to the approved EMPR, dated October 1999 Vol. III, the majority of people in Kimberley has no income, while those with an income earns between R 1 000 and R 30 000 per annum. Refer also to the income graph attached in Annexure 24 to the approved EMPR, dated October 1999 Vol. III, extracts of which are attached hereto in **Appendix G**.

A count was made regarding the employment status of the Sol Plaatje Local Municipality in which Kimberley is located during the 2001 census. Refer to **Table 4.28** for an indication of the results for the Kimberley area as obtained during the mentioned census.

Table 4.28: Employment statistics for the Sol Plaatje Local Municipality (Stassa, 2001)

Status	Black African	Coloured	Indian/Asian	White
Males				
Employed	12346	7373	334	6018
Unemployed	9550	4737	55	385
Not economically active	12968	7333	132	2537
Females				
Employed	9241	5922	238	4940
Unemployed	12276	5534	56	335
Not economically active	16719	10258	258	4013

4.16.4 HOUSING

4.16.4.1 Regional

According to the approved EMPR dated October 1999 Vol. 1, there are approximately 741 000 people in the Northern Cape, living in 190 000 households. Of these households, approximately 65 % are found in urban areas, while 81 % of these households live in formal brick structures such as a house, a flat or a backyard room.

4.16.4.2 Kimberley

As mentioned previously, a census was conducted in 2001. Results of this census regarding housing in the Sol Plaatje Municipality (including Kimberley), are included in **Table 4.29** below.

Table 4.29: Types of Dwelling present in the Sol Plaatje Municipality (Statssa, 2001)

Type of Dwelling	Black African	Coloured	Indian/ Asian	White
House or brick structure on a separate stand or yard	19678	10618	338	6261
Traditional structure made of traditional materials	253	157	14	62
Flat in block of flats	154	573	41	664
Townhouse	328	102	5	296
House/ flat / room in back yard	809	435	11	256
Informal dwelling / shack in back yard	1479	244	2	18
Shack in informal settlement	4788	1885	8	23
Room / flat let not in back yard but on a shared property	233	58	1	233
Caravan or tent	135	56	1	13
Private ship/boat	12	1	0	2

According to the approved EMPR, dated October 1999 Vol.1, there is currently no need for housing at De Beers Kimberley Mines. However, De Beers Kimberley Mines encourages home ownership and employees could acquire their own houses by means of the Home Ownership Scheme. A survey is currently underway regarding the housing situation and could influence policy discussion in this regard.

4.16.5 SOCIAL INFRASTRUCTURE

4.16.5.1 Regional

According to the above-mentioned EMPR, there were 533 schools in the Northern Cape in 1995. A total of approximately 198 000 pupils were enrolled at these schools in total, with a pupil-teacher ratio of 27 to 1. According to statistics, there were no universities and technikons in the province in 1996. According to the report compiled by CSS, dated 1998, approximately 79 % of the entire adult population (aged 20 years and older) of the Northern Cape did not have Standard 10 in 1995. Education levels in the Northern Cape are therefore generally rather low.

The majority of people (80 %) make use of a public health-care facility, i.e. a public clinic or hospital. Less than three in every ten households (29 %) in Northern Cape have access to a telephone within their home.

4.16.5.2 Kimberley

According to the approved EMPR, dated October 1999 Vol. I, the town Kimberley provides for all social infrastructure which includes the following, amongst other:

- Schools (including pre-primary-, primary- and secondary schools).
- Private and provincial hospitals.
- Clinics.
- Sport (e.g. rugby, cricket, soccer, etc.)
- Recreation facilities.

- Shopping centres.

In addition to the above-mentioned social infrastructure, offices of national state departments (e.g. DWAF and DMR) and provincial state departments (e.g. Northern Cape Nature Conservation Service) are situated within Kimberley.

4.16.6 WATER SUPPLY

4.16.6.1 Regional

In 1999, approximately 63.9 % of the households in Northern Cape obtained clean water for domestic purposes (including drinking) from a tap inside their own home.

4.16.6.2 Kimberley

Kimberley town is supplied of water by the Kimberley Municipality. Refer to **Table 4.30** for an indication of the type of water supply at households in the Sol Plaatje Local Municipality (including Kimberley).

Table 4.30: Type of water supply at households in the Sol Plaatje Local Municipality

Type of Water Supply	Black African	Coloured	Indian/ Asian	White
Piped water inside dwelling	19678	10618	338	6261
Piped water inside yard	253	157	14	62
Piped water on community stand: distance less than 200m from dwelling	154	573	41	664
Piped water on community stand: distance greater than 200m from dwelling	328	102	5	296
Borehole	809	435	11	256
Spring	1479	244	2	18
Rain-water tank	4788	1885	8	23
Dam/pool/stagnant water	233	58	1	233
River/stream	135	56	1	13
Water vendor	12	1	0	2
Other	472	100	2	174

4.16.7 POWER SUPPLY

According to the approved EMPR, dated October 1999 Vol. 1, only 45.5 % of households in the Northern Cape have electricity within their homes to utilise for cooking, lighting and heating. De Beers Kimberley Mines are supplied with electricity be Eskom.

Table 4.31 below presents the sources of fuel utilised in households in the Sol Plaatje Local Municipality according to Statistics South Africa and Census 2001.

Table 4.31: Sources of fuel utilised in households in the Sol Plaatje Local Municipality (Census 2001)

Source	Lighting	Cooking	Heating
Electricity	8274467	31866	31491
Gas	34926	1489	428
Paraffin	773367	16504	7587
Solar	25141	104	122
Other	35702	60	3382
Candles	2638000		
Wood		776	6860
Coal		172	1137
Animal dung		123	87

4.16.8 COMMUNITY INVOLVEMENT

De Beers Kimberley Mines are actively involved in the local community. Various projects are supported by De Beers Kimberley Mines. De Beers Consolidated Mines has endorsed in various small business enterprises which includes small mining enterprises by Superstone mining, Dumpco, as well as mushroom cultivation, amongst others.

Refer to **Table 4.32** for detail pertaining to the above-mentioned projects, amongst other.

Table 4.32: Detail of projects supported by De Beers Consolidated Mines: De Beers Kimberley Mines

Project	Responsible company / person
Cattle and sheep farming	Mr. J. Khumalo Mr. J. Galloway
Street children	Big Green Committee
Scrap metal recycling	Mr. A. Malaula Mr. J. Khumalo Mr. A. Mofomela
Chicken farming	Mr. J. Mohamahd
Mining	DUMPCO
Mining	Superstone
Mushroom cultivation	Diamond mushroom
Prosopis control	Contract workers

In addition to the above-mentioned projects, a local area Chairman's Fund has been established to assist with numerous requests for assistance.

4.17 INTERESTED AND AFFECTED PARTIES

Table 4.33 lists the Interested and Affected Parties relevant to De Beers Kimberley Mines. This list will be updated for the purposes of public participation that will be undertaken in the near future.

Table 4.33: Interested and Affected Parties relevant to De Beers Kimberley Mines

Interested and Affected Parties
Kimberley Municipality
Department of Minerals and Energy
Department of Health, Welfare and Environment
Department of water Affairs and Forestry
Department of Transport
Department of Agriculture, Nature Conservation and Land Reform
Eskom
Spoornet
National Monuments Council
Contractors for Waste Management
National Union of Mineworkers and other Employee Representatives
Company Employees
Kimberley residents, especially Greenside