1.1.6.1.4 Threatened Red Data Flora of the Northern Cape

According to the latest Red Data flora information available from SANBI, 234 species are considered to be threatened (Vulnerable, Endangered, Critical Endangered). Of these 234 species, 187 species (80%) are Vulnerable, 33 species (14%) are Endangered and 14 species (6%) are Critically Endangered. These 234 species are representative of 30 families, of the following eight (8) families contains more than 75% of the species:

> Iridaceae, Mesembryanthemaceae, Asteraceae, Amaryllidaceae, Hyacinthaceae, Fabaceae, Asphodelaceae, Eriospermaceae.

A total of 105 genera represent these 234 threatened plants from the Northern Cape, of which the following 16 genera contain 50% of the species:

> Romulea, Babiana, Eriospermum, Lithops, Moraea, Lachenalia, Conophytum, Geissorhiza, Hesperantha, Oxalis, Cheiridopsis, Aloe, Lotononis, Crassula, Strumaria, Gethyllis.

The majority of these threatened plants represent either forbs or woody species (shrubs and/ or trees), of which the dominant growth form is forbs. More details regarding the Red Data Flora for the Northern Cape, are presented in Appendix 3.

Environmental data about these species were obtained from SANBI's PRECIS officer, which represented 1421 records. From these records a profile was created of the habitat preference of these 234 species based on altitude, geology, aspect, soil, substrate, moisture, vegetation, exposure and biological effects, the details of which are presented in Appendix 3. The information presented suggests that the majority of the Red Data Flora is found between 500 and 1000 mamsl and is mainly associated with granites and sandy well-drained soils and rocky areas, seldom associated with water. It is noted that no granites are present within the project area, as discussed in Section 1.1.9 below. The information presented in Appendix 3 suggests that agricultural activities have the largest biological effect (66%) on Red Data Flora.

Based on the information presented above, EkoInfo concludes that there is a low likelihood that threatened flora could occur within the project area. The threatened species that may occur within the project area are listed in Table 12.

The most optimal time to verify the anticipated low probability of occurrence for these species is September and March, when the species either bear flowers or fruit.

Table 12 List of potential threatened plants that may occur on site

Botanical Name	Conservation Status	Growth forms	No of Habitat Criteria	Altitude	Soil texture
Avonia recurvata (Schönland) G.D. Rowley ssp. recurvata	Vulnerable	Herb, succulent	2	1	1
Babiana sambucina (Jacq.) Ker Gawl. var. longibracteata G.J.Lewis	Endangered	Geophyte, herb	2	1	1
Bulbinella latifolia Kunth var. latifolia	Vulnerable	Geophyte, herb	2	1	1
Crassula brevifolia Harv. ssp. brevifolia	Vulnerable	Dwarf shrub, succulent	2	1	1
Disperis purpurata Rchb.f. ssp. purpurata	Vulnerable	Geophyte, herb	2	1	1
Haemanthus graniticus Snijman	Endangered	Geophyte	2	1	1
Hesperantha latifolia (Klatt) M.P.de Vos	Vulnerable	Geophyte, herb	2	1	1
Hesperantha rivulicola Goldblatt	Endangered	Geophyte, herb	2	1	1
Hessea incana Snijman	Vulnerable	Geophyte	2	1	1
Moraea indecora Goldblatt	Vulnerable	Geophyte, herb	2	1	1
Moraea kamiesensis Goldblatt	Endangered	Geophyte, herb	2	1	1
Moraea longiflora Ker Gawl.	Vulnerable	Geophyte, herb	2	1	1
Moraea pendula (Goldblatt) Goldblatt	Vulnerable	Geophyte, herb	2	1	1
Otholobium hamatum (Harv.) C.H.Stirt.	Vulnerable	Shrub	2	1	1
Romulea pearsonii M.P.de Vos	Vulnerable	Geophyte, herb	2	1	1

1.1.6.1.5 Protected plants of the Northern Cape

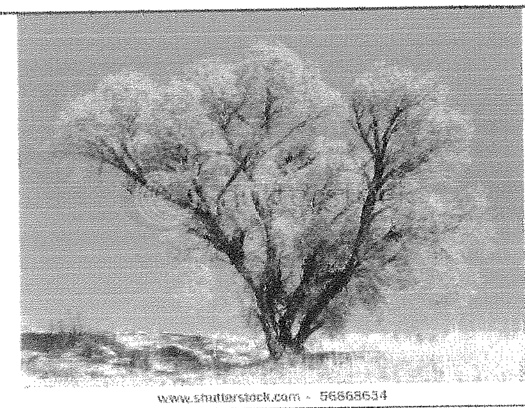
A detailed on-site vegetation survey has not been completed for the project, however, 23 species belonging to protected genera and families were recorded in the topocadastral grids in which the study area occurs as well as in surrounding grids (Table 13). Therefore it is highly likely that these species are present within the study area.

Table 13 List of species belonging to provincially protected genera

Protected Taxon	Species recorded in topocadastral grids	Conservation note
AMARYLLIDACEAE	Boophone disticha (L.f.) Herb.	All species
AMARYLLIDACEAE	Nerine laticoma (Ker Gawl.) T.Durand & Schinz	All species
APOCYNACEAE	Brachystelma circinatum E.Mey.	All species
APOCYNACEAE	Brachystelma cupulatum R.A.Dyer	All species
APOCYNACEAE	Fockea angustifolia K.Schum.	All species
APOCYNACEAE	Gomphocarpus fruticosus (L.) Aiton f. subsp. fruticosus	All species
APOCYNACEAE	Gomphocarpus tomentosus Burch. subsp. tomentosus	All species
APOCYNACEAE	Microloma armatum (Thunb.) Schltr. var. burchellii (N.E.Br.) Bruyns	All species
APOCYNACEAE	Piaranthus decipiens (N.E.Br.) Bruyns	All species
APOCYNACEAE	Raphionacme velutina Schltr.	All species
APOCYNACEAE	Sarcostemma viminale (L.) R.Br. subsp. viminale	All species
IRIDACEAE	Babiana bainesii Baker	All species
IRIDACEAE	Babiana hypogaea Burch.	All species
IRIDACEAE	Gladiolus permeabilis D.Delaroche subsp. edulis (Burch. ex Ker Gawl.) Oberm.	All species
IRIDACEAE	Lapeirousia erythrantha (Klotzsch ex Klatt) Baker	All species
IRIDACEAE	Lapeirousia sandersonii Baker	All species
IRIDACEAE	Moraea longistyla (Goldblatt) Goldblatt	All species
IRIDACEAE	Moraea pallida (Baker) Goldblatt	All species
IRIDACEAE	Moraea polystachya (Thunb.) Ker Gawl.	All species
MESEMBRYANTHEMACEAE	Prepodesma orpenii (N.E.Br.) N.E.Br.	All species
Aloe	Aloe claviflora Burch.	All species, check exceptions
Anacampseros	Anacampseros filamentosa (Haw.) Sims subsp. filamentosa	All species
Haworthia	Haworthia venosa (Lam.) Haw. subsp. tessellata (Haw.) M.B.Bayer	All species

The following two trees, which were observed during the site visit, are protected in terms of National Forest Act (Act no. 84 of 1998):

Acacia erioloba



Acacia haematoxylon

It should be noted that permits are required from the national and provincial authorities to destroy these protected plants.

1.1.6.1.6 Medicinal plants

In the absence of a comprehensive list of species for the site, it is not possible to list all the medicinal plants that could occur in the area; however the following sixteen species with medicinal properties were recorded in the topocadastral grids associated with the study area and therefore is highly likely to occur there:

Acacia karroo, Croton gratissimus, Datura stramonium, Elephantorrhiza elephantina, Euclea undulata, Gomphocarpus fruticosus, Harpagophytum procumbens, Olea europaea, Pellaea calomelanos, Rumex lanceolatus, Scabiosa columbaria, Sutherlandia frutescens, Tarchonanthus camphoratus, Terminalia sericea, Thesium hystrix, Withania somniferaa

1.1.6.1.7 Alien Invasive Plant Species

In terms of the Conservation of Agricultural Resources Act (No 43 of 1983), four declared species were recorded in the topocadastral grids associated with the study area. These species are classified as Category 1 and 2 respectively (Table 14).

Table 14 List of possible alien invasive species present on site

Species	Common name	Description
Argemone ochroleuca Sweet subsp. ochroleuca	White flowered Mexican poppy	Category 1 plants are weeds and serve no useful economic purpose and possess characteristics that are harmful to humans, animals or the environment.
Datura stramonium L.	Common thorn apple	Category 1 plants are weeds and serve no useful economic purpose and possess characteristics that are harmful to humans, animals or the environment.
Prosopis glandulosa Torr. var. glandulosa	Honey mesquite	Category 2 plants are plants that are useful for commercial plant production purposes but are proven plant invaders under uncontrolled conditions outside demarcated areas.
Prosopis velutina Wooton	Velvet mesquite	Category 2 plants are plants that are useful for commercial plant production purposes but are proven plant invaders under uncontrolled conditions outside demarcated areas.

The following invasive species were recorded on site, especially southwest of the road (Umfaan, 2012):

Schinus molle	Pepper tree
Prosopis glandulosa	Honey Mesquite
Nicotiana glauca	Wild tobacco
Argemone ochroleuca	White-flowered Mexican Poppy
Melia azedarach	Seringa
Salsola kali	Russia tumbleweed
Datura ferox	Large-leafed thorn apple

Their presence in the study area should be verified and if present managed accordingly to the requirements of the act.

1.1.6.2 Fauna

This assessment was undertaken by Dewald Kamffer of Ecocheck Environmental Services on behalf of EkoInfo. The detailed report is contained in Appendix 3.

It is important to view the study area on an ecologically relevant scale and consequently, all sensitive animal species (specific faunal groups) known from the Northern Cape Province are included in this assessment, except for avifauna which focuses on the Q-grids of the study area. Data on all faunal groups are lacking (notably for most of the invertebrate groups), as a result, only data sets on specific faunal groups allow for habitat sensitivity analyses based on the presence/absence of sensitive faunal species, such as red data species, and their specific habitat requirements. At present, the following faunal groups are included in these analyses:

- Butterflies (Invertebrata: Insecta: Lepidoptera – Nymphalidae, Lycaenidae, Hesperiidae, Pieridae and Papilionidae). References used include the IUCN Red List (2011) – http://www.iucnredlist.org and the South African Butterfly Conservation Assessment (SABCA, 2011) – http://sabca.adu.org.za.
- Frogs (Amphibia: Anura). References used include the Atlas and Red Data Book of the South Africa, Lesotho and Swaziland, the Giant Bullfrog Conservation Group (2011) – http://www.up.ac.za/bullfrog and a Complete Guide to the Frogs of Southern Africa (du Preez & Carruthers, 2009).
- Reptiles (Reptilia: Testudines and Squamata). References used include the IUCN Red List (2011) and the South African Reptile Conservation Assessment (SARCA, 2011) – http://sarca.adu.org.za.
- Birds: All bird groups (Roberts VII Multimedia: Birds of Southern Africa, PC Edition).
- Terrestrial Mammals (Mammalia: Insectivora, Chiroptera, Primates, Lagomorpha, Pholidota, Rodentia, Carnivora, Tubulidentata, Proboscidea, Hyracoidea, Perissodactyla and Artiodactyla). References used include the Red Data Book of the Mammals of South Africa: A Conservation Assessment (Endangered Wildlife Trust - 2004).

1.1.6.2.1 Red Data Faunal Assessment

The probability of occurrence assessments of red data species presented is based on the size of the study area, the location and connectivity of the study area to other natural faunal habitats and the presence or absence, status and diversity of faunal habitats within the project area.

The above-mentioned criteria were used in partnership with the known distribution of red data species as well as their known habitat requirements to estimate their likelihood of occurring in the study area.

Ninety-two red data species from five categories are known to occur in the Northern Cape, as detailed in Appendix 3. It is estimated that 63 of the 92 species have a low probability of occurring in the study area; 8 have an estimated moderate-low probability of occurring, 15 a moderate and 4 a moderate-high probability, as detailed in Table 15.

Table 15 Red Data Species likely to occur in the project area

Biological Name	English Name	STATUS	Probability
BUTTERFLIES			
Tuxentius melaena griqua	Black Pie	DD	moderate
AMPHIBIANS			
Pyxicephalus adspersus	Giant Bullfrog	NT	moderate
BIRDS			
Phoenicopterus roseus	Greater Flamingo	NT	moderate
Phoenicopterus minor	Lesser Flamingo	NT	moderate
Ciconia nigra	Black Stork	NT	moderate-low
Leptoptilos crumeniferus	Marabou Stork	NT	moderate-low
Sagittarius serpentarius	Secretary bird	NT	high
Gyps africanus	White-backed Vulture	VU	moderate
Gyps coprotheres	Cape Vulture	VU	moderate-low
Torgos tracheliotus	Lappet-faced Vulture	VU	moderate
Terathopius ecaudatus	Bateleur	VU	moderate-low
Circus maurus	Black Harrier	VU	moderate
Aquila rapax	**Tawny Eagle**	**VU**	**moderate-high**
Polemaetus bellicosus	Martial Eagle	VU	moderate
Falco naumanni	**Lesser Kestrel**	**VU**	**moderate-high**
Falco biarmicus	**Lanner Falcon**	**NT**	**moderate-high**
Ardeotis kori	Kori Bustard	VU	high
Neotis ludwigii	Ludwig's Bustard	VU	moderate
Charadrius pallidus	Chestnut-banded Plover	NT	moderate-low
Glareola nordmanni	Black-winged Pratincole	NT	moderate-low
MAMMALS			
Crocidura cyanea	**Reddish-grey Musk Shrew**	**DD**	**moderate-high**
Crocidura hirta	Lesser Red Musk Shrew	DD	moderate
Parahyaena brunnea	Brown Hyaena	NT	moderate
Mellivora capensis	Honey Badger	NT	moderate
Miniopterus schreibersii	Schreiber's Long-fingered Bat	NT	moderate
Rhinolophus clivosus	Geoffroy's Horseshoe Bat	NT	moderate
Rhinolophus darlingi	Darling's Horseshoe Bat	NT	moderate-low
Rhinolophus denti	Dent's Horseshoe Bat	NT	moderate-low
Tatera leucogaster	Bushveld Gerbil	DD	moderate

Two red data are estimated to have a high probability of occurring in the study area, as listed in Table 15:

The Secretarybird, *Sagittarius serpentarius* (Falconiformes: Sagittariidae), is a Near Threatened (NT) bird found throughout sub-Saharan Africa. The Secretarybird prefers open grassland with scattered trees, shrubland and open woodland savanna. The species is currently not threatened but local populations in South Africa are decreasing.

The Kori Bustard, *Ardeotis kori* (Gruiformes: Otididae), is listed as Vulnerable – the species is found singly or in loose groups in the non-breeding season. The Kori Bustard is found in fairly dry, open savanna (rainfall between 100 and 600 mm per annum); also in Nama-Karoo dwarf shrubland and occasionally in western grasslands and dry grassy pan edges. Threats to the species include habitat loss, poisoning, deliberate snaring and dogs. The species is also vulnerable to overhead collisions with power lines.

1.1.6.2.2 Protected Faunal Species

The Northern Cape includes ten provincially listed protected species (www.speciesstatus.sanbi.org – NEMBA status), as detailed in Appendix 3.

Table 16 List of possible protected species in the study area

Biological Name	English Name	NEMBA status	Probability
Felis nigripes	Black-footed Cat	protected	moderate
Parahyaena brunnea	Brown Hyaena	protected	moderate
Vulpes chama	Cape Fox	protected	moderate

It is estimated that seven of the ten species listed in Appendix 3 are unlikely to occur in the study area (low estimated probability of occurrence). Three species are considered to have a moderate probability of occurrence, as detailed in Table 16.

The study area is untransformed and well connected. The effects of habitat transformation and fragmentation (loss of connectivity, edge effects etc.) are therefore likely to be insignificant in the region of the study area, except for the developed areas such as the town of Hotazel. It is therefore considered highly likely that at least two red data animals will be present in the study area, namely the Secretarybird and Kori Bustard; and at least moderately likely, that at least another nineteen species will occur, as listed in Tables 15 and 16. Species such as the Black-footed Cat are poorly known and the potential impacts of the proposed project on these species are difficult to predict.

1.1.6.3 Conservation areas

The Tswalu Game Range is situated approximately 50m northwest of the Perth Project area.

The R31 route stretches in a north-western direction towards the Kgalagadi Transfrontier Park (Kalahari Gemsbok National Park), which is more than 100km from the project area.

1.1.7 Surface Water

This specialist study was compiled by Epoch Resources (2012). The full specialist report is contained in Appendix 4.

The project is situated in the D41K quarternary sub-catchment of the Orange (D) primary drainage area. (WRC Report No. 298/3.1/94 First Edition and WRC Report No. 298/3.2/94 First Edition).

- The D41K Quarternary Sub-catchement has a gross catchment area of 4216km^2, net catchment area of 2664km^2.
- The Mine is situated in the D4A rainfall zone, with Mean Annual Precipitation (MAP) of 334mm, Mean annual Runoff (MAR) of 1.1 mil m^3, Gross MAR of 4.4 mil m^3 and a net MAR of 2.8 mil m^3.
- The Mine is situated in the 8A Evaporation zone with a Mean Annual Evaporation (MAE) of 2070mm.

A summary of the expected average monthly rainfall and evaporation at the mine site is presented in Table 17 with a summary of potential storm events as a function of recurrence interval and duration presented in Table 18.

Table 17 Average Monthly Rainfall and Evaporation

Month	Average Monthly Rainfall as Percentage of MAP (%)	Average Monthly Rainfall (mm)	Average Monthly Evaporation as Percentage of MAE (%)	Average Monthly Evaporation (mm)
January	17.00	59.5	13.60	286.3
February	18.01	63.0	10.45	220.0
March	19.03	66.6	9.02	189.9
April	9.95	34.8	6.30	132.6
May	4.05	14.2	4.54	95.6
June	1.30	4.6	3.45	72.6
July	0.79	2.8	3.99	84.0
August	1.65	5.8	5.44	114.5
September	2.04	7.1	7.53	158.5
October	5.08	17.8	10.07	212.0
November	8.52	29.8	11.90	250.5
December	12.57	44.0	13.71	288.6
TOTAL	**100.0**	**350**	**100.0**	**2104.8**

Table 18 Expected Rainfall as a Function of Recurrence Interval

Event Duration (days)	Recurrence Interval (yrs)							Min Annual Max	Max Annual Max
	2	5	10	20	50	100	200		
	$P_{Occurrence}$ for Specified Life of Mine of15yrs								
	100%	96%	79%	54%	26%	14%	7%		
1	**47.8**	**68**	**82.2**	**96.5**	**116.0**	**131.4**	**147.5**	**16**	**162**
2	56.7	81.6	99.3	117.4	142.4	162.5	183.7	18	162
3	62.0	89.4	109.0	129.1	157.0	179.5	203.3	24	190
7	75.9	110.2	134.9	160.3	195.6	224.0	254.2	24	200

The Witleegte dry water course which runs through the mine area in a north westerly direction, is a tributary of the Ga-mogara dry water course, which in turn drains into the Kuruman river. There is no available streamflow data for the Kuruman river or its trubutaries. The Witleegte and Ga-mogara are shown as dry water courses on the 1:50 000 topographical maps of southern Africa (2722 BD) indicating that they run dry during winter months, as shown on Figure 1.

The surface water catchments in the area are characterised by very gentle gradients and sandy soils, with the end result that only fairly heavy rain is expected to induce any significant surface runoff.

The design of surface water works associated with mining operations must comply with the requirements of GN704 published in terms the National Water Act, 1998 (Act No. 36 of 1998), which specify Regulations on the Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources. The most relevant of the requirements considered in this section, are summarised in Appendix 4.

Figure 15 Proposed Mine Layout and the Witleegte Drainage Line

1.1.7.1 Estimated Flow Rates and Flood Volumes

Estimates of the Mean Annual Runoff and Average Monthly Runoff for the Witleegte drainage line are presented in Table 19 (Source: Surface Water Resources of South Africa, 1994). While it should be noted that the figures apply to the whole of the catchment, the mine is close enough to the bottom of the catchment for the estimates to give a reasonably accurate estimate of expected flows at the mine. As the situation currently stands, unless a diversion is constructed around the open pit, these flows would report to the pit.

Estimates of peak flow rates and associated flood volumes associated with events of specific recurrence intervals have also been compiled and are presented in Table 20. The flood peaks have been calculated with the RMF Method (K=2.8 and 3.4) and flood volumes were calculated using the SCS's method's hydrograph shape and the flood peaks from the RMF method.

The flood peaks have been calculated for "K" values of both 2.8 and 3.4 as the catchment lies in an area of some uncertainty with regard to the values.

It is recommended that if under estimation of the flood peaks could result in loss of life and economic value, it would be advisable to carry out a much more detail flood hydrology study or adopt the flood peaks calculated using a "K" value of 3.4 which would be conservative.

Table 19 Estimated Monthly Surface Water Runoff

River Name		Gamogara	Witleegte	Vlermuisleegte
MAR (10^6 m^3)		6.0	0.73	0.54
Catchment Area (km^2)		5182	661	487
Month	% MAR	Average Monthly Runoff (10^6 m^3)		
January	32.80	1.97	0.24	0.18
February	22.90	1.37	0.17	0.12
March	19.70	1.18	0.14	0.11
April	8.90	0.53	0.06	0.05
May	1.30	0.08	0.01	0.01
June	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00
September	0.00	0.00	0.00	0.00
October	0.90	0.05	0.01	0.00
November	4.60	0.28	0.03	0.02
December	8.70	0.52	0.06	0.05

Ref : *Surface Water Resources of South Africa 1994, Volume 3*

Table 20 Estimated Peak Flow Rates and Flood Volumes

Event Description	Peak Flow Rate (m^3/s) (K = 2.8)	Peak Flow Rate (m^3/s) (K = 3.4)	Alt. Rational Method
Regional Maximum Flood	187	382	
Q 200 (RMF Method)	103	211	187
Q 100 (RMF Method)	77	157	152
Q 50 (RMF Method)	56	114	116

Note : *Calculation of flood peaks based on Qt/QRMF relationship for Kovács regions*

1.1.8 Groundwater

This specialist study was completed by Future Flow (2012). The complete specialist report is contained in Appendix 5. The geology of the project area is discussed in Section 1.1.9 below and forms the basis for the characterisation of the aquifers in the area.

The hydrogeological maps of the area show the presence of north-south trending regional fault lines that divide the Makganyene and Danielskuil Formations into blocks with N-S displacement noted along these faults. The presence of these faults is also confirmed from the results of the ground geophysical investigation undertaken as part of this assessment. The N-S offset between opposite sides of the faults can be up to 6.75 km. Based on the size of the regional faults and the large displacement along the fault lines it is assumed that the faults will extend below the sandy gravel cover and possibly reach the proposed Sebilo Perth mining area.

The hydrogeology of the study area is described at the hand of data collected during the desk study as well as from the field investigation. The field investigation included a hydrocensus, geophysical investigation to identify faults and fractures that can act as preferential groundwater flow paths, installation of five monitoring boreholes, aquifer testing of the newly drilled boreholes, and hydrochemical analyses.

1.1.8.1 Aquifer description

Three aquifers occur in the area. These three aquifers are associated with a) the primary sandy gravel material, b) the fractured rock and leached banded iron formation aquifer, and c) the dolomitic aquifers of the Griqualand West Sequence.

The fractured rock aquifers are not high yielding, but the dolomitic karst aquifer is well known for its high potential (Van Dyk and Jones, 2006). The following is a description of the natural aquifer systems in the area.

1.1.8.1.1 Upper primary sandy gravel aquifer

The upper aquifer forms due to the vertical infiltration of recharging rainfall through the primary sandy gravel material being retarded by the lower permeability of the underlying competent rock. Exploration borehole log data shows that this aquifer ranges between 3 and 10m in thickness and is on average 5.6m thick. Groundwater collecting above the sandy gravel / competent material contact migrates down gradient along the contact to lower lying areas. In places where the contact is near surface the groundwater can daylight on surface as springs. Such areas where the groundwater level in the sandy gravel material is close to surface can also be expected to be near the streams where it contributes baseflow to the streams.

However, it has to be cautioned that drilling results show this aquifer to be dry in large portions of the study area. It is considered that this aquifer is seasonal and mostly carries water only during and shortly after rainfall events when rainfall recharges into the material. The relatively high transmissivity of the sandy gravel material allows the recharging water to migrate quickly through and out of the material. This combined with the high positive evaporation rates in the area (see Section 1.1.7), lays the material dry for large portions of the year.

It is considered that up to 5 or 7 % of the mean annual rainfall (MAR) recharges into this material. However, taking into consideration evaporation and other losses possibly as little as 1 to 3% of the MAR reaches the saturated zone in the underlying fractured rock aquifer.

1.1.8.1.2 Fractured rock and leached banded iron formation aquifer

Although the lower permeability of the competent rock material will retard vertical infiltration of groundwater, some of the water in the upper aquifer will recharge the lower aquifer. The geological map (Figure 21) does not show major faults or fractures in the area, which will also help recharge the lower aquifers. However, large portions of the area are covered by the sandy gravel, therefore surface mapping of fault and fractures are hampered. The hydrogeological map of the area does show the presence of some regional faults in the Makganyene (Vm) and Danielskuil (Vad) Formations that outcrop 12 km to the east.

Drilling results from previous projects in the area have shown that the flat-pebble conglomerate (potsherd marker) that is intercepted in the Danielskuil Formation is the only water-bearing zone in the area.

Groundwater flows in the fractured rock aquifer are associated with the secondary fracturing in the competent rock that was formed by the major N-S striking faulting seen from the hydrogeological maps and confirmed by the ground geophysical survey (see Appendix 5 for more detail). As such, groundwater flows and contaminant transport will be along discrete pathways associated with the fractures. The general transmissivity of the competent rock material is considered to be around 0.1 m^2/day or less.

Aquifer testing performed on the newly drilled boreholes (SB01 to SB05) show that the transmissivity of individual fractures range between 0.25 and 0.7 m^2/day. Drilling results show that aquifer strikes can occur down to 80 m in this area. Using the borehole depths and the aquifer transmissivities stated above, the hydraulic conductivity of the non-fractured, competent material is calculated to be around 0.001 m/day, and that of the individual fractures up to 0.021 m/day.

1.1.8.1.3 Dolomitic aquifer

Dolomitic aquifers are recognised to potentially be of concern to mining activities due to the potential large inflow volumes in areas where karstic dolomite is intersected. The dolomitic karst aquifer in the region is well known for its high potential (Van Dyk and Jones, 2006). A number of springs have been mapped in the area (van Dyk & Jones, 2006) of which the Kuruman, Klein

Karoo, and Manyeding are perennial.

Smit (1978) and Wiegmans (2006) defined compartments within the dolomite in separate groundwater management units. The project area falls within the D41K groundwater management area. Wiegmans (2006) also calculated recharge to each of the compartments and the associated management criteria in terms of sustainable abstraction volumes.

Inspection of exploration drilling core on neighbouring farms show that the dolomite in the area appears to be competent with no indication of weathering or karstification. Karstic dolomite is highly variable in competence and transmissivity over short distances and this is no guarantee that karstic dolomite won't be found on site, however, based on the general constant high competence and total absence of indications of karstic dolomite it can be concluded that the likelihood of intercepting karstic dolomite is very low.

1.1.8.2 Depth to groundwater level and flow patterns

The depth to groundwater level was measured during the hydrocensus that was performed as part of the study (please refer to Figure 18 for the borehole positions) where eighteen boreholes were identified. In addition to this, the depth to groundwater level was measured in the newly drilled monitoring boreholes. The recorded data is summarised in Table 21 and shown graphically in and Figure 16. From Table 21 it can be seen that the depth to groundwater level generally range between 14.60 and 36.70 mbgl. The average depth to groundwater is calculated to be 28 mbgl, with the groundwater level around the pit specifically (boreholes SB01, SB03 and SB04) calculated at 27.3 mbgl.

Borehole PK indicates an anomalous deep depth to groundwater when compared to the other boreholes (indicated in red on Figure 16). The borehole is used for mining purposes at Amari and it is possible that the depth to groundwater was influenced by pumping shortly before the measurement was taken.

In areas where there are no large scale external impacts on the groundwater environment, such as the lowering of groundwater level through mine dewatering, and where the geology and aquifer interactions are not excessively complex, it is expected that the groundwater level contours reflect topographical contours, although at a moderated gradient. Plotting groundwater level elevation versus topographical elevation for this area (and omitting the anomalous depth to groundwater in borehole PK) yields a 94.6 % correlation for the fractured rock aquifer (see Figure 17). From these correlation figures it can be concluded that there are no large-scale impacts on the groundwater levels in the area. When PK is included a correlation of 90 % is still achieved.

Considering the average depths to groundwater level in Figure 16 and Figure 17, it is concluded that the water level in the historic Perth Pit is equivalent to the surrounding, and regional, groundwater levels and the system is in equilibrium. Based on this, and the high net evaporation from the area, it can be concluded that there is a net inflow into the pit, and the pit does not recharge into the surrounding aquifers.

Regional groundwater level contours are calculated using Bayesian interpolation based on topographical elevation and the good correlation between groundwater levels and topography as shown above. The groundwater level contours and flow patterns for the weathered rock aquifer are shown in Figure 18. From the figure it can be seen that groundwater flows are directed from the east towards the topographical lows representing the Witleegte stream bed. Flow gradients are calculated at 1:100 to 1:350.

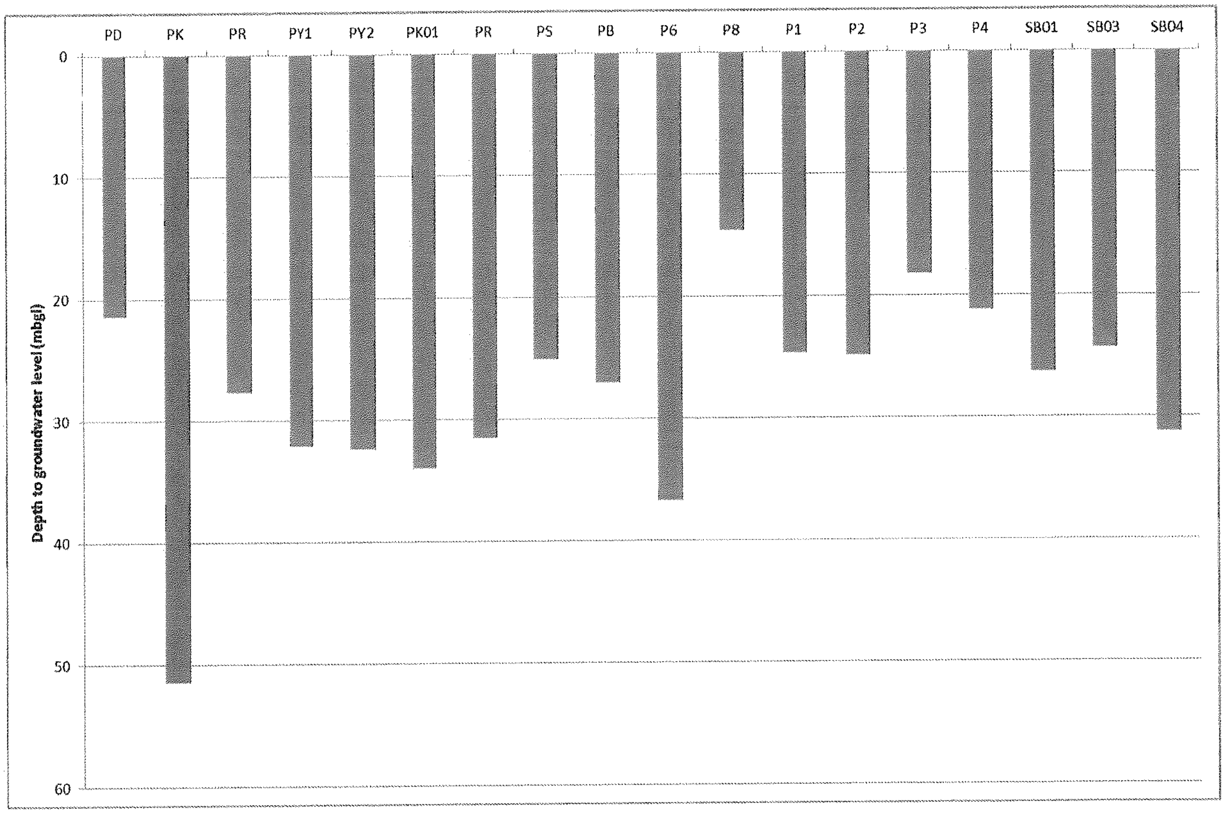


Figure 16 Depth to groundwater level

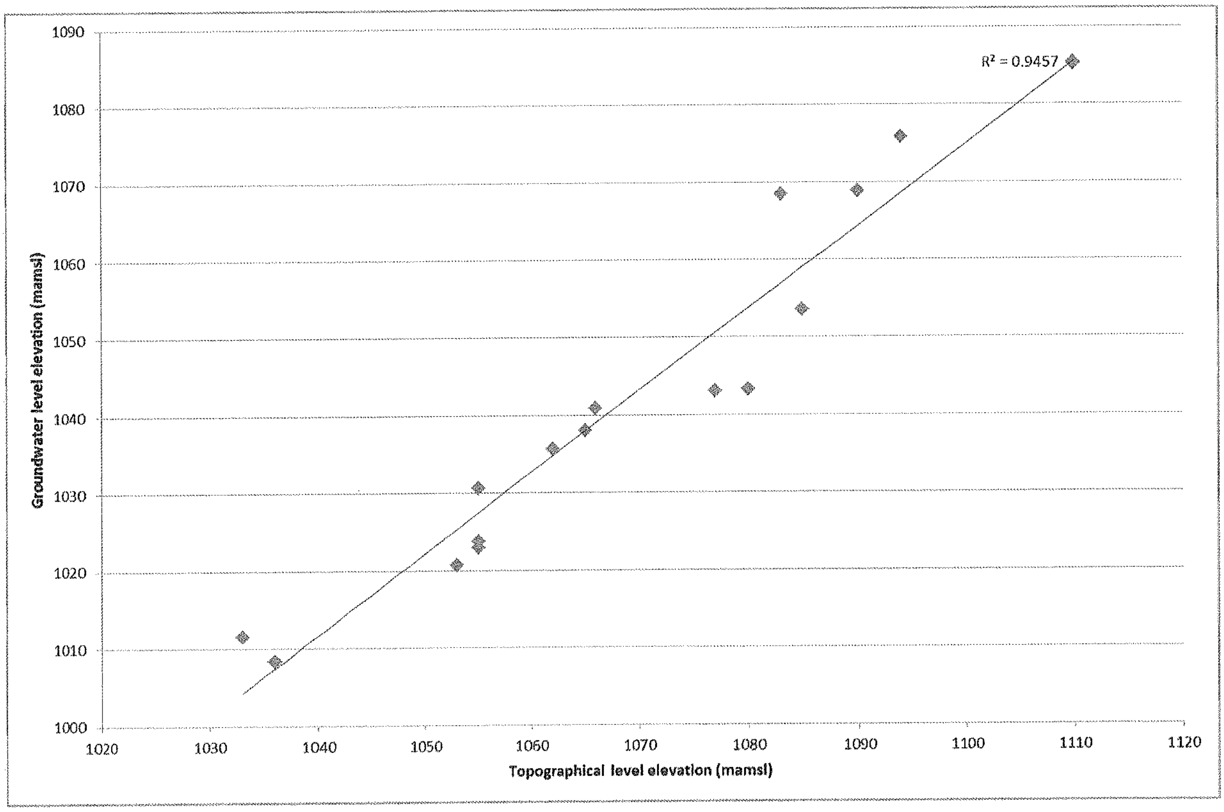


Figure 17 Topography vs. groundwater level elevations

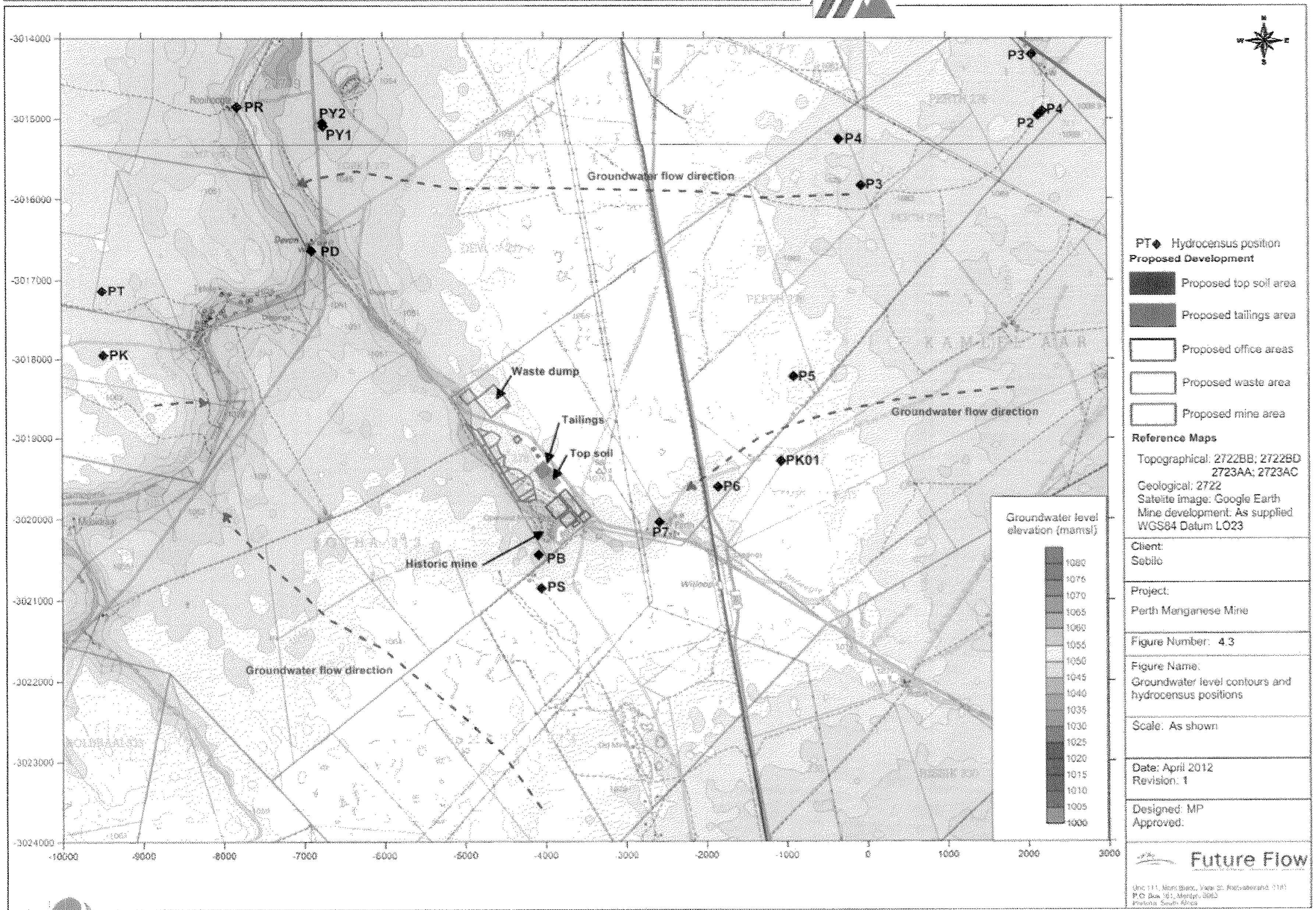


Figure 18 Groundwater flow & hydrocensus boreholes

Table 21 Hydrocensus results

BH	Owner	Contact	Easting	Northing	Elevation	Collar	Water level			Depth	Use	Comment
			WGS84, LO23	WGS84, LO23	mamsl	magl	mbc	mbgl	mamsl	mbgl		
PD	Mrs Koba Albagten	Unknown	-6 885	-3 016 632	1 033	0.24	21.65	21.41	1 011.59	Unknown	Agricultural	Spoke to Nick Bosh, Devon
PK	Arnari Mine	Unknown	-9 486	-3 017 952	1 063	0.5	51.92	51.42	1 011.58	Unknown	Mining	Spoke to Johannes Mmessi, Kongoni
PT	Andries Bursman	082 550 7242	-9 492	-3 017 148	1 062	0.58	Unknown	Unknown	Unknown	Unknown	Agricultural	Mono pump, no access for dip meter.
PR	Japie Steyn	082 458 6864	-7 810	-3 014 854	1 036	0.39	28.04	27.65	1 008.35	Unknown	Agricultural	On Rooihoogte
PY1	Asia Minerals	Unknown	-6 745	-3 015 096	1 055	0.2	32.27	32.07	1 022.93	Unknown	Agricultural	On York
PY2	Asia Minerals	Unknown	-6 751	-3 015 060	1 053	0.302	32.64	32.338	1 020.66	Unknown	Agricultural	On York
PK01	Henk Venter	082 507 7716	-1 064	-3 019 284	1 077	0.4	34.37	33.97	1 043.03	Unknown	Agricultural	On Kameel Aar
PR	UMK Mine	082 940 1876	-1 734	-3 025 031	1 085	0.72	32.23	31.51	1 053.49	Unknown	Monitoring	Protea (Env manager) UMK10 on Rissik
PS	UMK Mine	082 940 1876	-4 053	-3 020 851	1 066	0.86	25.94	25.08	1 040.92	Unknown	Monitoring	Protea (Env manager) Umk 14 on Smart
PB	UMK Mine	082 940 1876	-4 078	-3 020 445	1 065	0.1	27.10	27.00	1 038.00	Unknown	Monitoring	Protea (Env manager) on Botha
P7	Eben Anthonissen	073 163 4665	-2 577	-3 020 041	1 073	0.05	Unknown	Unknown	Unknown	Unknown	Agricultural	On Perth at UMK office
P5	Eben Anthonissen	073 163 4665	-902	-3 018 216	1 087	0.3	Unknown	Unknown	Unknown	Unknown	Agricultural	On Perth, no access for dip meter.
P6	Eben Anthonissen	073 163 4665	-1 845	-3 019 607	1 080	0.5	37.20	36.70	1 043.30	72	Not in use	On Perth
P8	Eben Anthonissen	073 163 4665	2 077	-3 014 193	1 083	0.4	15.00	14.60	1 068.40	Unknown	Domestic	Supplies water to the farm supply store
P1	Eben Anthonissen	073 163 4665	2 206	-3 014 904	1 110	0.3	25.00	24.70	1 085.30	Unknown	Agricultural	Pumped close to time of measurement
P2	Eben Anthonissen	073 163 4665	2 154	-3 014 959	1 110	0.32	25.20	24.88	1 085.12	Unknown	Agricultural	Pumped close to time of measurement.
P3	Eben Anthonissen	073 163 4665	-55	-3 015 830	1 094	0	18.20	18.20	1 075.80	Unknown	Agricultural	On Perth
P4	Eben Anthonissen	073 163 4665	-327	-3 015 258	1 090	0.1	21.30	21.20	1 068.80	Unknown	Agricultural	On Perth
SB01	Sebilo	011 782 4322	-4 073	-3 019 568	1 062	0.42	26.70	26.28	1 035.72	50	Monitoring	Newly drilled monitoring borehole
SB02	Sebilo	011 782 4322	-4 147	-3 020 048	1 066	-	27.00	27.00	1 039.00	42	Monitoring	Drilled into underground mine
SB03	Sebilo	011 782 4322	-4 683	-3 019 248	1 055	0.30	24.65	24.35	1 030 65	101	Monitoring	Newly drilled monitoring borehole
SB04	Sebilo	011 782 4322	-4 620	-3 019 162	1 055	0.35	31.62	31.27	1 023.73	50	Monitoring	Newly drilled monitoring borehole
SB05	Sebilo	011 782 4322	-4 747	-3 018 894	1 062	-	Dry	Dry	Dry	50	Monitoring	Newly drilled monitoring borehole

All coordinates in WGS84 datum, LO23 projection
mamsl = metres above mean sea level
magl = metres above ground level
mbc = metres below collar
mbgl = metres below ground level

Table 22 Groundwater chemical analysis: Hydrocensus and new monitoring boreholes (2012 data)

Element	Units	SABS 241 guideline		P1&2	P3 & 4	P5	P6	P7	PD	PS1	UMK14	PK 01	SB01	SB02	SB03	SB04	SB05	Perth Pit
		Class I	Class II															
Date				24/03/12	24/03/12	24/03/12	24/03/12	24/03/12	24/03/12	21/03/12	26/03/12	19/04/12	18/04/12	18/04/12	18/04/12	18/04/12	19/04/12	01/02/12
pH		5-9.5	<4 and >10	8.1	7.46	7.3	7.6	7.92	8	7.4	7.78	8.37	7.43	7.41	7.45	7.54	7.49	7.9
EC	mS/m	<150	>150-370	97.2	191.4	328.8	142.1	244.1	202.8	339.1	149.2	113.4	195.3	1176	262.5	205.8	268.8	1 050
TDS	mg/L	<1000	>1000-2400	466	1100	2533	767	1520	1172	2215	727	947	998	6773	1447	1102	1348	9 026
T Alkalinity	mg/L	NS	NS	267.7	235.5	192.1	284.7	75.8	256.9	201.8	237.7	239	261.9	29.5	218.5	276	208.4	104
Chloride	mg/L	<200	>200 – 600	67.5	436.2	1330.7	230.6	646.5	388.4	833.9	204.2	359.5	267.7	3500	557.5	351.8	452.4	2 311
Sulphate	mg/L	<400	>400 -600	19.2	45.87	152.19	24.9	174.75	91.13	79.15	22.51	55.34	71.95	437.63	72.43	75.74	68.13	350
Nitrate	mg/L	<10	>10 – 20	33.099	64.59	82.573	41.665	72.947	84.756	283.54	67.556	61.642	118.60	592.63	157.46	97.381	193.34	547
Ammonium	mg/L	NS	NS	0.265	0.172	0.469	<0.015	<0.015	<0.015	0.102	<0.015	0.146	0.145	0.75	0.125	0.099	0.298	-
Phosphate	mg/L	NS	NS	<0.025	<0.025	0.029	<0.025	<0.025	<0.025	<0.025	0.046	0.221	0.133	0.133	0.103	0.14	0.127	-
Fluoride	mg/L	<1.0	1 – 1.5	0.511	0.278	0.255	0.211	<0.183	0.337	0.364	0.36	0.44	0.425	2.117	0.733	0.496	0.864	0.2
Calcium	mg/L	<150	>150-300	87.789	197.82	459.96	144.67	206.11	163.27	480.01	113.5	155.54	197.03	844.69	207.52	183.84	266.63	793
Magnesium	mg/L	<70	>70-100	61.11	109.16	251.04	77.15	93.921	137.67	299.71	93.406	101.60	114.05	910.72	173.38	124.83	153.66	716
Sodium	mg/L	<200	>200-400	34.51	102.15	136.27	74.99	276.61	144.13	108.02	76.77	67.26	66.23	450.47	141.19	96.54	82	402
Potassium	mg/L	<50	>50-100	2.322	3.282	5.017	2.544	3.688	8.752	9.577	6.155	2.844	4.834	19.481	6.693	5.96	6.462	-
Aluminium	mg/L	<0.3	>0.3-0.5	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.026	0.012	<0.006	<0.006	0.015	<0.006	0.176
Iron	mg/L	<0.2	>0.2-2	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.024	0.03	0.086	0.073	0.014	0.012	<0.025
Manganese	mg/L	<0.1	>0.1-1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.752	0.499	1.618	2.926	0.376	0.23	0.025
Chromium	mg/L	<0.1	>0.1-0.5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.025
Copper	mg/L	<1	>1-2	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.148	<0.001	0.008	0.005	<0.025
Nickel	mg/L	<0.15	>0.15-0.35	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.036	<0.003	<0.003	<0.003	<0.025
Zinc	mg/L	<5	>5-10	0.024	0.074	1.038	0.034	0.211	0.027	<0.004	0.04	2.275	2.028	6.721	1.95	2.616	1.537	0.207
Cobalt	mg/L	<0.5	>0.5-1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.025
Cadmium	mg/L	<0.005	>0.005 – 0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005
Silver	mg/L	NS	NS	<0.002	0.002	0.005	<0.002	0.002	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	0.002	-
Gallium	mg/L	NS	NS	0.006	0.006	0.012	0.007	0.007	0.007	0.015	0.006	0.008	0.008	0.061	0.007	0.006	0.007	-
Boron	mg/L	NS	NS	0.173	0.378	0.443	0.248	1.871	0.579	0.337	0.766	0.256	0.329	5.894	1.95	0.873	0.361	5.11
Barium	mg/L	NS	NS	0.121	0.228	0.14	0.185	0.067	0.1	0.228	0.032	0.185	0.073	0.03	0.068	0.06	0.175	0.039
Beryllium	mg/L	NS	NS	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Bismuth	mg/L	NS	NS	0.02	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Tellurium	mg/L	NS	NS	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	<0.023	-
Lithium	mg/L	NS	NS	0.003	0.01	0.011	0.006	0.017	0.016	0.014	0.011	0.006	0.009	0.037	0.023	0.015	0.009	-
Molybdenum	mg/L	NS	NS	0.039	0.039	0.073	0.038	0.052	0.039	0.074	0.038	0.013	0.013	0.104	0.014	0.016	0.014	<.0025
Lead	mg/L	<0.02	>0.02-0.5	<0.001	0.002	0.041	<0.001	<0.001	<0.001	0.037	<0.001	<0.001	<0.001	0.017	<0.001	0.001	<0.001	<0.020

Element	Units	SABS 241 guideline		P1&2	P3 & 4	P5	P6	P7	PD	PS1	UMK14	PK 01	SB01	SB02	SB03	SB04	SB05	Perth Pit
		Class I	Class II															
Rubidium	mg/L	NS	NS	0.092	0.085	0.184	0.091	0.088	0.084	0.205	0.05	0.096	0.136	1.102	0.071	0.085	0.084	-
Silica	mg/L	NS	NS	33.544	25.662	23.371	25.853	15.633	17.155	26.502	14.448	20.288	19.384	13.714	14.881	15.378	16.754	-
Strontium	mg/L	NS	NS	0.6	1.12	2.064	0.715	1.248	1.457	2.971	0.785	0.712	1.132	2.974	1.226	1.205	1.512	2.23
Vanadium	mg/L	<0.2	>0.2-0.5	<0.087	0.004	<0.003	0.006	0.003	0.015	0.004	0.008	0.003	0.007	<0.003	<0.003	0.005	0.005	<0.025
Thallium	mg/L	NS	NS	471	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	-
T Hardness	mg/L	NS	NS	264.5	943	2182	679	901	975	2433	668	807	962	5860	1232	973	1299	4 966
Bi-carbonate	mg/L	NS	NS	8.1	234.8	191.8	283.7	75.2	254.4	201.3	236.3							-

Legend:	
<Class II	
> Class II	

1.1.8.3 Groundwater use and aquifer classification

Groundwater forms the sole source of water supply to the local landowners for both domestic use and agricultural (stock watering) purposes. No measured water use volumes are available. Using standard minimum use volumes of 25 l per person per day for domestic use, it is calculated that less than 100m^3 of water is used per day for domestic use.

Agricultural water use from the 12 agricultural use boreholes is estimated at 120 m^3/day (10 m^3/day from each borehole).

Mine water use at Amari from borehole PK is unknown.

Following the Parsons Classification system the aquifers in the area is classified as a **minor** aquifer based on the low yields from the aquifer. However, the aquifers are of **high importance** to the local landowners due to the fact that it forms the sole source of water supply.

1.1.8.4 Groundwater quality

A total of fourteen groundwater quality samples were collected as part of this study. Nine were collected during the hydrocensus and another five during the drilling and aquifer testing of the five new monitoring boreholes (please refer to Table 21). In addition to this, reference is made to previous groundwater studies and groundwater monitoring in the area (please refer to Appendix 5). This includes National Groundwater Data Base (NGDB) data from sampling runs stretching back to 1970 which is quite some time ago and there are some doubts regarding the relevance of the results. However, the water sample taken at Black Rock during October 2010 compares well with the other samples in terms of the groundwater character and element concentrations. The values from the NGDB database used in this report will be compared to the analysis results for the current groundwater study in the final EIA report.

The results from the NGDB sampling are summarised in Appendix 5. The results are compared to the SANS 241:2006 water quality guidelines for domestic use (Class I and Class II). Class I values represent the recommended operational limit whilst Class II represents the maximum allowable levels for a limited duration. All elements that are expected to exceed the guideline ranges are highlighted.

From Appendix 5 it can be seen that the regional groundwater quality in general is relatively poor with almost all samples having elements within Class II and exceeding Class II, with the exception of samples Hotazel, England and the Telele, taken during May 1976. The main elements that show elevated concentrations include chloride, nitrate, calcium, magnesium and sodium.

The chemical analysis results obtained during the current Future Flow study are presented in Table 22. Samples P1-2 and P3-4 represent the combined groundwater quality from boreholes P1 and P2, and P3 and P4 respectively. The boreholes are equipped with wind pumps and piping which do not allow direct collection of groundwater samples from the individual boreholes. Therefore, water samples were collected from the two holding dams in which groundwater from the two pairs of boreholes is stored.

The groundwater samples taken from the new monitoring boreholes (samples SB01 to SB05) that were drilled around the existing pit and into the extended ore body, show a notable difference from all the other boreholes in that they uniformly show elevated manganese concentrations. These concentrations are associated with leaching from the ore body, and possibly the pit water. It should be taken into consideration that the static leach testing that was done (please refer to Section 1.1.8.6) show that manganese can be expected to be present in elevated concentrations in the post-mining environment.

Borehole SB02 was drilled into the existing underground mine. The water sample was taken therefore taken directly from the old underground workings. It is considered that the SB02 water quality and character provides an indication of the expected long-term groundwater quality and character after the Sebilo Perth operations has stopped.

All the collected samples show elevated chloride, calcium, nitrate and magnesium concentrations. Inspection of the data indicates an increase in element concentrations between the data from the DWA NGDB (1970's) and the current groundwater quality (Future Flow, 2012). Because there is no time series data available between the 1970's and the present it is not possible to determine whether the change in element concentrations were gradual, or whether the current increased element concentrations are due to short term seasonal changes (yearly fluctuations in rainfall etc). Additional groundwater quality comparisons are presented in Appendix 5.

The Piper Diagrams in Figures 19 and 20 illustrate the character of the water samples included in the DWA NGDB and the 2012 Future Flow samples. From the Piper Diagram, the chemical character of water, in relation to its environment, can be observed and changes in the quality interpreted. Different waters from different environments always plot in diagnostic areas or "hydrochemical facies". The upper half of the diamond normally contains water of static and disordinate environments, while the middle area normally indicates an area of dissolution and mixing. The lower triangle of this diamond shape indicates an area of dynamic and co-ordinated environments. Sodium chloride brines normally plot in the right hand corner of the diamond shape while recently recharged water plots on the left-hand corner of the diamond plot. The top corner normally indicates water contaminated with gypsum (SO_4^{2-} mine impact). Additional information on Piper Diagrams are contained in Appendix 5.

The Piper Diagrams show that in general the groundwater quality plot within the upper half of the diamond indicating static water. This correlates to the general site conditions, which include:

- The generally low transmissivity of the aquifers leading to slow groundwater migration through the area;
- The low topographical gradients contribution to slow groundwater flow velocities; and
- The low rainfall in the area leading to little recharge of fresh water to the groundwater systems.

From Figure 19 it can be seen that DWA NGDB Samples Telele 76/05/13 and Hotazel show some anomalous qualities. However, comparing the Telele 76.05.13 quality to the other six Telele samples indicate that the sample taken on 13 May 1976 might have been subject to erroneous laboratory analysis or sampling methodology.

Figure 20 shows that groundwater from the recently drilled boreholes plot in the upper half of the diamond. The combined P1 and P2 sample show a slightly less evolved character than the rest. The chemical character of the 2012 Future Flow groundwater samples can be summarised:

- Combined Sample P1 & P2: magnesium / bi-carbonate dominant;
- Combined Sample P3 & P4: calcium / chloride dominant;
- Sample P5: calcium / chloride dominant;
- Sample P6: calcium / chloride dominant;
- Sample P7: sodium / chloride dominant;
- Sample PD: magnesium / chloride dominant;
- Sample PS1: magnesium / chloride dominant;

- Sample UMK14: magnesium / chloride dominant;
- PK01: magnesium / chloride dominant;
- SB01: calcium / chloride dominant;
- SB02: magnesium / chloride dominant;
- SB03: magnesium / chloride dominant;
- SB04: magnesium / chloride dominant; and
- SB05: calcium / chloride dominant.

It should be noted that borehole P6, which has been reported by the local landowner to have a very poor taste, show a notably different cation character than the rest of the samples taken by Future Flow during 2012. The Piper diagram clearly show a more balanced contribution from all cations, with an increased contribution from sodium and potassium to the chemical balance. However, the sample still shows a chloride dominant character, which is the same as samples P3&P4, P5, and P7.

The groundwater quality is compared to the Perth Pit water sample in Figure 20. The surface water quality as analysed by a SANAS accredited laboratory was supplied by the client.

Results show that the pit was character is magnesium chloride dominant, which is comparable to a number of groundwater samples, including samples PD, PS1, UMK14, SB02, SB03, and SB04. All element concentrations are elevated compared to the SANS241 guidelines in the pit water, and in general compares to the element concentrations measured in the groundwater samples. The increased element concentration is most probably attributable to the effect of the high net evaporation in the area causing high losses of water from the pit, thereby increasing the element concentration in the remaining water.

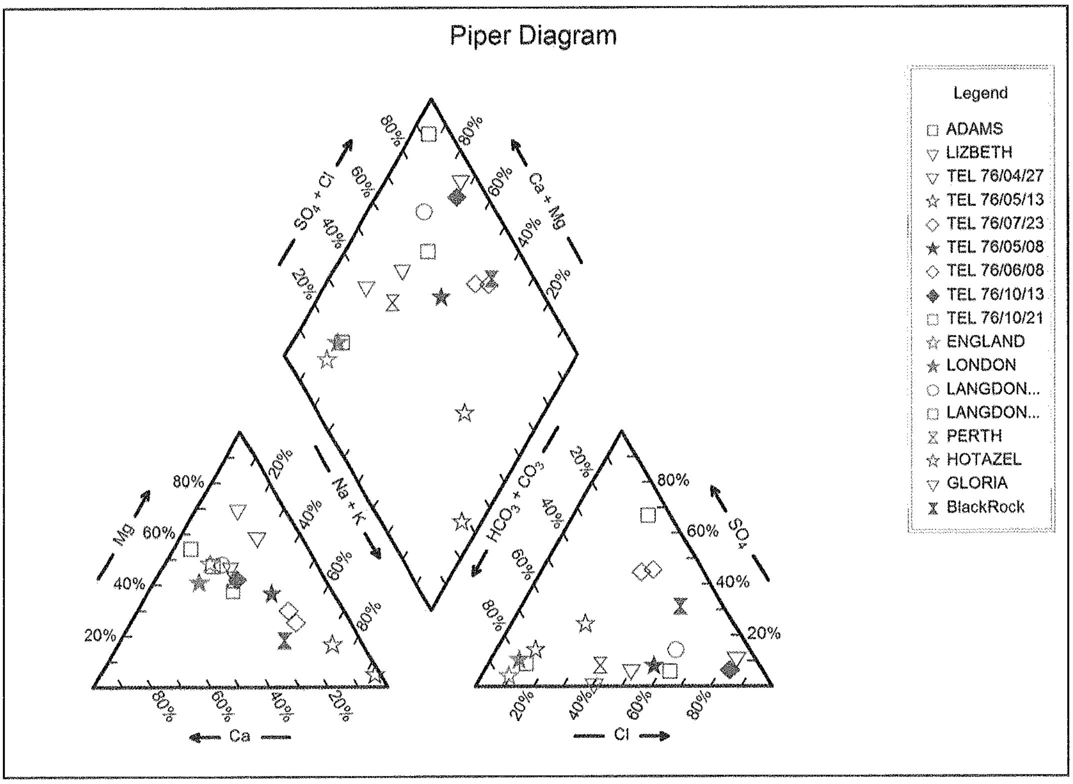


Figure 19 Piper Diagram: DWA NGDB borehole data

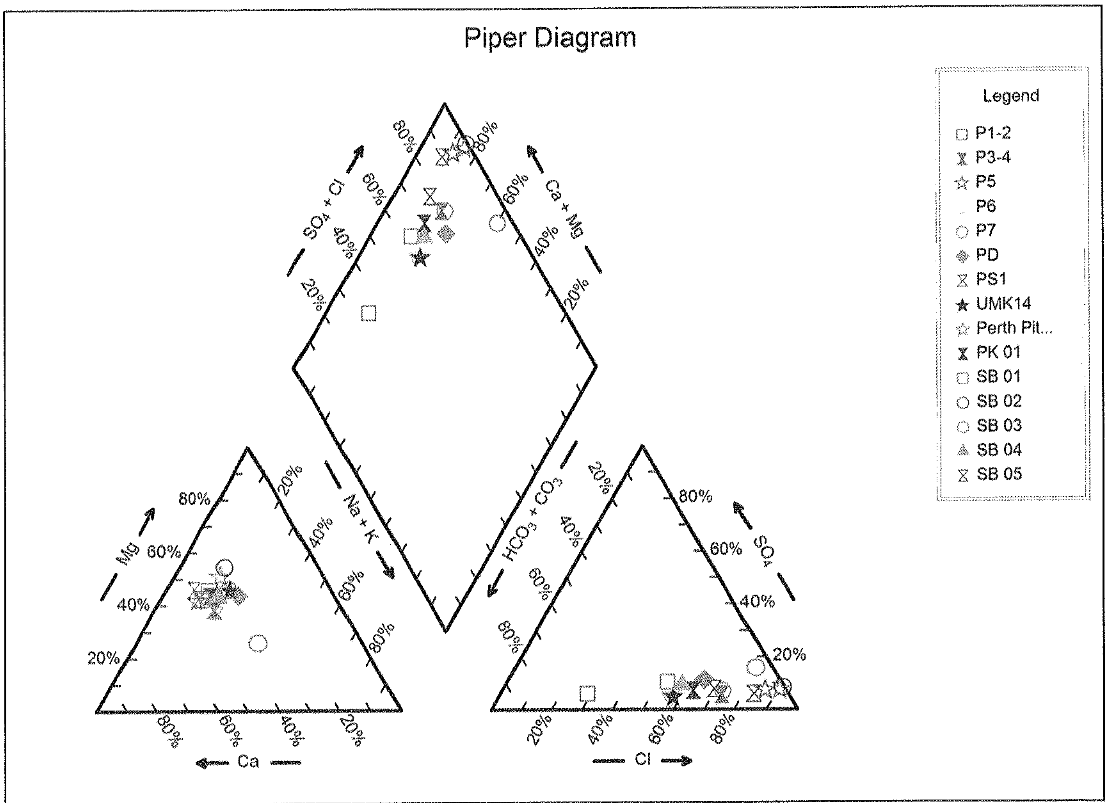


Figure 20 Piper Diagram: Future Flow 2012 study

1.1.8.5 Aquifer transmissivity and storativity

Aquifer testing was performed on three of the five new monitoring boreholes that were drilled around the proposed mining area. The results of the data interpretation are summarised in Table 23. The transmissivity of the overlying quaternary sand have not been tested in this or other studies through normal pump testing due to the sands being dry outside of rainfall events and therefore not acting as a notable aquifer in the area during the majority of the year. In addition, no falling head tests have been performed on the sands. For the purpose of this study it is assumed that the transmissivity of these sands are between 1 and 5 m^2/day.

From Table 23 it can be seen that the aquifer transmissivity of the fractured rock material ranges between 0.25 and 0.7 m^2/day. It has to be noted that these boreholes targeted geological structures that could act as potential groundwater flow pathways, and the transmissivity of these boreholes are considered to be higher than the average transmissivity of the general competent, fractured, host rock. The general aquifer transmissivity of the un-fractured host rock is considered to be less than 0.1 m^2/day. This is confirmed by the very low transmissivity seen in borehole P5, which yielded extremely little water. At 72 hours after completion of the drilling only 2 to 3 m of water had accumulated in the borehole.

The aquifer hydraulic conductivities can be calculated from the obtained data using the equation:

T = k x d
Where:
T = aquifer transmissivity (as calculated from the aquifer test results);
k = aquifer hydraulic conductivity; and
d = saturated thickness of the aquifer (which of the purpose of this calculation is assumed to be the depth of the borehole minus the depth to groundwater level in that borehole).

As seen from Table 23 the hydraulic conductivities of the fractured rock aquifer are calculated to range around 0.012 and 0.021 m/day. This means that groundwater migrate at a rate of between 0.012 and 0.021 m/day through the aquifers. These are very low numbers are not conducive to large flow volumes through the area.

Aquifer storativity of the rock material is estimated from the aquifer test results. It should be noted that the obtained values are likely to be inaccurate due to the fact that they were calculated from single borehole tests. Ideally storativity of an aquifer is calculated from the groundwater level response to pumping measured in a borehole some distance away from the borehole being pumped. Calculating the storativity from the data collected in the borehole being pumped leads to uncertainty in the obtained results. Unfortunately, there were no boreholes close to each other that could be used as monitoring boreholes during the aquifer tests. The calculated aquifer storativity values range between 1.18E-10 and 2.18E-9, which are very.

Table 23 Aquifer test results

Parameter	Unit	P1	P2	P3	P4	P5
Borehole depth	m	50	42	101	50	50
Water strike	mbgl	None	42 (U/G mine)	82	50	Dry
Static water level	mbgl	26.28	27.00	24.35	31.27	-
Pumping rate	L/s	0.2	No test – Borehole drilled into underground mine	0.5	0.2	No test – borehole is dry
Transmissivity	m^2/day					
Theis		0.25		0.60	0.28	
Cooper-Jacob		0.31		0.67	0.33	
Recovery		0.02		0.33	0.12	
Average transmissivity		0.28		0.53	0.24	
Aquifer hydraulic conductivity	m/day	0.012		0.021	0.013	
Storage capacity (estimate)	-	1.74E-10		2.18E-9	1.18E-10	

m = metre
mbgl = metres below ground level
L/s = litres per second
m^2/day = metres squared per day
m/day = metres per day

1.1.8.6 Acid-base accounting and static leach testing results

1.1.8.6.1 Acid-base accounting

Many South African mines are associated with acid mine drainage conditions developing due to sulphide minerals such as pyrite being present in the host rock or mined ore body. Sulphide minerals are geochemically inherently unstable and will, in the presence of oxygen, spontaneously begin to oxidise to produce undesirable effects such as a low pH, high sulphate concentrations, and significant increases in heavy metals and radionuclide contents. The acidic water produced by pyrite oxidation can be neutralised when it comes into contact with base minerals such as carbonates, hydroxides, oxides and silicates. The potential of the ore and mine waste material to produce acid and the subsequent buffering capacity is referred to as the Acid Base Potential. Acid Base Accounting (ABA) provides an average of this process over a period of time, during which either acidic or alkaline conditions can dominate.

ABA involves a combined measurement of sulphur contents (total sulphur, sulphuric acid, sulphur, and organic sulphur), neutralisation capacity (NP), paste pH and the calculation of acid potential (AP), net neutralisation potential (NNP) and NP/AP ratio (NPR). The assessment obtained by ABA techniques needs to be refined and calibrated with detailed mineralogical characterisation, site-specific observation and kinetic testing. This assessment should be complimented by geochemical modelling in order to increase the reliability of the ARD prediction study.

In this study, ABA tests have been performed by iLEH on two samples as detailed in Table 24. Samples were collected from waste and ore material.

Table 24 ABA test results

Acid-Base-Accounting (Modified Sobek (EPA-600)	Waste	Ore
Paste pH	7.7	8.0
Total Sulphur % (LECO)	<0.01	<0.01
Acid Potential (AP) (kg/t)	0.313	0.313
Neutralising Potential (NP)	158	143
Net Neutralising Potential (NNP)	158	143
Neutralising potential ratio (NPR) (NP:AP)	507	459
Rock Type	III	III

As shown by Robertson & Broughton (1992) it can be noted that:

- NNP - Greater than 20 kg $CaCO_3$/tonne are considered "safe";
- NNP - Less than -20 kg $CaCO_3$/tonne is potentially acidic drainage;
- NNP - -20 to 20 kg $CaCO_3$/tonne is a grey area and prediction is difficult.
- NPR – Less than 1 kg $CaCO_3$/tonne is potentially acid producing;
- NPR – 1 to 3 is a grey area and prediction is difficult;
- NPR – Greater than 3 is potentially acid neutralising

Table 25 AMD screening criteria

	NAG pH	NPR	ARD Potential	Comment
Sulphide-S <0.3%	>5.5	-	None	No further ARD testing required provided there are no other metal leaching concerns. Exceptions: host rock with no basic minerals, sulphide minerals that are weakly acid soluble.
Sulphide-S >0.3%	<5.5	<1	Likely	Likely to be ARD generating
		1-2	Possibly	Possibly ARD generating if NP is insufficiently reactive or is depleted at a rate faster than that of sulphides
		2-4	Low	Not potentially ARD generating unless significant preferential exposure of sulphides occurs along fractures or extremely reactive sulphides are present together with insufficiently reactive NP
		>4	None	No further ARD testing required unless materials are to be used as a source of alkalinity.

The results of the ABA test results in Table 24, compares as follows to the screening criteria:

- NNP: The NNP of samples "Waste" and "Ore" exceed 20 kg $CaCO_3$/tonne and can be considered safe;
- NPR: The NPR of the samples far exceeds the neutralising guideline of 3 and ranges between 450 and 510. Based on this the material can be classified as acid neutralising;
- Sulphide S and NAG pH: The Sulphide-S ratio for both samples is less than 0.01, while the final NAG pH is measured at between 7.7 and 8.0. Based on Price's guidelines no further ARD testing is required provided there are no metal leaching concerns.

It can be seen that the sulphide percentages in both samples fall below 0.3 %. Several factors calculated in ABA by Soregaroli and Lawrence (1998) indicated that for sustainable long-term acid generation, at least 0.3% sulphide-S is needed. Values lower than 0.3% can yield acidity but it is only of short-term significance.

From the above, it is concluded that it is unlikely that the material will be acid forming. Should some acid conditions form, it will be buffered and neutralised by the high neutralising capacity of the rock material. In addition, any such acid conditions that form will only be sustainable in the short term due to the very low Sulphur-S percentages.

1.1.8.6.2 Static leach testing

Static leach testing done on the two samples taken by iLEH shows that in general there is no concern around the element leach concentrations, as shown in Table 26. The measured element concentrations are compared to the SANS 241:2006 water quality guidelines for domestic use. Both Class I and Class II values are specified. Class I values represent the recommended operational limit whilst Class II represents the maximum allowable levels for a limited duration. All elements that are expected to exceed the guideline ranges are highlighted.

Cadmium, Mercury, and Manganese do indicate some elevated concentrations. However, cadmium and mercury is reported at the limit of the detection capability of the analysis method. Therefore, there is uncertainty around the actual concentration values for these two elements and whether they do in fact exceed the Class II guideline values.

Manganese is the only element where it can be said with certainty that the leach concentrations are expected to exceed domestic use guidelines. This is expected due to the natural elevated manganese concentrations in the area associated with the ore body.

Table 26 Static leach test results

Element	Units	SABS241		Waste	Ore
		Class I	Class II		
Total Dissolved Solids at 180°C	mg/L	<1 000	1 000 – 2 400	168	184
Alkalinity as $CaCO_3$	mg/L	NS	NS	384	328
Total Acidity as $CaCO_3$	mg/L	NS	NS	10	10
Total Hardness as $CaCO_3$	mg/L	NS	NS	412	347
Bicarbonate as HCO_3	mg/L	NS	NS	468	400
Nitrate as N	mg/L	<10	10 – 20	0.2	1
Chloride as Cl	mg/L	<200	200 – 600	<5	<5
Sulphate as SO_4	mg/L	<400	400 -600	<5	<5
Fluoride as F	mg/L	<1	1 – 1.5	<0.2	<0.2
Sodium as Na	mg/L	<200	200-400	<2	<2
Calcium as Ca	mg/L	<150	150-300	144	129
Magnesium as Mg	mg/L	<70	70-100	13	6
Ammonia as N	mg/L	<1	1 – 2	0.5	0.2
Aluminium as Al	mg/L	<0.3	0.3 – 0.5	<0.1	<0.1
Barium as Ba	mg/L	NS	NS	<0.025	<0.025
Boron as B	mg/L	NS	NS	<0.025	0.08
Cadmium as Cd	mg/L	<0.005	0.005 – 0.01	<0.5	<0.5
Total Chromium as Cr	mg/L	<0.1	0.1 - 0.5	<0.025	<0.025
Cobalt as Co	mg/L	<0.5	0.5 – 1	<0.025	<0.025
Copper as Cu	mg/L	<1	1 – 2	<0.025	<0.025
Iron as Fe	mg/L	<0.2	0.2 – 2	<0.025	0.044
Mercury as Hg	mg/L	<0.001	0.001 – 0.005	<0.01	<0.01
Lead as Pb	mg/L	<0.02	0.02 – 0.05	0.02	0.02
Manganese as Mn	mg/L	<0.1	0.1 – 1	0.515	5.69
Molybdenum as Mo	mg/L	NS	NS	<0.025	<0.025
Nickel as Ni	mg/L	<0.15	0.15 – 0.35	<0.025	<0.025
Selenium as Se	mg/L	<0.02	0.02 – 0.05	<0.02	<0.02
Strontium as Sr	mg/L	NS	NS	0.147	0.126
Vanadium as V	mg/L	<0.2	0.2 – 0.5	<0.025	<0.025
Zinc as Zn	mg/L	<5	5 - 10	<0.025	<0.025

Uncertain whether the actual concentrations exceed SANS guidelines
Exceed Class I guideline value
Exceed Class II guideline value

1.1.8.7 Conceptual model

1.1.8.7.1 Groundwater flow

The baseline data was analysed and compiled into a conceptual model, which is summarised below. There are three aquifers present in the area, associated with a) the upper sandy gravel material, b) the fractured rock material, and c). the dolomitic material

The upper **sandy gravel material aquifer** can be considered to be present throughout the whole of the study area. The aquifer is heavily dependent on rainfall and therefore yields from the aquifer vary seasonally. However, it has to be cautioned that drilling results show this aquifer to be dry in large portions of the study area. It is considered that this aquifer is seasonal and mostly carries water only during and shortly after rainfall events when rainfall recharges into the material. The relatively high transmissivity of the sandy gravel material allows the recharging water to migrate quickly through and out of the material. This combined with the high positive evaporation rates in the area lays the material dry for large portions of the year.

Drilling results from previous projects in the area have shown that the flat-pebble conglomerate (potsherd marker) that forms part of the **fractured rock aquifer** and is intercepted in the Danielskuil Formation is the only water-bearing zone in the fractured rock aquifer area. Groundwater flows in the fractured rock aquifer are associated with the secondary fracturing in the competent rock that was formed by the major N-S striking faulting seen from the hydrogeological maps and confirmed by the ground geophysical survey (please refer Appendix 5). As such groundwater flows and contaminant transport will be along discrete pathways associated with the fractures. The general transmissivity of the competent rock material is considered to be around 0.1 m^2/day or less.

Aquifer testing performed on the newly drilled boreholes (SB01 to SB05) show that the transmissivity of individual fractures range between 0.25 and 0.7 m^2/day. Drilling results show that aquifer strikes can occur down to 80 m in this area. Using the borehole depths and the aquifer transmissivities the hydraulic conductivity of the non-fractured, competent material is calculated to be around 0.001 m/day, and that of the individual fractures up to 0.021 m/day.

The **dolomitic karst aquifer** in the region is well known for its high potential (Van Dyk and Jones, 2006). A number of springs have been mapped in the area (van Dyk & Jones, 2006) of which the Kuruman, Klein Karoo, and Manyeding are perennial. Smit (1978) and Wiegmans (2006) defined compartments within the dolomite in separate groundwater management units. The project area falls within the D41K groundwater management area. Wiegmans (2006) also calculated recharge to each of the compartments and the associated management criteria in terms of sustainable abstraction volumes.

Inspection of exploration drilling core on neighbouring farms show that the dolomite in the vicinity of the proposed Perth mine appears to be competent with no indication of weathering or karstification. Karstic dolomite is highly variable in competence and transmissivity over short distances and this is no guarantee that karstic dolomite won't be found on site, however, based on the general constant high competence and total absence of indications of karstic dolomite it can be concluded that the likelihood of intercepting karstic dolomite is very low.

Groundwater levels recorded during the hydrocensus show relatively homogenous depths to groundwater level in the fractured rock aquifer ranging between 14.60 and 36.70 mbgl, with an average of 28 mbgl. Around the current Pert Pit area boreholes SB01, SB03 and SB04 show that the depth to groundwater level is around 27.5 m.

Considering the average depths to groundwater level, it is concluded that the water level in the historic Perth Pit is equivalent to the surrounding, and regional, groundwater levels and the system is in equilibrium. Based on this, and the high net evaporation from the area, it can be concluded that there is a net inflow into the pit, and the pit does not recharge into the surrounding aquifers.

Groundwater flow directions are directed from the east towards the low-lying areas in the west associated with the Witleegte stream channel. Calculations show that the groundwater gradient in study area ranges between 1:100 and 1:300.

Based on to the depth of the groundwater level near the Witleegte stream (measured to be 24.35 mbgl in borehole SB03, which is located very close to the stream channel), it is considered that the regional fractured rock aquifer do not contribute to the stream flows. During and directly after rainfall events when there is active recharge to the upper sandy gravel aquifer it is possible that there could be some baseflow contribution to the stream from the aquifer. However, it is considered that the Witleegte is a losing stream. Due to the very low aquifer transmissivity as calculated from the aquifer test data, river losses to the fractured rock aquifer are considered to be very low.

As mentioned, rainfall recharges into the aquifers. Long-term rainfall data show an average rainfall figure of 334 mm/a. Based on the coarse nature of the loose sandy gravel it is considered that gross recharge is in the order of 5 to 7 % of the mean annual rainfall effective recharge. Taking into consideration the evapotranspiration, field capacity etc. on gross recharge, the effective recharge is estimated at 1 to 3 % or mean annual rainfall.

Factors that could impact on groundwater flows in the catchment include:

- Drawdown of groundwater levels within and around the proposed mining developments;
- Dewatering of the historic mine areas;
- Recovery of groundwater levels when mining and the associated dewatering stop;
- Seepage from the overburden and discard stockpiles, as wells as ROM and product stockpiles where rainfall accumulates and artificially increase recharge to the underlying aquifers. Research done by Hodgson & Krantz (1998) show that recharge from such areas can be as high as 20% of the annual rainfall in comparison to 1 to 3 % for general areas;
- Seepage from the ultrafines empoundment area.
- Recharge into rehabilitated opencast areas where the recharge can be on average 8 % of the mean annual rainfall (Hodgson & Krantz, 1998). This will accelerate the rate of rise in the rehabilitated pit areas.

1.1.8.7.2 Contaminant transport

There are several potential sources of contamination to the aquifers from the proposed mining activities including accidental hydrocarbon and other spills from storage containers on site. For the purpose of this discussion it is assumed that good housekeeping such as storage of potentially hazardous material will be within properly constructed and lined or paved areas. Oil traps will be sized, operated and maintained to contain all discard oil from workshops and service areas etc. Surface infrastructure that could act as potential pollution sources include:

- Top soil stockpile;
- Waste dump;
- Ultrafines empoundment area;
- Product and ROM stockpiles;
- Pollution control dams; and
- Mined out or rehabilitated pit area;

The surface water management infrastructure (pollution control dams etc) will be sized to contain storm events. Therefore it is not expected that there will be any significant contamination from these surface points.

The opencast pit can act as a source of pollution to the surrounding aquifers through oxidation of the exposed lithologies. However, no AMD conditions are expected. Only manganese is expected to be present in elevated concentrations, exceeding SANS241:2006 guidelines for domestic use. This should be controlled against the elevated chloride, calcium, magnesium and nitrate concentrations measured in the regional groundwater and current Perth pit water samples that indicate the possibility of those elements also be present in high concentrations in the post-mining environment.

Groundwater seeping into the pit through the affected lithologies, or direct runoff on the pit walls over the lithologies, can lead to accumulation of the water in the mine area with elevated manganese and other concentrations. During the operational phase the groundwater flow directions will be directed towards the opencast pit and underground mine areas due to mine dewatering, thereby containing any contaminants that might form within the mining areas. The water pumped from the mined out area as part of the mine dewatering will be contained within surface water containment dams that will be sized to contain 1:50 flood events, and therefore it is not expected that there will be any significant contamination to the surrounding aquifers.

The opencast mine area will be continuous rehabilitated as mining progresses. The rehabilitation will entail backfilling, shaping, topsoiling, and re-vegetation of the mined out areas as mining progresses. The groundwater flows in the area will be impacted as follows:

- Recharge into the rehabilitated material can be assumed to be around 8 to 10 % of mean annual rainfall (Hodgson & Krantz 1998);
- There will be inflows into the pit from the surrounding aquifers. The inflow rate will depend to a large extend on the groundwater flow gradient between the surrounding aquifers and the water level in the rehabilitated material; and
- There will be little to no impact from evaporation on the rising water level in the rehabilitated material other than removal of shallow recharging water before it reaches the saturated zone.

The rising water level in the pit will allow the groundwater flow gradients to be re-directed to near pre-development directions. This will allow contaminated water to migrate away from site.

Acid mine drainage and leach testing results indicate that there is virtually no possibility of AMD conditions forming, and in the event that such conditions do form it will not be sustained in the long term. Leach testing results show manganese concentrations to be elevated in the post mining environment as can be expected from the ore body. Nitrate concentrations can also be elevated due to blasting during the mining operations. As mentioned above, it is recommended that the long term pit water quality be monitored for elements such as chloride, calcium and magnesium that from samples taken from regional boreholes and the current Perth pit are naturally present in elevated concentrations in the post-mining environment.

Water accumulating in the waste, fines, and topsoil storage facilities will artificially increase recharge into the underlying aquifers. As mentioned above work done by Hodgson & Krantz (1998) indicates that recharge in these areas can increase up to 20 % of the mean annual rainfall. This increased recharge will form a mounding in the groundwater levels underlying the infrastructure. The mounding in groundwater level will re-direct groundwater levels radially away from the stockpiles. Any poor quality seepage from the stockpiles will therefore migrate away from the stockpiles. Should these stockpiles fall within the zone of influence of the mine dewatering around the mining area it can be expected that contaminants will migrate towards the mining area from where it will be pumped into the water control infrastructure (PCD etc) where it will be managed.

1.1.9 Geology

The Kalahari Manganese Field is a compact (approximately 30 km by 15 km) deposit located in the Northern Cape Province of South Africa, which houses 70 % to 80 % of the world's high grade manganese resource. The Kalahari Manganese Field (KMF) has the shape of a tilted saucer with a sub-outcrop at approximately 45 m below surface in the east and more than 1000m in the west. The manganese deposits hosted in the Hotazel Formation at the top of the Griqualand West Sequence are vast, containing 13 billion tons of ore at a cut-off of 20 % (MDM Engineering, 2009).

The Hotazel Formation comprises of Banded Ironstone Formation inter-bedded with three manganese horizons termed the Upper, Middle and Lower Manganese Ore bodies. The lower body varies in thickness from 5 to 45 m in the area and constitutes the main ore body. The middle body is only 1 to 3 metres thick and is often considered uneconomic. The average thickness of the upper body is 5 meters but it can be as thick as 30 m. Of these, the lower 5 to 6 meters of the lower body normally represents the economic ore horizon (MDM Engineering, 2009).

The lower ore body is characterized by a braunite assemblage. This is referred to as Mamatwan-type ore and represents approximately 79 % of the total manganese resource in the field. The main contaminants in Mamatwan ore are calcium and magnesium carbonates. Whilst the average economically exploitable Mamatwan ores have a 35 % Mn content, sintering results in Mn values exceeding 44 %. Along the north-western margin of the field intense faulting, thrusting and associated hydrothermal activity enriched the ore through the removal of carbonates and silica. This ore type is known as Wessels Ore and has manganese content in excess of 40 %, but only constitutes approximately 21 % of the Kalahari Manganese Field (MDM Engineering, 2009).

The major rock types that occur in the study area include dolomite, limestone and chert of the Ghaap Group, Banded Iron Formation within the Griquatown West Sequence and shales and schists of the Ecca Group of the Karoo Supergroup, as shown in Figure 21. These rocks were deposited about 2200 – 2300 million years ago in an oceanic environment. The source of the iron and manganese is thought to have been submarine volcanic activity. Subsequently, during the formation of the Namaqua Metamorphic Province approximately 1000 – 1300 million years ago, the valuable high-grade ores formed as a result of hydrothermal reconstitution of the original low-grade sedimentary ores.

Approximately 12 km to the east of the proposed Sebilo Perth mine area the Makganyene (Vm) and Danielskuil (Vad) Formations outcrop. The Makganyene Formation comprises diamictite, banded jasper, siltstone, mudstone, sandstone, grit, and dolomite with chert. The Danielskuil Formation is represented by yellow-brown banded or massive jaspilite with crocidolite, flat-pebble conglomerate (potsherd marker) and an upper speckled marker.

The site geological map, inferred from the exploration borehole information by Sphinx Consulting, is presented in Figure 22. It is shown that the manganese-bearing ore is situated along the southwestern border of the mining right application area. The ore is hosted in the Banded Iron Formation (BIF). Dwyka Tillite is present in the northern section of the project area. The remainder of the area consists of Ongeluk Lava, as shown.

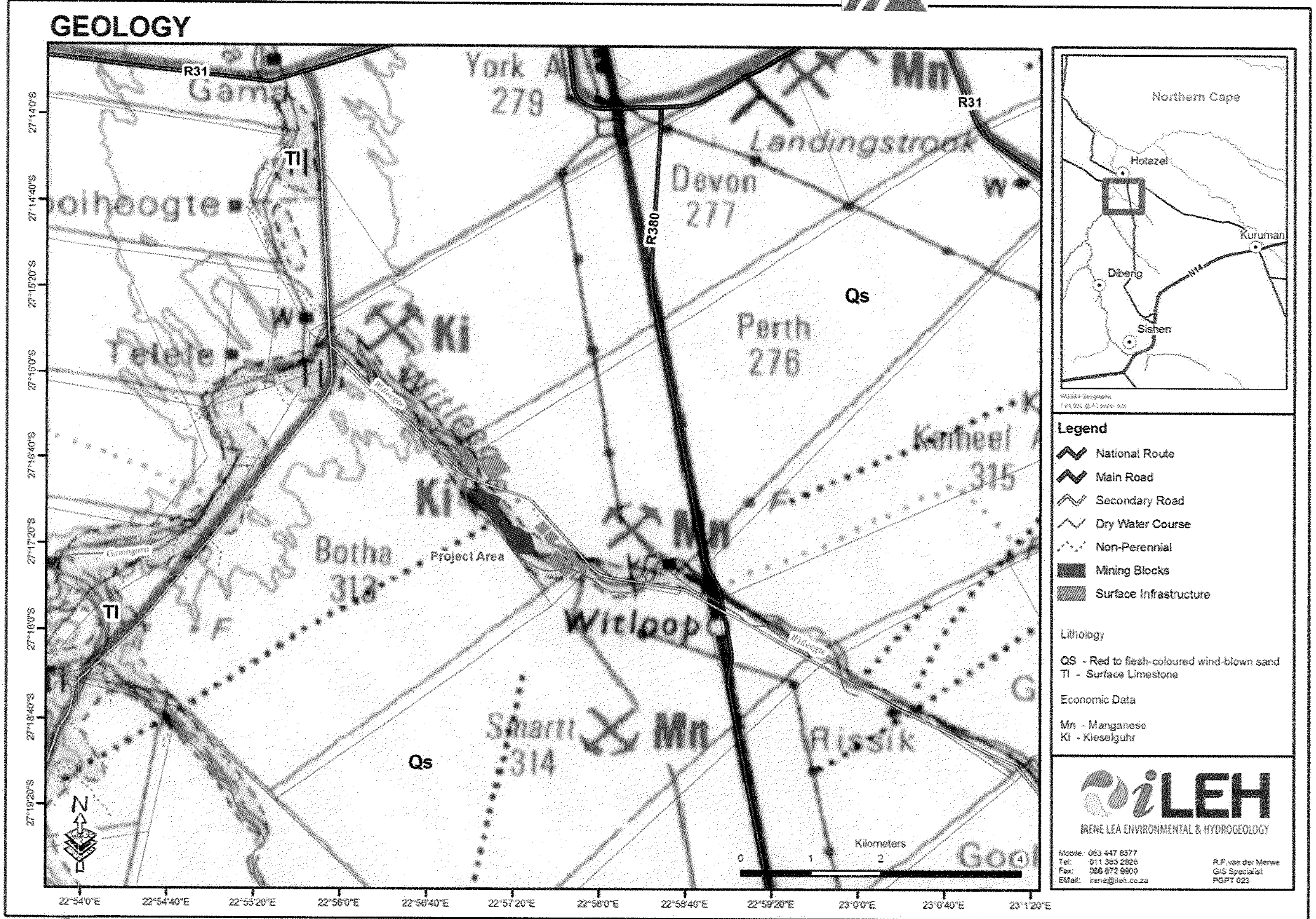


Figure 21 Local geology

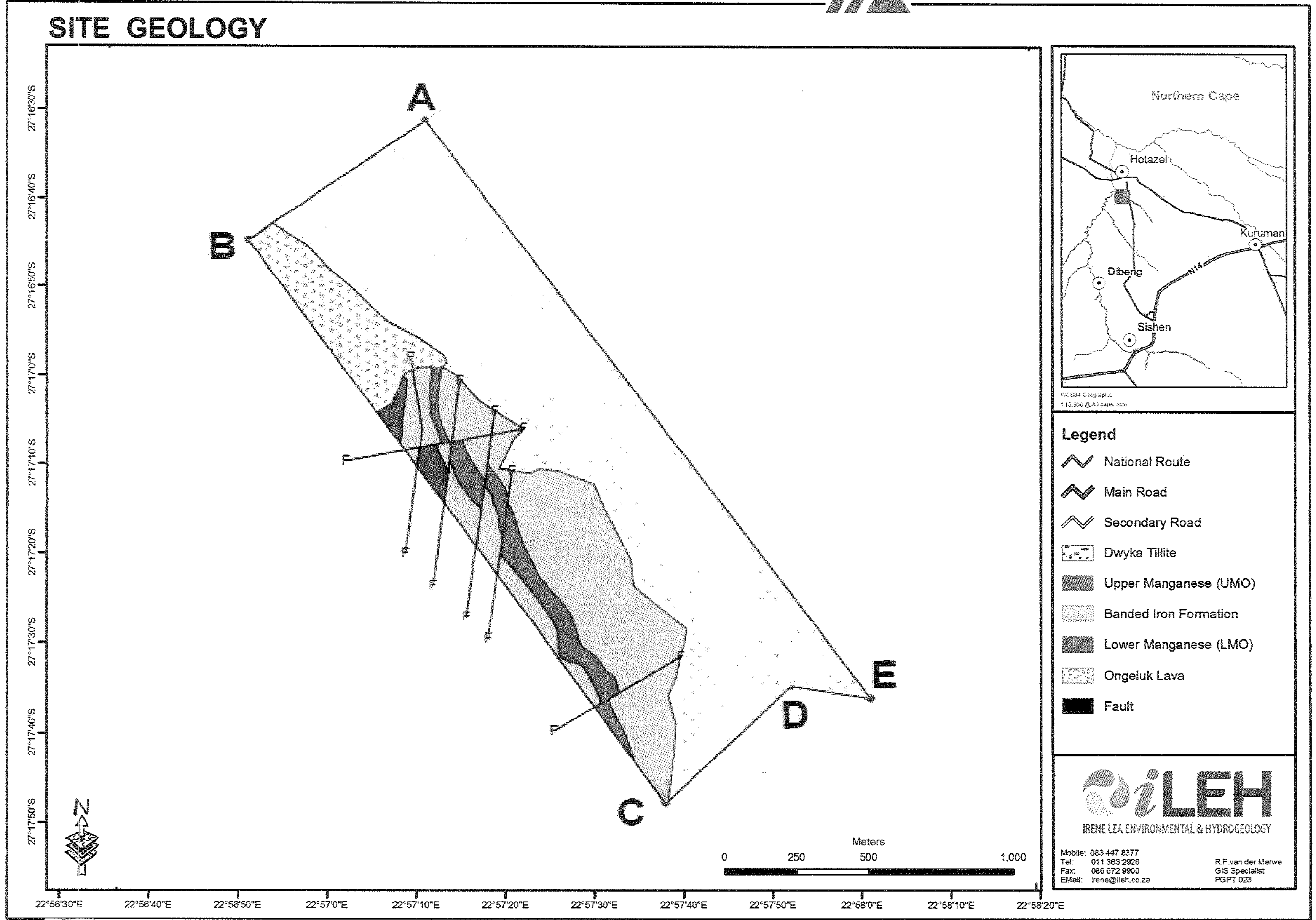


Figure 22 Site geology

1.1.10 Noise

The noise specialist study was undertaken by dBAcoustics (2012). The complete specialist report is contained in Appendix 6.

1.1.10.1 Types of noise exposure and noise level guidelines

- Continuous exposure to noise – The level is constant and does not vary with time e.g. traffic on freeway and an extractor fan;
- Intermittent exposure to noise – The noise level is not constant and occurs at times e.g. car alarms and sirens;
- Exposure to impact noise – A sharp burst of sound at intermittent intervals e.g. explosions and low frequency sound.

Depending upon the intensity of the sound, the length of time of exposure and how often over time the ear is exposed to it, noise affects humans differently. Urban dwellers are besieged by noise, not only in the city streets but also in the busy workplaces and household noises. The recommended sound pressure levels are detailed in Table 27 below.

Table 27 Recommended sound pressure levels

Descriptor	Limit	Situation or effect
LAeq, 24	70 dBA	Negligible risk of hearing impairment
LAeq, 8	75 dBA	Negligible
LAeq	30 dBA	Excellent speech intelligibility
LAeq	55 dBA	Fairly good speech intelligibility
LAeq	30 dBA	No sleep disturbance in a bedroom
LAmax	45 dBA	No sleep disturbance – peak inside bedroom
LAeq	55 dBA	Residential areas, outdoors, daytime
LAeq	45 dBA	Residential areas, outdoors, night time

The time-varying characteristics of environmental noise are described using statistical noise descriptors:

- Leq: The Leq is the constant sound level that would contain the same acoustic energy as the varying sound level, during the same period of time.
- L_{Max}: The instantaneous maximum noise level for a specified period of time.
- L_{Min}: The instantaneous minimum noise level for a specified period of time.

The World Bank in its Environmental Health and Safety Regulations, laid down the following noise level guidelines:

- Residential area – 55 dBA for the daytime and 45 dBA for the night-time period;
- Industrial area – 70 dBA for the day- and night-time periods.

The difference between the actual noise and the ambient noise level and the time of the day and the duration of the activity, will determine how people will respond to sound and what the noise impact will be. In order to evaluate this, there must be uniform guidelines to evaluate each scenario. The SANS 10103 of 2008 has laid down sound pressure levels for specific districts and has provided the following continuous noise levels per district which is illustrated in Table 28.

Table 28 Recommended noise levels for different districts

1	2	3	4	5	6	7
Type of district	Equivalent continuous rating level $L_{Req.T}$ for ambient noise dBA					
	Outdoors			Indoors, with open windows		
	Day-night L_{Rdn} 2)	Daytime L_{Rd} 1)	Night-time L_{Rn} 1)	Day-night L_{Rdn} 2)	Daytime L_{Rn} 1)	Night-time L_{Rn} 1)
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with some workshops, with business premises and with main roads	60	60	50	50	50	40
e) Central business district	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

The reference time intervals can be specified to cover typical human activities and variations in the operation of noise sources and are for daytime between 6h00 to 22h00 and for night-time between 22h00 and 6h00.

The response to noise can be classified as follows:

- An increase of 1dBA to 3dBA above ambient noise level will cause no response from the affected community. For a person with normal hearing an increase of 0dBA to 3 dBA will not be noticeable
- An increase between 1dBA – 10dBA will elicit little to sporadic response. When the difference is more than 5 dBA above the ambient noise level a person with normal hearing will start to hear the difference.
- An increase between 5dBA and 15 dBA will elicit medium response from the affected community.
- An increase between 10dBA and 20 dBA will elicit strong community reaction.

Because there is no clear-cut transition from one community response to another as well as several variables, categories of responses can overlap. This should be taken into consideration during the evaluation of a potential noise problem. There is therefore a mixture of activities and higher noise levels as per the above recommended continuous rating levels within i.e. residential, industrial and feeder roads in close proximity of each other.

The ambient noise level will differ throughout the study area, depending on the region and the measuring position in relation to areas with existing mining activities.

People exposed to an increase in the prevailing ambient noise level will react differently to the noise levels and the response is given in Table 29.

The difference between the actual noise and the ambient noise level will determine how people will respond to sound.

Table 29 Community response: Ambient noise level exceedance

1	2	3
Excess)$L_{Req,T}$ [1)] dB	Estimated community/group response	
	Category	Description
0	None	No observed reaction
0-10	Little	Sporadic complaints
5-15	Medium	Widespread complaints
10-20	Strong	Threats of community/group action
>15	Very strong	Vigorous community/group action

1) Calculate)$L_{Req,T}$ from the appropriate of the following:

a) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation).

b) $L_{Req,T}$ = $L_{req,T}$ of ambient noise under investigation MINUS the maximum rating level for the ambient noise given in Table 27.

c) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from Table 28.

1.1.10.2 Noise measuring points

A noise survey was conducted in terms of the provisions of SANS 10103 of 2008 within the vicinity of the proposed Perth mining operations. Details regarding the methodology used during the survey are presented in Appendix 6. The results of the survey are discussed below.

The measuring points, as illustrated in Figure 23, were selected in and around the proposed mining area to determine the prevailing ambient noise levels of the study area.

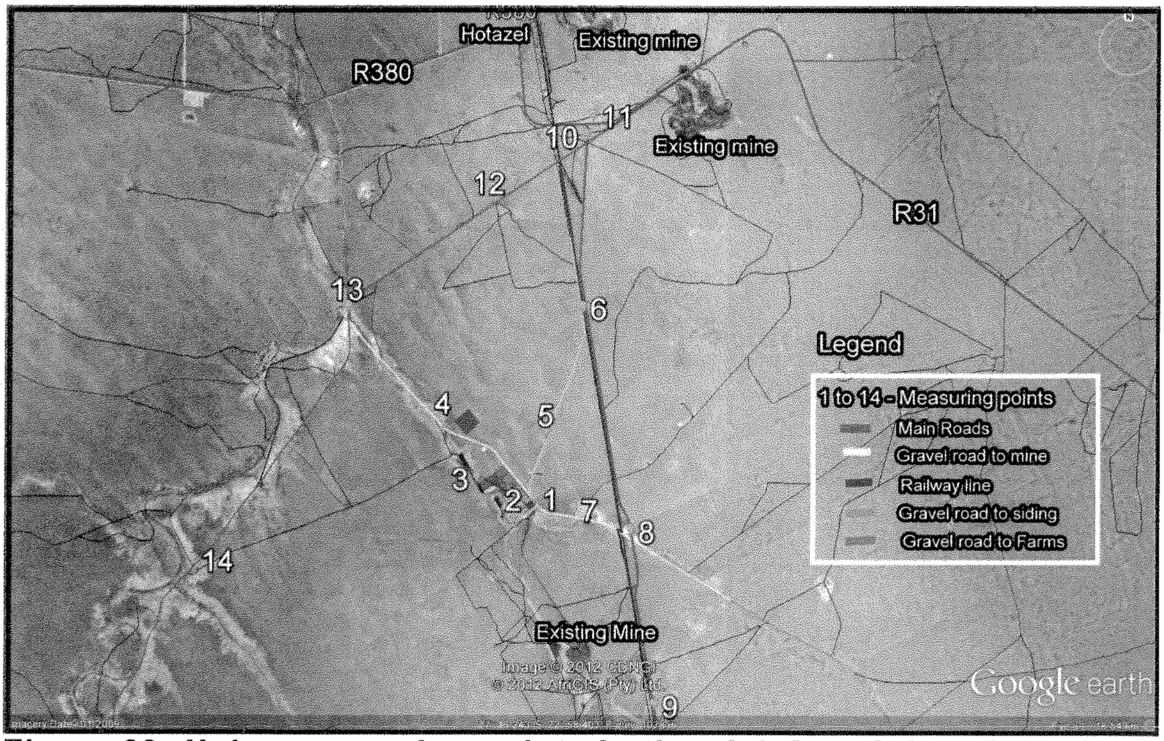


Figure 23 Noise measuring points in the vicinity of the mine

The distances between the proposed mine and noise sensitive areas are as follows:

- Sebilo mine and Hotazel – 9 750m
- Sebilo mine and the farm Devon (Measuring point 13) – 4 210m
- Sebilo mine and the Farm Mooidraai (Measuring point 14) – 5 310m
- Sebilo and staff accommodation (Measuring point 7) – 1 750m

The spatial information of the measuring points is given in Table 30.

Table 30 Noise measuring points for the proposed Perth mine

Position	X WGSDD	Y WGSDD	Remarks
1	27^0 17,522 S	022^0 57,924 E	On the south-eastern boundary of the proposed mine next to the entrance road to UMK mine.
2	27^0 17,589 S	022^0 57,668 E	Southern corner of the proposed mine. Distant mine activity noise.
3	27^0 17,329 S	022^0 57,302 E	Western side of the proposed mine. Distant mine activity noise.
4	27^0 16,790 S	022^0 56,931 E	North-western side of the mine. Insect and wind noise.
5	27^0 16,906 S	022^0 56,046 E	Along the gravel road to the railway siding. Distant traffic, mine and railway noise.
6	27^0 16,906 S	022^0 56,046 E	Along the railway line. Finite type noise when train pass measuring point. Traffic noise.
7	27^0 17,623 S	022^0 58,336 E	Along the gravel road leading to the UMK and Sebilo mine. Traffic and distant mine noise.
8	27^0 17,825 S	022^0 58,943 E	Along the R380 road. Traffic and railway noise.
9	27^0 13,920 S	022^0 58,526 E	Opposite the crushers, silos of UMK mine along the R380. Mine and traffic noise.
10	27^0 17,461 S	022^0 59,199 E	Along the R380 road. Traffic noise.
11	27^0 14,110 S	022^0 58,458 E	Along the R31 road. Traffic noise.
12	27^0 14,545 S	022^0 57,694 E	Along the gravel feeder road. Farm activity noise, birds, insects and wind noise.
13	27^0 15,717 S	022^0 55,914 E	Along the gravel feeder road. Farm activity noise, birds, insects and wind noise. Devon.
14	27^0 18,098 S	022^0 54,295 E	Along the gravel feeder road. Farm activity noise, birds, insects and wind noise.

The following is of relevance to the ambient noise measurements:

- The L_{Aeq} was measured over a representative sampling period exceeding 10 minutes at each measuring point;
- The noise survey was carried out during the day (6h00 to 22h00) and at night-time (22h00 to 6h00).

1.1.10.3 Site characteristics

The following observations were made in the vicinity of the proposed Sebilo Perth mine:

- The traffic noise is the main contributor to the prevailing ambient noise level along the main feeder roads and a finite type noise is created along the gravel roads and railway line;
- The distant mine activities from the abutting open cast mines were audible along the southern side of the mine and at some of the other measuring points;
- Heavy duty vehicles are using the gravel road to UMK mine and the R380 and R31 roads for hauling ore from other mines;
- There are natural and manmade topographical barriers, which can deflect and absorb the open cast mine activity noise;
- Train noise is audible at times at the measuring points which are situated between the

proposed mine and the R380 road;

The study area cannot be classified as a rural district according to SANS 10103 of 2008 (Table 28), due to the existing mine activities, main feeder roads and railway infrastructure in the vicinity of the proposed Sebilo Perth mine.

1.1.10.4 Current noise sources

The following are noise sources in the vicinity of and the boundaries of the study area:

- Heavy duty vehicles travelling along the R31 and R380 roads;
- Railway noise;
- Rattling sounds from vehicles travelling on the gravel road;
- Existing traffic noise along the gravel road that lead to the proposed mine;
- Existing blasting noise and vibration at the UMK open cast mine;
- Farming type noise;
- Birds and insects;
- Wind noise.

Atmospheric conditions during the noise survey are described in more detail in Appendix 6.

1.1.10.5 Results of the noise survey

Table 31 indicates the prevailing ambient noise levels for the specific areas, which include all the noise sources currently in the study area. Some of the noise readings include existing mine activities, existing plant noise and traffic noise along haul roads and/or gravel roads.

Table 31 Noise levels for the day and night time periods

Position	Day time			Night time		
	Leq -dBA	Lmax (Fast) - dBA	Lmin (Fast) - dBA	Leq - dBA	Lmax (Fast) - dBA	Lmin (Fast) - dBA
1	56.3	79.7	25.7	46.0	52.4	44.8
2	36.5	62.8	18.4	32.2	47.5	27.0
3	30.8	63.1	20.1	35.5	57.2	26.3
4	31.1	61.8	18.9	31.2	56.2	25.7
5	33.8	62.5	20.2	30.8	47.4	22.6
6	40.9	64.8	20.9	48.1	60.9	33.7
7	49.9	75.6	26.7	45.1	79.6	28.0
8	57.4	73.3	22.7	56.4	77.6	27.0
9	57.4	73.3	22.7	55,5	66.7	52.5
10	58.8	77.4	30.1	48.3	73.6	25.4
11	64.1	82.1	30.0	55.1	78.6	27.0
12	36.1	60.6	26.2	31.2	56.2	25.7
13	33.4	58.3	25.0	31.2	56.2	25.7
14	34.6	60.4	21.1	31.2	56.2	25.7

The prevailing wind during the time of the noise survey was NNE during daytime and NE during night-time. The prevailing ambient noise levels for the study area are typical of the noise levels expected in a district with mining activities. The noise survey indicates that there are already increased noise levels because of existing mining activities.

The prevailing ambient noise levels within the study area during daytime and night-time are given in Table 32.

Table 32 Prevailing ambient noise levels

Location	Ambient noise level during daytime - dBA	Ambient noise level during night time - dBA
R31 Road	64.1	55.1
R380 Road	57.4	56.4
Gravel roads	33.0	31.2
Boundary of the mine - northern	33.7	33.9
Boundary of the mine - southern	56.3	46.0
Gravel road to siding	37.4	39.5
Gravel road to mine	49.9	45.1

1.1.10.6 Noise levels associated with mine machinery

In an open cast mine there is different mine machinery that is used for drilling, excavation of soil and the removal of ore etc. The typical noise levels at 15m from the machinery are given in Table 33.

Table 33 Typical noise attenuation of mine machinery and equipment

Equipment	Line-of-Sight Estimated Noise Level Attenuation - dBA						
	5m	10m	20m	40m	80m	160m	320m
Cumulative distance from source	5m	15m	35m	75m	155m	315m	635m
Excavator 1200	78.3	68.3	58.3	52.3	46.3	40.3	34.3
Excavator 870	81.4	71.4	61.4	55.4	49.4	43.4	37.4
Excavator 650	81.6	71.6	61.6	55.6	49.6	43.6	37.6
Dozer D11R	89.4	79.4	73.4	76.4	70.4	64.4	58.4
Dozer D10T	88.4	78.4	72.4	66.4	60.4	54.4	49.4
Dozer D9T	96.1	86.1	76.1	70.1	64.1	58.1	52.1
Dozer D155	83.3	73.3	63.3	57.3	51.3	45.3	39.3
Dozer D6R	90.2	80.2	70.2	64.2	58.2	52.2	48.2
Grader 140H	97.4	87.4	77.4	71.4	65.4	59.4	53.4
Terex TR60	99.9	89.9	79.9	73.7	67.7	61.7	55.7
Volvo A40	85.6	75.6	65.6	59.6	53.6	47.6	41.6
HD 325	91.3	81.3	71.3	65.3	59.3	53.3	47.3
Diesel Browser Hino WHM 503GP	103.4	93.4	83.3	77.3	71.3	65.3	59.3
TLB	94.4	84.4	74.4	68.4	62.4	56.4	50.4
Lighting plant	85.8	75.8	65.8	59.8	53.8	47.3	41.3
Hitachi 670	102.9	92.9	82.9	76.9	70.9	64.9	58.9
Bell B40	86.1	76.1	66.1	60.1	54.1	58.1	52.1
Crawler Drill & Ingersol Rand compressor	96.5	86.5	76.5	70.5	64.5	58.5	52.5
Tornado – Tyre drill	102.0	92.0	82.0	75.0	69.0	63.0	57.0
Drill rig	99.3	89.3	79.3	73.3	67.3	61.6	56.6

The noise levels calculated in Table 33 is for direct line of sight and medium soft ground conditions. There will be a further noise reduction of up to 7.0dBA, should the activities take place lower than ground level as the rock face will create a noise barrier.

1.1.11 Blasting and ground vibration

This section was prepared by dBAcoustics (2012) as well as by CVB Cunningham (2012). The complete specialist reports are contained in Appendix 6 and Appendix 7.

Human reaction to vibration will be in response to the resulting effects of both ground and airborne vibration and in particular the combined effects of such vibration. The blasting process is the biggest contributor to vibration.

Routine blasting operations regularly generate air over pressure levels at 15m from the blast of about 120 dB. A constant wind velocity of $5m/s^{-1}$ will generate the pressure equivalent of 120 dB at 15m from the blasting area. At 140 dB the wind velocity will increase to $8m/s^{-1}$.

Wavelength differences associated with this frequency range mean that any effects of topography are likely to be pronounced for the audible component of air over pressure levels rather than the concussive component. A topographic barrier i.e. an earthberm or rock face will play an important role in reducing the audible effect rather than the concussive effect. A series of quarry faces between the receptor and the source will be more effective to reduce the air over pressure levels.

The shock waves have a relatively high dominant frequency and the energy contained in the shock wave will reduce rapidly as the resultant energy will be subjected to geometric and natural attenuation. Rock formations absorb the vibrations and/or the distance from the source, which will result in the shock wave to be attenuated by 6dB in the doubling of distance from the source.

The blast design chart suggested in Rock Slope Engineering by Wyllie and Mah (2004) will be used to quantify damage potential to residential properties. It is generally accepted that residential buildings of sound construction can safely withstand a peak particle velocity (PPV) of 50mm/s. Poorly constructed buildings should however not be subjected to PPV's of more than 10mm/s. Figure 24 depicts the typical vibration control diagram where the charge per delay is combined with the distance from the blast to indicate the safe and damage zones and when damage to structures can be expected.

Meteorological conditions such as wind speed, direction, temperature, cloud cover and humidity will affect the intensity of the air over pressure levels perceived at a distance from the blasting area. A blast in a motionless atmosphere will reduce the air over pressure level by 6.0 dB as the distance from the source doubles.

The air over pressure levels at the source should be minimized in order for the energy to be within acceptable criteria at a distance. This could be achieved by proper blast design. In general, individual blasts should not exceed 50mm/s in the vicinity of properly constructed buildings and the average level should not exceed 10mms in the vicinity of poorly constructed buildings. These levels conform to the British Standards 6472 and the USA Bureau of Mine Standards, RU 8507.

1.1.11.1 Blast design

Table 34 shows the fundamental blast design assumed for this operation, which represents a worst-case scenario.

Table 34 Blast Design Parameters (CVB Cunningham, 2012)

Parameter	Units	Ore	Waste
Bench height	m	5	12
Hole diameter	mm	165	165
Spacing	m	4	4
Burden	m	4	4
Sub drill	m	1	1.5
Hole depth	m	6	13.5
Explosive density	g/cm^3	1.25	
Explosive mass/metre	kg/m	26.73	26.73
Stemming length	m	3	3
Mass per hole	kg	80.19	280.67
Powder Factor	kg/m^3	1.00	1.46
PRODUCTION			
Penetration rate	m/hr	20	20
Avg penetration rate	m/min	0.33	0.33
Time per hole	min	18.2	40.9
In-situ SG	t/m^3	3.7	3.7
t/hole		296	710.4
t/min drilled		16.26	17.37
t/hr drilled		975.6	1,042.2
Working hours		12	12
t/day drilled		11,707	12,506
t required per day		1,678	10,506

Days production		14	14
On floor		23,492	147,084
Drilling days		2.01	11.76
NoHoles		79	207
No Rows		4	5
No lines		20	40
Explosives per blast	kg	6,361	58,090
Frequency	days	14	7

Arising from Table 34, one can plot the expected vibration levels around the pit, if the number of holes firing in any one instant are controlled.

The number of holes, rows and lines of holes to be blasted is discussed in more detail in Appendix 7. The worst-case situation for the proposed design is four holes per delay, which is applied to the explosive charge per hole.

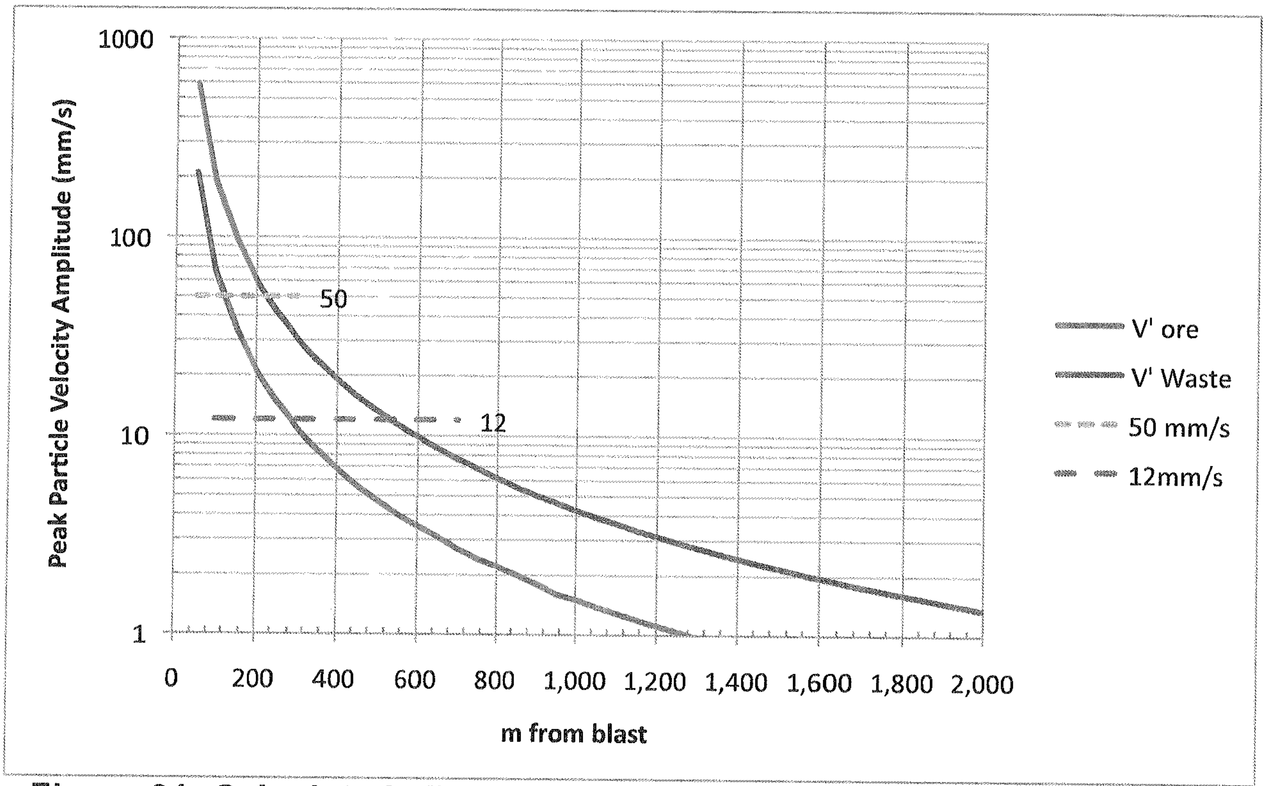


Figure 24 Calculated vibration amplitude for ore and waste

Figure 26 can be used to estimate the radii around the pit at which various vibration levels might be expected.

The equation used for vibration prediction is presented in Equation 1, commonly used in South Africa, originally derived from the du Pont explosives handbook in the USA. Many other similar equations exist, and it is only possible to make any correction once blasting commences under the regime of this equation, by measuring actual, statistically valid measurements, and fitting modified curves for different parts of the pit.

'=1143∗ .05−1.65 (Eq 1)

Where

V' = Predicted PPV, mm/s

D = Distance from blast, m

E = charge mass per delay period, within 8ms of any other shot, kg

By applying Equation 1 to the expected charge masses from the blast designs, Figure 24 shows the anticipated vibration levels at various distances from the blasting site.

1.1.11.2 Vibration criteria

As indicated, PPV (Peak Particle Velocity) is the parameter of choice for limiting blasting vibration. It is registered using specially configured and calibrated Blasting Seismographs, which adhere to internationally accepted standards for recording blasting events.

There are no legislated criteria of vibration in South Africa, and the criteria used by various authorities tend to be corrupted by successive waves of arbitrary cuts in previous criteria, "to be on the safe side" (CVB Cunningham, 2012). If this process had been followed on the roads, we'd be restricted to 60 km/h on the motorways and 20 km/h in the towns. The setting of criteria therefore tends to be a political rather than a technical issue.

The frequency of the signal affects the likelihood of damage, and the US Office of Surface Mining and Reclamation Enforcement (OSMRE) works to a well-known "Z" curve, represented in Figure 25.

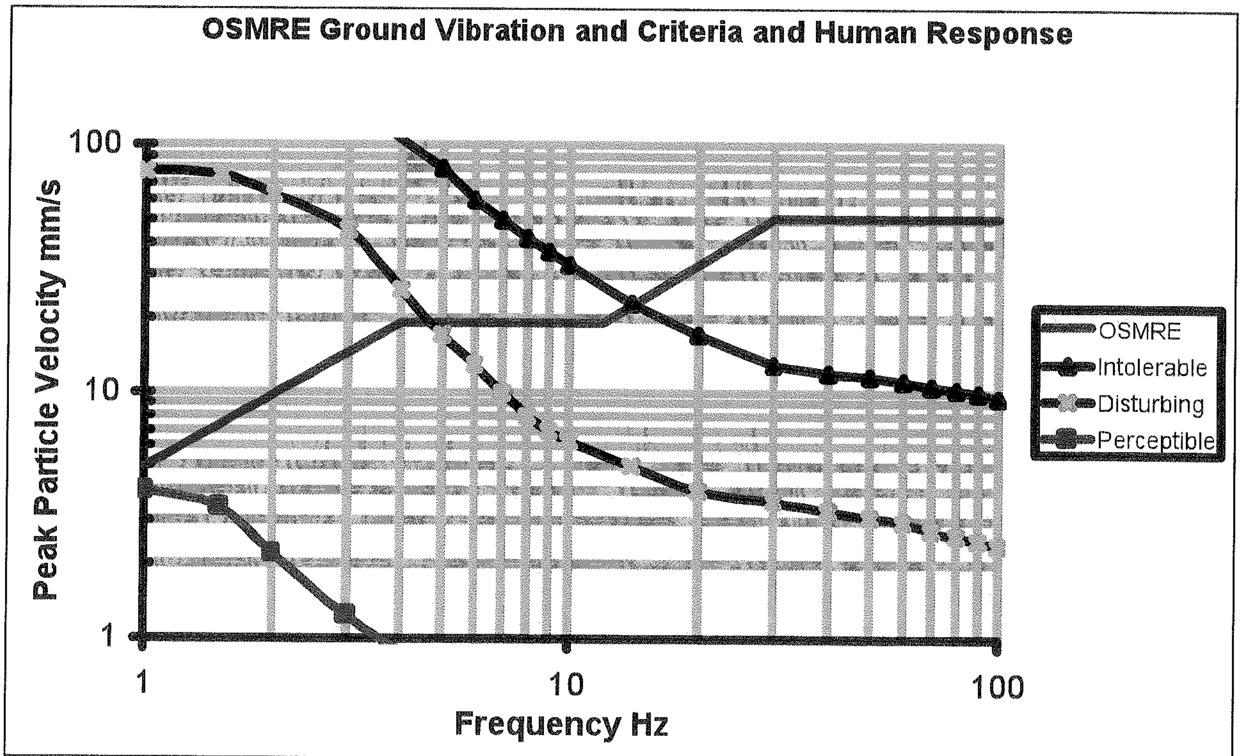


Figure 25 OSMRE vibration criteria with human response curves

Table 34 Human and structural response to airblast (concussion)

Level	Description
100 dB (2.0 Pa)	Scarcely noticeable
110 dB (6.3 Pa)	Rattling of loose windows/doors/ceiling panels
128 dB (50.2 Pa)	Public concern due to sudden and unexpected nature. May cause dogs to bark and disturb domestic animals
134 dB (100.2 Pa)	Good Highveld thunderstorm. Poorly mounted wall pictures, rattling of objects on shelves/display units, potential for these to fall.
170 dB (6300 Pa)	Will break well mounted windows, note not individual frames

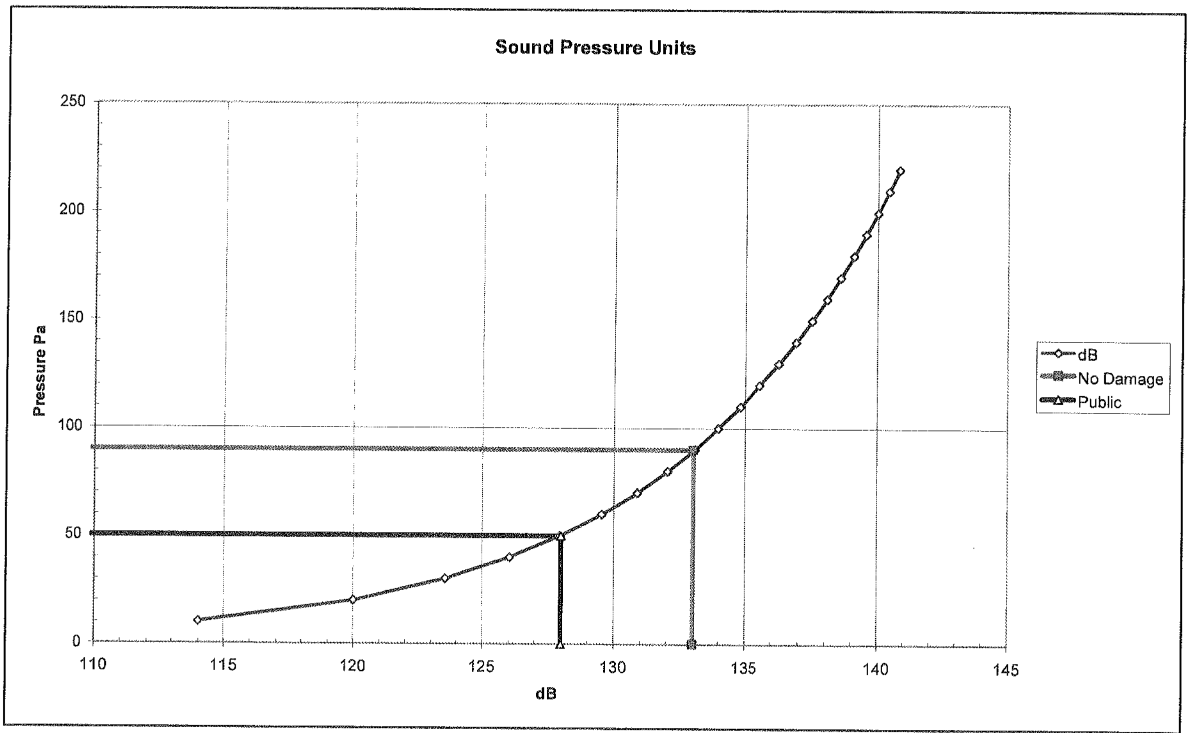


Figure 26 Airblast Units, showing pressures at dB limits.

1.1.12 Air quality

The air quality assessment was undertaken by SSI (2012). The complete specialist study is contained in Appendix 8.

The nature of the local climate will determine what will happen to air pollution when it is released into the atmosphere. Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion of pollution. The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion. More information regarding inversion is presented in Appendix 8.

The project area is situated in a semi-arid zone of the Northern Cap and is characterised by cold, dry winters (May to August) and hot summers (October to March), with April and September being transition months. More detailed information regarding the temperatures for the project area, is contained in Appendix 8.

1.1.12.1 Winds

From the wind rose in Figure 27, it is noted that the dominant wind is from the north easterly sector. Due to the distances from reporting monitoring stations as well as the complexity of the terrain in the area, all meteorological data used for modelling purposes was obtained from the Lakes Environmental MM5 Model. The average wind speed from this direction is between 3.6 to 5.7 m/s, but the winds from a more northern direction may exceed 5.7 m/s. Calm periods for this region are less than 4% of the time period. The wind from the west, and south west occur less than 6% of the time, when the wind can reach speeds of up to 5.7 m/s.

1.1.12.2 Other air polluting sources in the area

A detailed emissions inventory for the Kuruman area is currently not available. Based on site visits and 1:50 000 topographical maps, the following sources of air pollution have however been identified. These are important to consider in terms of assessing the cumulative impact potential on air quality in the region:

- Agricultural activities;
- Vehicle entrainment and exhaust gas emissions;
- Veld Fires; and
- Domestic Fuel Burning

A qualitative discussion on each of these source types is provided in Appendix 8.

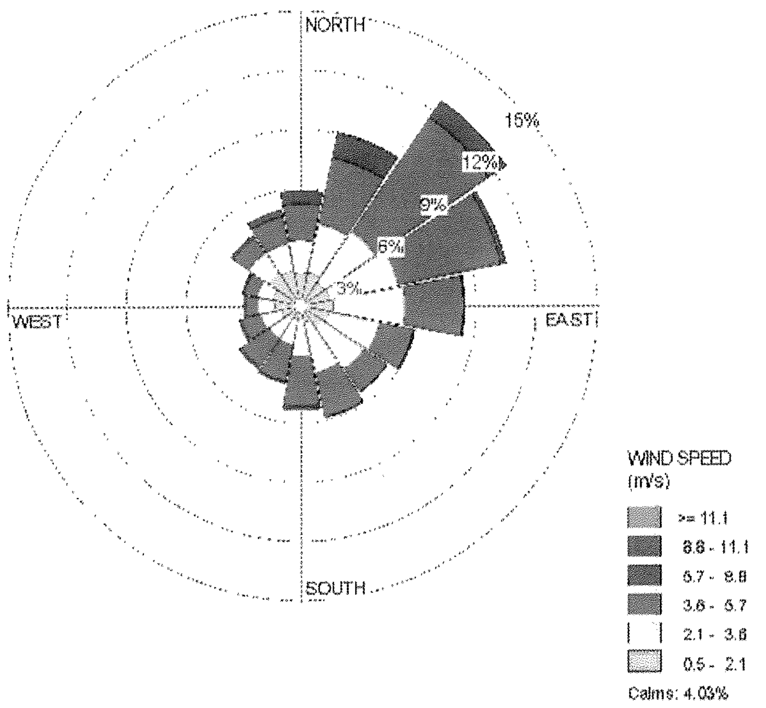


Figure 27 Wind rose for the project for the period 2007 - 2011

Note: Wind roses comprise 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The resultant vector represents the mean wind direction.

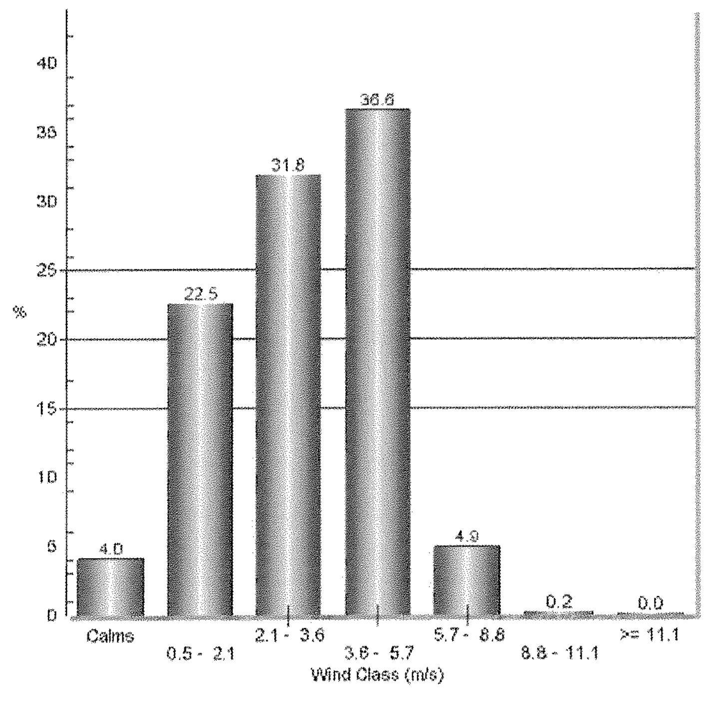


Figure 18 Wind class frequency distribution for the period 2007 - 2011

1.1.12.3 Air quality standards and guidelines

1.1.12.3.1 Inhalable Particulates

The main air pollutant of concern, which may pose a health risk to surrounding sensitive receptors and possible communities during the current investigation, is particulate matter. Particulate matter is a collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles. An overview is provided of the available local regulations and standards (SANS), and then for comparison, international guidelines and standards prescribed for inhalable particulate and nuisance dust exposure, these include the World Bank (WB), European Union (EU), United Kingdom (UK), World Health Organisation (WHO), and the United States Environmental Protection Agency (USEPA) in Table 34 and a more detailed discussion regarding these standards are presented in Appendix 8.

Table 34 Local and International Standards for PM10

Origin	24-Hour Exposure (µg/m³)	Annual Average Exposure (µg/m³)	Number of Exceedances Allowed per year
RSA[(1)]	120[(1)]	50[(1)]	4 daily exceedances
RSA[(2)]	75[(2)]	40[(2)]	0 daily exceedances
Australia	50		5 daily exceedances
World Bank[(3)]	500	100	NA
EU[(4)]	50	20	7 daily exceedances
US-EPA[(5)]	150	50[(6)]	1 daily exceedance
UK[(7)]	50	40	35 daily exceedances
WHO[(8) (9) (10)]	50	20	NA

Notes: [(1)] Standard laid out in the National Environment Management: Air Quality Act. No. 39 of 2004:

[(2)] Compliance by 1 January 2015

[(3)] World Bank Air Quality Standards summary obtainable at URL http://www.worldbank.org/html/fpd/em/power/standards/airqstd.stm#paq.

[(4)] European Union Air Quality Standards summary obtainable at URL http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=1999&nu_doc=30.

[(5)] United States Environmental Protection Agencies National Air quality Standards obtainable at URL http://www.epa.gov/air/criteria.html

[(6)] To attain this standard, the 3-year average of the weighted annual mean PM_{10} concentration at each monitor within an area must not exceed 50 µg/m^3.

[(7)] United Kingdom Air Quality Standards and objectives obtainable at URL http://www.airquality.co.uk/archive/standards.php

[(8)] WHO = World Health Organisation

[(9)] Guidance on the concentrations at which increasing, and specified mortality responses due to PM are expected based on current scientific insights (WHO, 2005).

[(10)] Air quality guideline

1.1.12.3.2 Nuisance dust

Nuisance dust is known to result in the soiling of materials and has the potential to reduce visibility. Atmospheric particulates change the spectral transmission, thus diminishing visibility by scattering light. The scattering efficiency of such particulates is dependent upon the mass concentration and size distribution of the particulates. More information regarding nuisance dust is presented in Appendix 8.

Air pollution is a recognized health hazard for man and domestic animals. Air pollutants have had a worldwide effect on both wild birds and wild mammals, often causing marked decreases in local animal populations. The major effects of mining-related air pollution on wildlife include direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation. Some air pollutants have caused a change in the distribution of wildlife species.

South Africa is one of the only countries who have issued guideline limits for the evaluation of nuisance dust levels. A four banding system has traditionally been used which describes the dust deposition as resulting in a slight, moderate, heavy or very heavy nuisance impact, as detailed in Table 35.

Table 35 Guideline limits for the evaluation of nuisance dust levels

Category	Guideline limits
Slight	< 250 mg/m²/day
Moderate	> 250 mg/m²/day < 500 mg/m²/day
Heavy	> 500 mg/m²/day < 1200 mg/m²/day
Very Heavy	> 1200 mg/m²/day

The Department of Mineral Resources (DMR) use the 1 200 mg/m²/day threshold level as an action level. In the event that on-site dustfall exceeds this threshold, the specific causes of high dustfall should be investigated and remedial steps taken.

The South African Bureau of Standards in their SANS 1929:2005 publication, "Ambient air quality – limits for common pollutants", provides additional criteria which can be used for the evaluation of fallout dust deposition. A four banded scale has been provided, with target, action and alert thresholds indicated. Permissible margins of tolerances are outlined with possible exceptions noted. Tables 36 and 37 detail these evaluation criteria.

Table 36 SANS Evaluation criteria for dust deposition

Band Number	Band Description	Dustfall rate, D (mg/m²/day, 30-day average)	Comment
1	Residential	D < 600	Permissible for residential and light commercial
2	Industrial	600 < D < 1200	Permissible for heavy commercial and industrial
3	Action	1200 < D < 2400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year
4	Alert	2400 < D	Immediate action and remediation required following the first incidence of the dustfall rate being exceeded. Incidence reported to be submitted to the relevant authority.

Table 37 SANS Target, action & alert thresholds for dust deposition

Level	Dustfall rate, D (mg/m²/day, 30-day average)	Averaging Period	Permitted Frequency of Exceeding dustfall rate
Target	300	Annual	
Action residential	600	30 days	Three within any year no two sequential months
Action industrial	1200	30 days	Three within any year not sequential months
Alert threshold	2400	30 days	None. First incidence of dust fall rate being exceeded requires remediation and compulsory report to the relevant authorities.

1.1.12.4 Sensitive receptors

The residential, educational and recreational land uses are considered to be sensitive receptors. For this study, the position of houses/dwellings on the farms was taken off 1:50 000 topographical cadastral maps and verified as far as possible using Google Earth and site visits. Even though the latest editions were used, the relevant maps are out of date and there may be new dwellings and/or some of the existing shown buildings may be derelict. The proposed mine is located to the south of Hotazel (Figure 1)). The surrounding areas are predominately farming based and therefore the farms, homesteads and crops being produced, can be classified as a sensitive.

1.1.12.5 Emmissions inventory

The methodology used during the air quality impact assessment, is presented in Appendix 8. Based on available information, the emission rate for the project, are presented in Table 38.

Table 38 Emmission inventory

Area	Description	Emission Rate
Roads	Access	0.637 g/s
	Internal haul roads	0.694 g/s
	Mining Haul Roads	0.313 g/s
Rail	Access and train loading	-
Bulldozing	± 1800 tonnes per day	0.587 g/s
Grading	Grading of haul roads	0.115 g/s
Drilling	Dust collectors on drill 80% efficient	0.003 g/s
Blasting ore	Every 2 weeks over 2750m^2 area	0.336 g/s
Conveyor transfer points	220t/hr throughput with 8% moisture content	2.934 TPA
Tipping ore	Loading and tipping	4.070 TPA
Loading and offloading haul trucks	1800 t/hr throughput, impact sprinklers 70% effective	4.070 TPA
Loading and offloading train	2200 t/hr, with 8% moisture content	4.070 TPA
Storage piles, discard dump and ultrafines	Topsoil: 22.5ha area, 21m high	-
	Overburden: 90ha area, 31m high	-
	RoM: 0.09ha, 12m high	-
	Saleable stockpiles: 0.04ha, 12m high	-
	Ultrafines empoundment: 22.5 ha, 6m high	-
Opencast pits	70m deep over 600 ha	-
Ventilation shaft	Flow of 400 m^3/s	-
Beneficiation plant (crushing)	220t/hr throughput, double screens (wet type)	-

1.1.13 Visual impact assessment

The visual impact assessment was undertaken by EnviroCam (2012). The complete specialist report is presented in Appendix 9.

1.1.13.1 Sense of place

Central to the concept of sense of place is that the landscape requires uniqueness and distinctiveness. The primary informant of these qualities is the spatial form and character of the natural landscape taken together with the cultural transformations and traditions associated with the historic use and habitation of the area.

The area to the north of the proposed Sebilo Perth Project has a definite mining character with a strong relationship to the mining activities at Hotazel and Black Rock. The power line corridors and railway line transecting this surrounding area strengthens the mining character of the region. The mining activities degrade the visual appeal along the R31 and R380 main roads (please refer to Appendix 9 for photographs illustrating the sense of place at this point).

Figure 29 Historic mining activities on site.

Areas to the west and east is characterised by a rural sense of place with agriculture (livestock) and game farming dominating the area. The immediate area around the site is characterised by historic mining activities and degrades the rural visual character of the surrounding area (Figure 29).

Figure 30 Existing power line corridors (background)

The study area has a relatively low sense of place due to the close proximity of the various clashing land use types (mining, game and livestock farming and vacant land). It is anticipated that the sense of place will be negatively affected. The impact on sense of place can be reduced by adhering to the mitigating measures suggested later on.

1.1.13.2 Scenic and tourism value

Related to the scenic value of a specific area is the tourism value attached to that area. The properties in the immediate vicinity of the Sebilo Perth Project are not regarded as areas with a high scenic and/or eco-tourism potential due to the exiting mining activities at Hotazel, Black Rock and to the south at Mamathwane. The R31 main road is however utilised by tourists to access well know tourist hot spots in the Kalahari (e.g. The Kalahari Gemsbok National Park).

1.1.13.3 Visual Analysis

1.1.13.3.1 The Viewshed

A viewshed analysis is carried out to define areas that contain all possible observation sites from which the proposed infrastructure would be visible. Topographic data was captured for the site and the surrounding environment (20 m contour intervals) to create the Digital Elevation Model (DEM). The DEM was draped over the topographic data (rivers, roads, cadastral, etc) to complete the model used to generate the viewshed analysis. This viewshed analysis assists this assessment, by identifying possible affected viewers and the extent of the affected environment.

Figure 31 spatially depicts the viewshed area and the areas, which have direct visibility of the proposed Sebilo Perth Project. A single analysis viewshed for the proposed Sebilo Perth Project was used, meaning that the figures show all the points from which the proposed Sebilo Perth Project can be seen incorporating an offset height of 40m for the waste dump, 20m for the ultrafines empoundment facility, 1.5m for the ore stockpile, etc. and an offset height of 1.6 m for observation points (please refer to Table 1).

The viewshed indicates that the proposed Sebilo Perth Project viewshed is extensive in all directions with some minor screening by topography towards the northwest and west. This is mainly due to the flat terrain, physical dimensions of the proposed Sebilo Perth Project and the limited vegetation screening in some areas.

Views towards the R380 and R31 main roads are also extensive with views onto the project area. The viewshed also indicates that the proposed Sebilo Perth Project will be visible to the majority of homesteads in the region.

Light sources at night, particularly poorly directed security flood lighting, can influence the visual impact of the project. Unobstructed light sources can cause a general glow in the area and will be visible from significantly longer distances than any structural features during daylight hours.

Using the criteria in Table 39, visibility of the proposed Sebilo Perth Project from the surrounding areas during the construction and operational phases will be high even if mitigation measures are correctly adhered to.

Table 39 Viewshed evaluation for proposed Sebilo Perth Project

High	Moderate	Low
If the project and its infrastructure is visible from over half the zone of potential influence, and/or views are mostly unobstructed.	If the project and its infrastructure are visible from less than half the zone of potential influence, and/or views are partially obstructed.	If the project and its infrastructure is visible from less than a quarter of the zone of potential influence, and/or views are mostly obstructed.

1.1.13.3.2 The Viewing Distance

The visual impact of an object in the landscape diminishes at an exponential rate as the distance between the observer and the object increases (Hull and Bishop, 1988) (please refer to Figure 32). Thus, the visual impact at 1000m would be approximately a quarter of the impact as viewed from 500m. Consequently, at 2000m, it would be one sixteenth of the impact at 500m. More details regarding the viewing distance, is provided in Appendix 9.

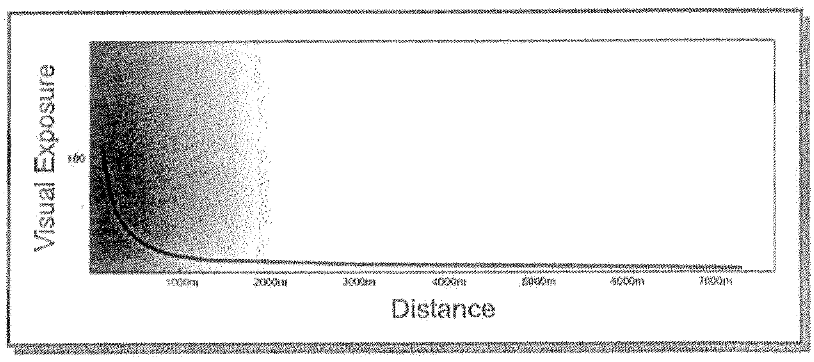


Figure 32 Visual Exposure Curve