7.4 ENVIRONMENTAL ATTRIBUTES ASSOCIATED WITH THE PROJECT AND ALTERNATIVES

The baseline information provided is aimed at giving the reader perspective on the existing status of the cultural, socio-economic and biophysical environment. Where appropriate it includes the detail derived from the specialist reports and other research undertaken for the EIA.

7.4.1 BASELINE ENVIRONMENT AFFECTED BY THE PROPOSED ACTIVITY

7.4.1.1 Topography

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

The topography of a project area influences surface water flow, safety of third parties and animals, the location of soils and the visual character of a landscape. Existing mining infrastructure and activities have altered the topography of the site. The project components have the potential to contribute to the alterations. This in turn could result in changes to drainage patterns, landforms which could prove hazardous to people and animals, as well as changes to the visual character of the site. As a baseline, this section provides an understanding of the topographical features relevant to the project site and surrounding area from which to measure potential change.

DATA SOURCES

The information for this section was sourced from approved mine EIA, housing BAR, and through the studying of topographical maps and site observations by the vegetation specialist (De Castro and Brits, 2016a). Refer to Appendix K.

RESULTS

The topography of the Frischgewaagd and Mimosa areas is generally flat with moderate slopes leading down to the Elands River in the southern parts. The pipeline is situated mostly on a gentle south-west facing slope. The elevation of the project area ranges from 1031 to 1073 mamsl (De Castro and Brits, 2016a).

The topography is characterised by various ephemeral drainage lines, channels and wetlands, the Sandspruit and the Elands River (TWP, 2008; ABEC, 2014 and De Castro and Brits, 2016a). The topography within the project area has been partially altered by the development of mine infrastructure, not all approved infrastructure has yet been developed.

Within a 5km radius to the north of the project area is the Pilanesberg mountain range which is remnant of an ancient volcano, reaching an approximate height of 1480 mamsl (Airshed, 2016). Isolated ridges between 80 m and 100 m above the surrounding plains occur to the south and to the east of the project area. These mountains and ridges have steep slopes and are highly visible from the proposed site (TWP, 2008).

CONCLUSION

The topography of the site has been altered by approved mining activities that range from clearing and flattening of areas for the shaft bank, construction of roads, noise berms and establishment of the waste rock dump. Not all of the approved facilities have been constructed as yet. The project components include the tailings storage facility, housing, soil berms and topsoil stockpiles. These changes to the approved mining operations need careful consideration with respect to safety, water and visual aspects.

7.4.1.2 Geology

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

The assessment of the proposed project presents the potential for significant negative impacts to occur (in the unmitigated scenario in particular) on the bio-physical, cultural and socio-economic environments both on the project sites and in the surrounding area. With mitigation these potential impacts can be prevented or reduced to acceptable levels.

It follows that provided the EMP is effectively implemented there is no environmental, social or economic reason why the project should not proceed.

DATA SOURCES

The information for this section was sourced from approved mine EIA, the housing BAR and the TSF design report (Knight Piesold, 2016)

RESULTS

<u>Regional geology</u>

The project area is underlain by the Rustenburg Layered Suite (RLS) of the Bushveld Igneous Complex in which the PGM bearing Merensky Reef and UG2 Reef occur. The RLS comprises five stratigraphic zones representing the sequential fractional crystallisation that accompanied the cooling of this magmatic body:

- The Marginal Zone, which comprises pyroxenites and norites with no economic potential
- The Lower Zone which comprises ultramafic rocks, such as pyroxenites and harzburgites, containing thin, high-grade chromitite seams
- The Critical Zone pyroxenites, norites and anorthosites that host all the significant platinum group metals chromite deposits
- The Main Zone, which consists mainly of homogeneous norites and gabbros that are locally exploited as dimension stone
- The Upper Zone norites, gabbros and diorites, which host over 20 massive magnetite seams, some of which are exploited for vanadium and iron ore.

The Pilanesberg mountain range north of the project area is made up of an isolated ring of alkaline hills covering over 500 km2. It was formed by the coalescence of a number of small volcanoes and the welling up of successive ring dykes around the collapsed crown. The overlying layer, which is largely eroded, consists of alkaline volcanic and pyroclastic rocks. The pyroclastic rocks consist of fragmental volcanic material blown into the atmosphere by explosive activity. There are also small outcrops of quartz-rich rocks belonging to the Magaliesberg Quartzite Formation that are related to fracture events (TWP, 2008).

Local geology

The Merensky Reef is a regular and complete cyclic unit within the Critical Zone and is a persistent magmatic sedimentary entity. It is located 60 m to 100 m below the top of the Critical Zone and grades upward in the cycle to norite, a 'spotted' anorthosite and then into a 'mottled' anorthosite at the top of the cycle.

The Merensky Reef occurs over the project area in three types. These three types are based on the physical appearance, mineralisation and immediate footwall stratigraphy of the Merensky Reef. These are the Normal Merensky (approximately (~) 1.19 m thick), the Single Chromitite Merensky (~ 0.08 m thick) and the Normal Footwall Merensky (~ 0.69 m thick). They vary in mineralogy and thickness but are bounded within the Critical Zone.

The UG2 Chromitite Layer is composed of a chromitite layer and generally has a basal feldspathic pyroxenite pegmatoid and some overlying chromitite layers. The UG2 reef is often underlain by a pegmatoidal feldspathic pyroxenite with the greatest concentration of PGMs occurring at the base of the UG2 chromitite (TWP, 2008).

The depths below surface of the Merensky and UG2 reefs are in Table 7.2.

TABLE 7.2: DEPTH BELOW THE SURFACE OF MERENSKY AND UG2 REEFS AT THE BPM MINING AREA (TWP, 2008)

	Depth below surface	
Reef	**Deepest Point**	**Shallowest Point**
Merensky Reef	1 234 m	584 m
UG2 reef	1 272 m	616 m

Structural Features

There are numerous faults and north-south striking dykes that cut through and across the area. These include the Rustenburg and Caldera faults, as well as many other minor faults. The Rustenburg fault line bisects the farm Mimosa, and the Caldera fault line bisects the farms Frischgewaagd and Ledig.

Quartz veins are also known to be present in the lithologies on site. The in-situ nature of the soils on site increases the likelihood that residual quartz veins may be present close to surface. These quartz veins can act as preferential flow paths for water and potential contaminants into the underlying aquifers (Knight Piesold Consulting, 2016).

Geochemistry

As part of the updated TSF design and waste classification, laboratory scale tests such as acid base accounting, acid digest, XRD analysis and leach testing and mineralogical examination were used to determine whether the TSF was potentially acid generating. The results found that the tailings material is considered to be non-acid forming. The leach testing indicated that the total concentrations of barium, copper and nickel classify the tailings as a Type 3 hazardous waste, although both copper and barium were only marginal exceedances. The supernatant water was marked by having moderately high sulphate content but very low concentrations of heavy metals (Knight Piesold Consulting, 2016). The approved EIA and EMP indicated that the waste rock was also considered to be non-acid forming. Although acid production may not occur, the sulphide content may be sufficient to produce some soluble sulphates under oxidising conditions.

CONCLUSION

The structures that are present in the area may influence groundwater flow by forming preferential flow paths for groundwater. Laboratory testing showed that the TSF waste stream was not considered to generate acid leachate. Under oxidising conditions without appropriate buffering there could be soluble sulphates impacting water quality. It follows that short and long term pollution prevention and/or treatment measures must be considered.

7.4.1.3 Climate

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

As a whole, the various aspects of the climate that are discussed influence the potential for environmental impacts and related mine/infrastructure design. Specific issues are listed below.

- Rainfall could influence erosion, evaporation, vegetation growth, rehabilitation planning, dust suppression, and surface water management planning
- Temperature could influence air dispersion through impacts on atmospheric stability and mixing layers, vegetation growth, and evaporation which could influence rehabilitation planning
- Wind could influence erosion, the dispersion of potential atmospheric pollutants, and rehabilitation planning.

To understand the basis of these potential impacts, a baseline situational analysis is described below.

DATA SOURCES

Information in this section was sourced from the approved EIA, BAR and EMP reports, the air quality impact assessment (Airshed, 2016) and the annual water monitoring report (SLR, 2015).Rainfall and temperature data were sourced from the on-site weather station for May 2014 (when it started to operate) to October 2015.

RESULTS

Regional Climate

The North West province has varying climatic conditions across the province. The western region is arid while the central region typically has semi-arid conditions and the eastern region of the province (where the project area is located) is largely temperate. Rainfall over the province is highly variable over space and time.

The approved EIA and EMP indicated that rainfall occurs predominantly in the summer months, with the western region of the Province receiving less than 300 mm per annum, mainly during the mid-summer period. The central region receives approximately 550 mm per annum during the late summer season, while the eastern and south-eastern region receives over 600 mm per annum in the early season (spring). With the exception of the south-eastern region, evaporation exceeds precipitation in the province.

The approved EIA and EMP indicated that temperature patterns are characterised by great seasonal and daily variations, where the summers are hot and the winters are mild to cold. The seasonal fluctuations in mean temperatures between the warmest and the coldest months vary between 12ºC and 15ºC. Windy months occur between August and November.

Local climate

The site falls within the Highveld climatic zone which is characterised by warm temperatures, dry winters and summer rainfall which are erratic and extremely variable (SLR, 2015).

Rainfall and evaporation

Rainfall represents an effective removal mechanism of atmospheric pollutants. The project area experiences rainfall mainly between September and January, with maximum monthly rainfall occurring in December (Table 7.3).

TABLE 7.3: MONTHLY RAINFALL IN MM (MEASURED DATA, MAY 2014 TO OCTOBER 2015) (AIRSHED, 2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014					0	0	0	0	0	8.1	40.5	45.5
2015	20.3	8.3	21.1	7.4	0	0.7	1.6	0	33.1	0		

The floodline determination report in the approved BAR and EMP indicated that the Mean Annual Precipitation measured at the Rustenburg weather station was estimated at 630 mm.

Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume is able to rise), and determining the development of the mixing and inversion layers. Minimum, maximum and mean temperatures for the project area were obtained from on-site data. Maximum, minimum and average temperatures were 36.8°C, -2.3°C and 19.9°C, respectively. The month of June had the lowest temperature of -2.3°C while the maximum temperature of 36.8°C occurred in February. Temperatures reached their minimum just before sunrise and their maximum between midday and sunset (Airshed, 2016) (Table 7.4).

TABLE 7.4: MINIMUM, MAXIMUM AND AVERAGE TEMPERATURES (MEASURED DATA, OCTOBER 2014 TO OCTOBER 2015) (AIRSHED, 2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	24.8	25.7	23.6	20.0	17.3	12.0	12.9	17.1	20.9	24.1	22.2	23.7
Minimum	35.7	36.8	35.0	30.7	31.8	24.4	25.7	32.3	35.7	36.1	35.0	35.7
Maximum	15.7	13.3	14.4	9.4	3.9	-1.1	-1.1	-2.3	6.8	12.3	11.1	13.9

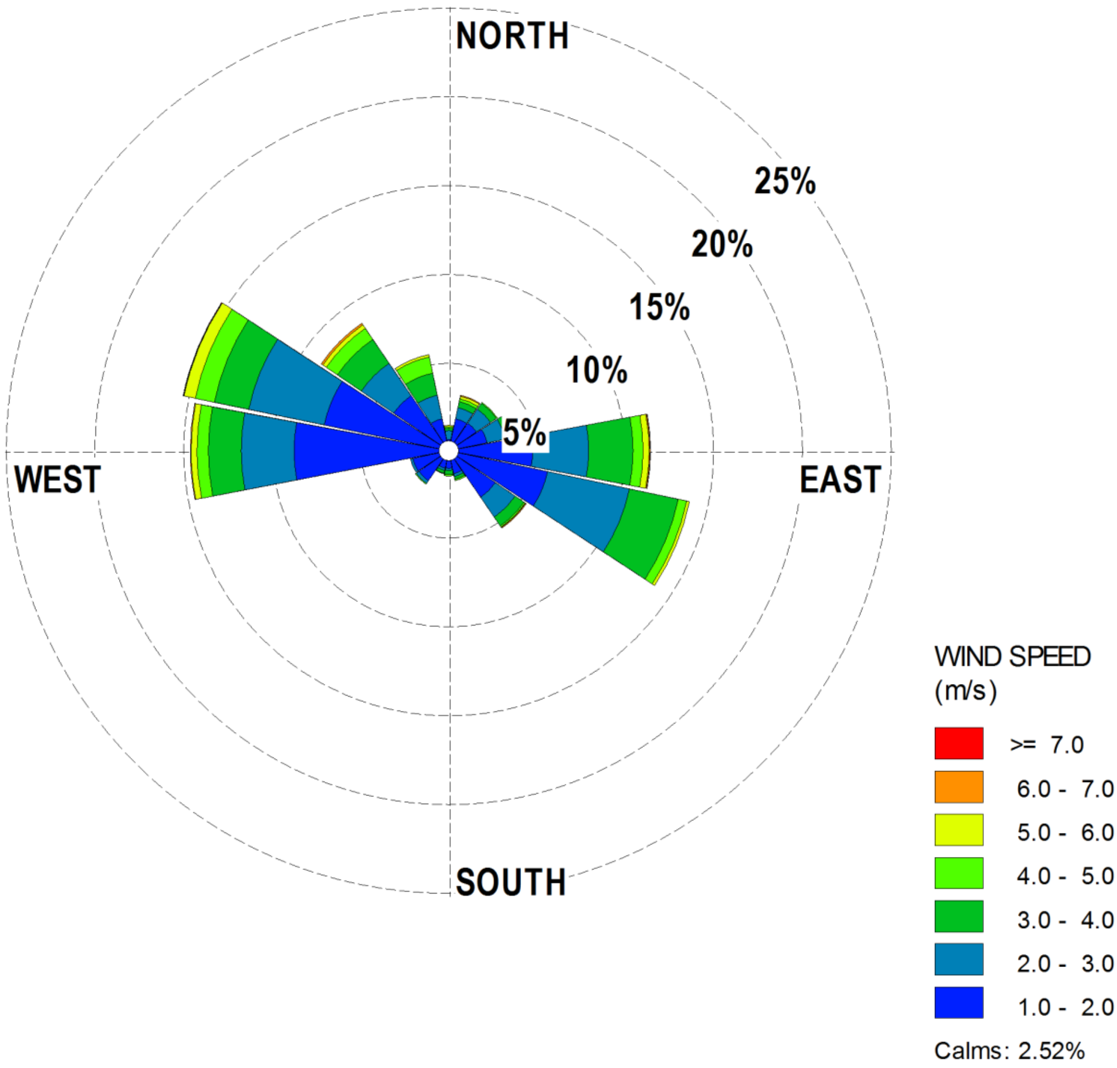
Wind Data

The wind field determines both the distance of downward transport and the rate of dilution of pollutants.

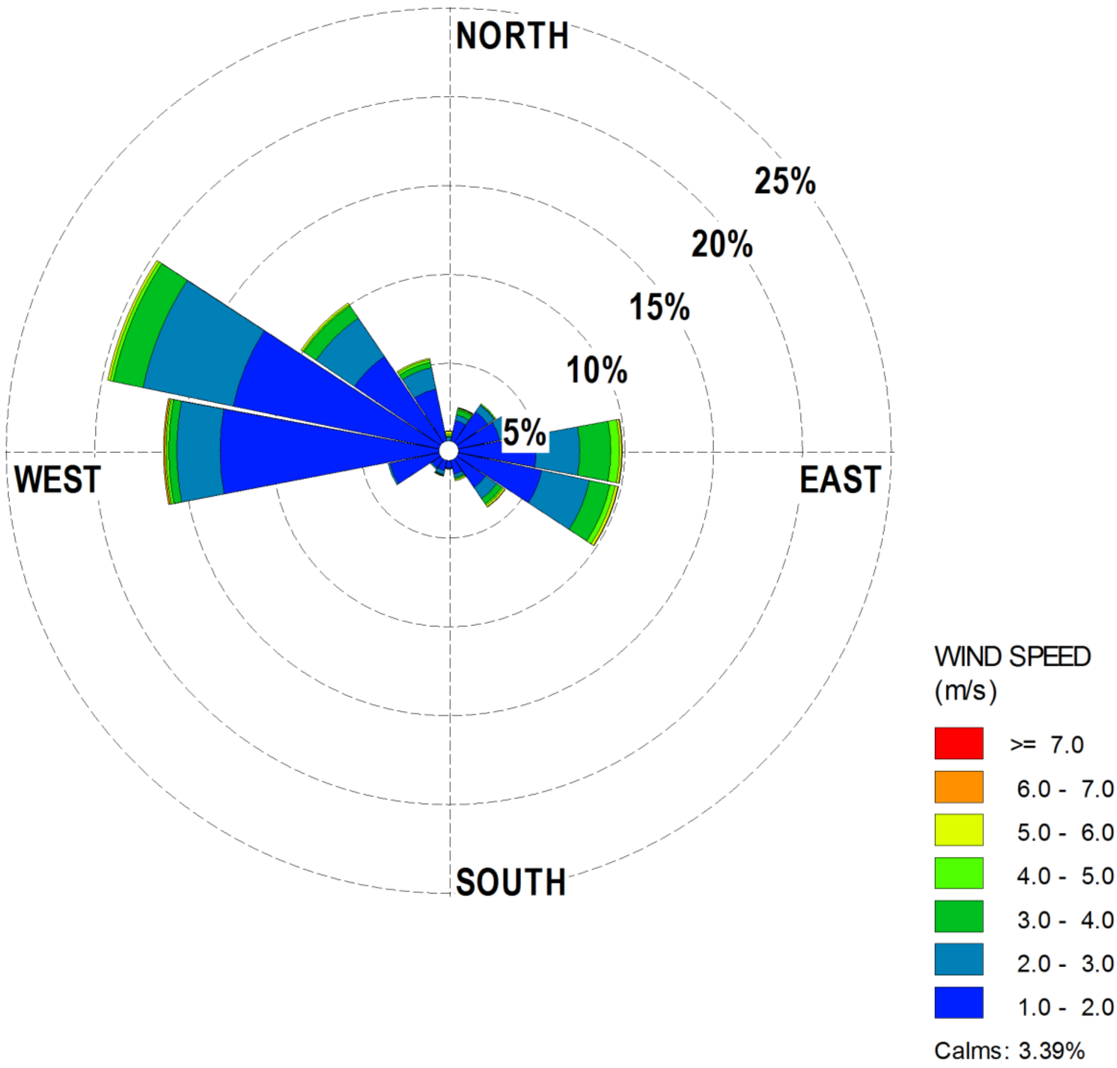
Wind roses comprise 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds, the yellow area, for example, representing winds of 5 m/s to 6 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency, at which calms occurred, i.e. periods during which the wind speed was below 1 m/s, is also indicated.

Based on data from the weather station at BPM from 7 October 2014 to 6 October 2015, wind roses generated show that the wind field was dominated by winds from the west-north-west and west (Figure 7-2). Calm conditions occurred approximately 3% of the time. During the day and night, frequent winds occurred from the west-north-westerly and westerly sectors with almost 3% calm conditions. Night-time airflow had less frequent winds from the east-south-easterly sector than the day-time and lower wind speeds. At night the percentage calm conditions increased to almost 4% (Airshed, 2016).

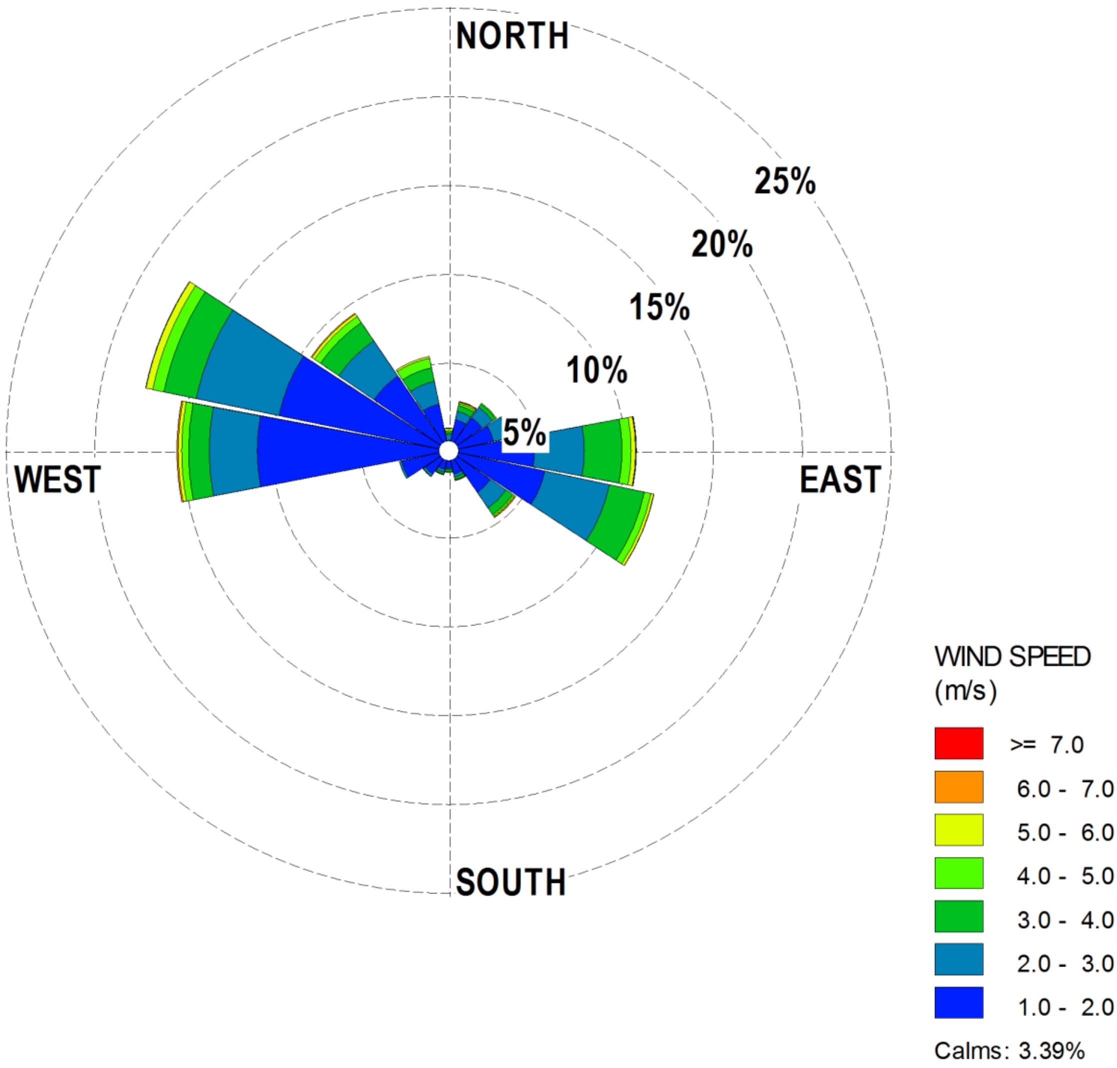
DAY WIND ROSE



NIGHT WIND ROSE



PERIOD WIND ROSE



Extreme weather conditions

The incidences of extreme weather were deduced from data from the Rustenburg weather station 05115234 for the period 1961-1990 as there was a lack of data for the period of 1994-2004. The mean annual average for thunderstorms was 71 days, for hail storms was 3 days, and for fog was 1 day (TWP, 2008). The approved BAR and EMP indicated that fairly frequent frosts occur during winter.

CONCLUSION

BPM falls within bushveld climatic conditions, with hot and wet summers and cold and dry winters. On average, winds blow from the west-north-west with less frequent winds from the east-southeast. Wind speeds hardly reach speeds higher than 5m/s. Wind direction, speed and atmospheric conditions influence the area of impact and the extent to which pollution can occur. The highest concentrations for low level releases would occur during weak wind speeds and stable (night-time) atmospheric conditions. These climatic aspects need to be taken into consideration during the assessment of impacts and the design and implementation of the mitigation measures

7.4.1.4 Soils and land capability

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

Soils are important natural resources that provide ecosystem services that are critical for life. As an ecological driver, soil is the medium in which most vegetation grows, which in turn provides food for plant-eating animals and provides habitat for a wide variety of life forms. Soil is also important for water filtration. In the context of mining related operations, soil is even more significant if one considers that mining is a temporary land use where after rehabilitation (using soil) is the key to re-establishing post closure land capability that will support post closure land uses. Soil forms rather slowly by the breaking down of rock material. Soil determines the type of land use the area is suitable for, for example, soil with low nutrients may not be able to support unassisted crop farming. Soil resources are often vulnerable to pollution, erosion and compaction, which could be caused by project-related activities.

Mining related projects have the potential to damage soil resources through physical loss of soil and/or the contamination of soils, thereby impacting on the soils' ability to sustain natural vegetation and altering land capability. Contamination of soils may in turn contribute to the contamination of surface and groundwater resources. Loss of the topsoil resource reduces chances of successful rehabilitation and restoration.

To understand the basis of the potential impacts, a soil baseline situational analysis is described below.

DATA SOURCES

The pipeline information for this section was sourced from the soil, agricultural potential, land capability and land use study by De Castro and Brits CC (De Castro and Brits, 2016d) (Appendix J). The TSF and plant information was sourced from the soil, land use and land capability study conducted by Rehab Green CC (2007) as part of the approved EIA and EMP (2008), as the 2007 specialist study covered a study area that is also relevant to the new and extended infrastructure area. A small southern section of the return water dam falls outside of the area covered in 2007 but the sampling conducted by Knight Piesold for the TSF design confirmed that the soils in that section are the same as the soils falling within the TSF area. The baseline findings of the 2007 study are thus still deemed applicable for the purposes of this report.

RESULTS

The area where the expanded TSF and additional plant infrastructure is to be placed is characterised by gabbro and norite rock. Five soil forms are present where the new and extended infrastructure is to be placed; these include Oakleaf, Shortlands, Mispah, Arcadia and Valsrivier (Rehab Green, 2007); refer to Figure 7-3 and Figure 7-4.

Seven soil forms occur along the route of the pipeline; these include Oakleaf, Shortlands, Mispah, Arcadia, Valsrivier, Sepane and Glenrosa (De Castro and Brits, 2016d). Shortlands was the most dominant and the Mispah, Sepane and Glenrosa being the least (Figure 7-5).

A description of the soil forms and associated land capabilities is provided in Table 7.5 (plant area), Table 7.6 (TSF area) and Table 7.7 and Table 7.8 (pipeline route). The distribution of the soils is shown in Figure 7-3 for the plant area, Figure 7-4 for the TSF area and Figure 7-5 for the pipeline route.

TABLE 7.5:SOIL FORMS AND ASSOCIATED LAND CAPABILITIES IN THE PLANT AREA (REHAB GREEN, 2007)

Soil Unit	Dominant Soil Form and Family	Average Depth (mm)	Summarized Description of Dominant Soil Form	Land capability	Area (ha)	% Of Total Area
Sd1	Shortlands 2210	900-1500+	Deep, well drained, red, moderate to strongly fine structured, sandy clay loam soils with occasional surface stones and stone layers within the soil profile. Gently slopes (1.5%).	Arable	102.01	20.67
E-Sd1	Shortlands 2210	100-300	Highly eroded area with similar soil properties as unit Sd1.	Grazing	0.59	0.12
Sd2	Shortlands 2210	100-400	A shallow phase of soil unit Sd1 with similar soil properties but with shallow underlying weathered or hard rock.	Grazing	5.73	1.16
Sd-S	Shortlands 2210	100-300	Similar soil properties as unit Sd1 but with scattered to dense stone layers on the surface and in the soil profile. Stones are rounded river pebbles with 30-200 mm diameter.	Grazing	16.52	3.34
E-Sd-S	Shortlands 2210	0-300	Highly eroded drainage zone with similar soil properties as unit Sd-S. Approximately 90% of the topsoil has been lost.	Wilderness	10.31	2.09
Ar1	Arcadia 1100	900-1300	Deep, strongly structured black clay soils with shrink and expand properties underlain by highly weathered rock; Occurs on flat to gently slopes (1.5%).	Grazing	122.88	24.89
E-Ar1	Arcadia 1100	400-1300	Highly eroded area with similar soil properties as unit Ar1	Wilderness	15.97	3.24
Ar1-S	Arcadia 1100	900-1300	Deep, strongly structured black clay soils with shrink and expand properties underlain by highly weathered rock with scattered river pebbles on the surface and in the soil profile; flat to gently slopes (1.5-2.5%).	Grazing	70.30	14.24
Ar1-R	Arcadia 1100	700-1200	Deep, strongly structured black clay soils with shrink and expand properties underlain by highly weathered rock frequent small rock outcrops; flat to gently slopes (1.5%)	Grazing	0.31	0.06
Bo1	Bonheim 1110	600-900	Deep, brown to dark coloured, strongly structured, clay loam to clay soils with somewhat shrink and expand properties; Occurs on gently slopes (1.5%).	Grazing	13.11	2.65
Oa1	Oakleaf 1220	600-900	Deep, well-drained, reddish brown, weekly structured, sandy clay loam, colluvial soils, characterised by many, black manganese concretions in subsoil. Flat to gently slopes (1.5%).	Arable	58.77	11.90
E-Oa1	Oakleaf 1220	400-1300	A highly eroded drainage zone with similar soil properties as unit Oa1. Consists of a deep narrow cutting of which more than 90% of the topsoil has been lost.	Wilderness	4.30	0.87
E-Oa2	Oakleaf 1220	1500+	Very steep (10-38% slopes) and highly eroded northern edge of the Elandsriver with similar soil properties as unit Oa2.	Riparian	13.18	2.67
Va1	Valsrivier 1111	600-900	Deep, well-drained, brown, moderately structured, sandy clay loam to clay loam soils on gently slopes (1.5%).	Grazing	17.70	3.58
Va2	Valsrivier 1221	600-900	Deep, well-drained, brown, strongly structured, sandy clay loam to clay loam soils on mild slopes (2-3%).	Grazing	28.67	5.81
E-Va2	Valsrivier 1221	400-700	Highly eroded drainage zones with similar soil properties as unit Va2	Wilderness	10.08	2.05
R/Ms	Mispah 1100	0-300	Rock outcrops with 10-70% surface rock. Shallow, reddish brown, sandy clay loam soils within soil rock complex.	Wilderness	2.35	0.48
Exc	-	0	Excavated areas where all topsoil has been removed.	Wilderness	0.97	0.20
				TOTAL	493.75	100.02

TABLE 7.6: SOIL FORMS AND ASSOCIATED LAND CAPABILITIES IN THE TSF AREA (REHAB GREEN, 2007)

Soil Unit	Dominant Soil Form and Family	Average Depth (mm)	Summarized Description of Dominant Soil Form	Land capability	Area (ha)	% Of Total Area
Sd1	Shortlands 2210	900-1500+	Deep, well drained, red, moderate to strongly fine structured, sandy clay loam soils with occasional surface stones and stone layers within the soil profile. Gently slopes (1.5%).	Arable	480.15	61.17
E-Sd1	Shortlands 2210	100-300	Highly eroded area with similar soil properties as unit Sd1.	Grazing	6.79	0.87
Sd2	Shortlands 2210	100-400	A shallow phase of soil unit Sd1 with similar soil properties but with shallow underlying weathered or hard rock.	Grazing	8.29	1.06
Ar1	Arcadia 1100	900-1300	Deep, strongly structured black clay soils with shrink and expand properties underlain by highly weathered rock; Occurs on flat to gently slopes (1.5%).	Grazing	255.83	32.59
E-Ar1	Arcadia 1100	400-1300	Highly eroded area with similar soil properties as unit Ar1	Wilderness	2.86	0.36
Oa2	Oakleaf 1110	1500+	Very deep, well-drained, brown, weakly structured, sandy loam to loam alluvial soils deposits on gently slopes (1.5%).	Arable	13.97	1.78
E-Oa2	Oakleaf 1220	1500+	Very steep (10-38% slopes) and highly eroded northern edge of the Elandsriver with similar soil properties as unit Oa2.	Riparian	8.19	1.04
Va1	Valsrivier 1111	600-900	Deep, well-drained, brown, moderately structured, sandy clay loam to clay loam soils on gently slopes (1.5%).	Grazing	2.94	0.37
R/Ms	Mispah 1100	0-300	Rock outcrops with 10-70% surface rock. Shallow, reddish brown, sandy clay loam soils within soil rock complex.	Wilderness	3.80	0.48
Exc	-	0	Excavated areas where all topsoil has been removed.	Wilderness	2.16	0.27
				TOTAL	**784.98**	**100.0**

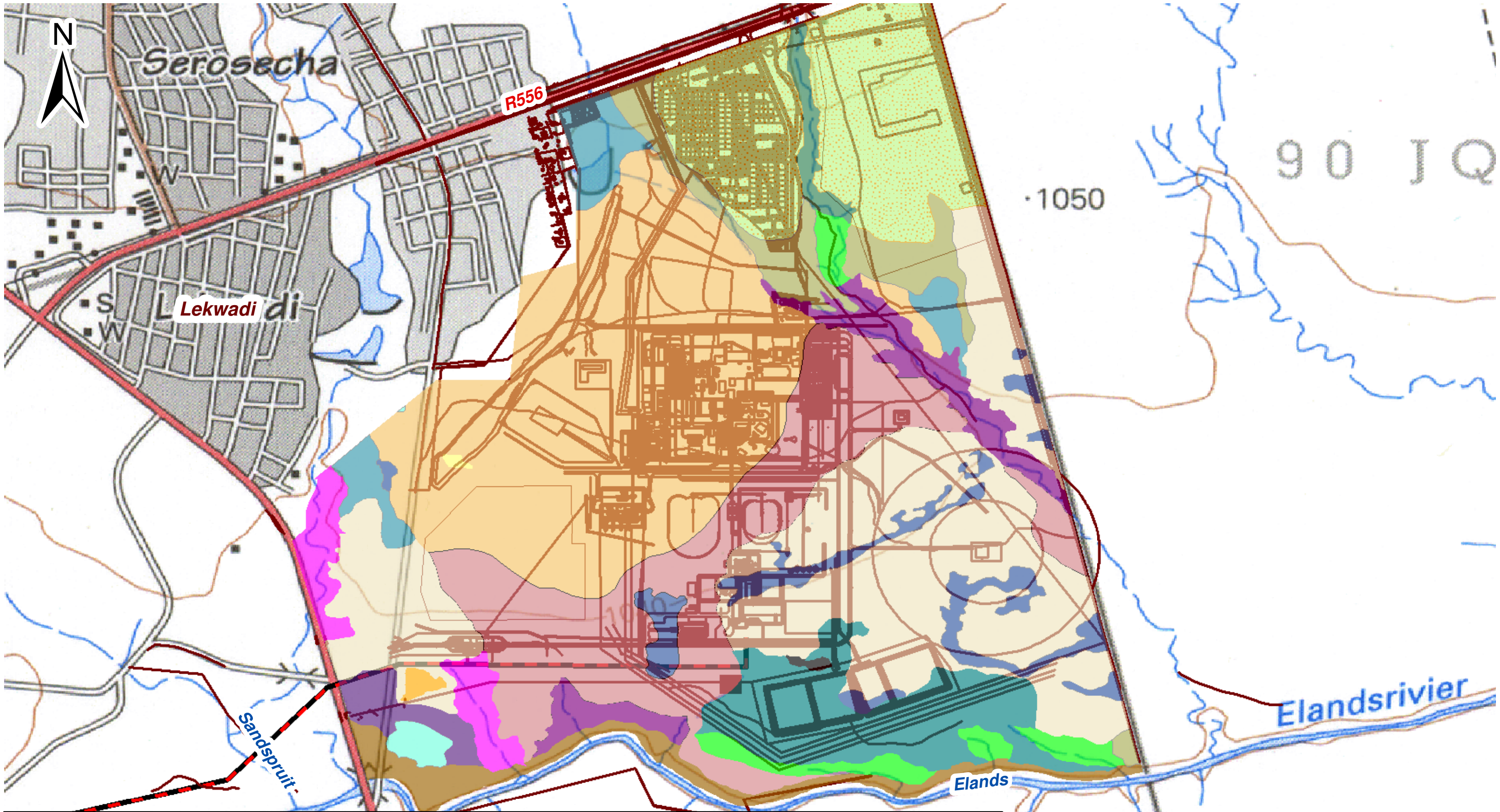
TABLE 7.7: SOIL FORMS AND ASSOCIATED LAND CAPABILITIES IN THE PIPELINE AREA (DE CASTRO AND BRITS, 2016D)

Dominant Soil Form	Average depth (mm)	Summarised description of dominant soil form	Land capability
Oakleaf	1200	The Oakleaf soil form comprises an orthic A-horizon that overlies a neocutanic B-horizon and unspecified material. The neocutanic B-horizon is characterised by colour variation due to clay movement and accumulation and exhibits an apedal or weakly developed structure.	Grazing and drainage complex
Shortlands	>1200	The Shortlands soil form comprises an orthic A-horizon that overlies a red structured B-horizon. The red structured B-horizon exhibits a uniform red colour that is not directly inherited from the rock, but is the result of the relative accumulation of iron oxides following mineral weathering. The horizon has strong rather than moderate blocky structure in the dry state.	Arable
Mispah	<300	The Mispah soil form comprises an orthic A-horizon on hard rock and is associated with the Glenrosa soil form and outcrops.	Grazing
Arcadia	150 -1200	The Arcadia soil form comprises a vertic A-horizon that overlies unspecified material. The vertic A-horizon has strongly developed structure and exhibits clearly visible, regularly occurring slickensides in some part of the horizon or in the transition to an underlying layer. The horizon has a high clay content, is dominated by smectite clay minerals and possess the capacity to swell and shrink markedly in response to moisture changes.	Arable

Dominant Soil Form	Average depth (mm)	Summarised description of dominant soil form	Land capability
Valsrivier	1500	The Valsrivier soil form comprises an orthic A-horizon which overlies a pedocutanic B-horizon and unconsolidated material without signs of wetness. The pedocutanic B-horizon has well developed angular or sub-angular structure with cutanic characteristics. Clay illuviation is common in these soils as is the presence of preferential water flow channels. These soils exhibit a sandy clay texture and are in many cases deeper than 150 cm. Calcium-magnesium carbonates nodules are present in the pedocutanic B-horizon and indicate a soil with neutral to slightly alkaline pH conditions. The calcium-magnesium carbonates nodules, in this case, is not a function of soil wetness (regular periods of inundation) but rather an indication of the parent material of the soils being of a basic igneous rock type.	Grazing (high potential) and Arable (low potential)
Sepane	500	The Sepane soil form comprises an orthic A-horizon which overlies a pedocutanic B-horizon and unconsolidated material with signs of wetness. The A- and B-horizons differ markedly in terms of texture and structure with the former being apedal and sandy while the latter is highly structured and sandy clay in texture. Manganese mottling and concretions are encountered at the transition of B- and C-horizons	Wetland / drainage line
Glenrosa	100 - 500	The Glenrosa soil form comprises an orthic A-horizon overlying a lithocutanic B-horizon. The lithocutanic B-horizon is a pedologically young horizon where clay illuviation has occurred. Soil depth ranges from 10 to 50 cm. These soils are encountered in the vicinity of rock outcrops.	Grazing

TABLE 7.8: AREA COMPRISED BY EACH SOIL FORM FOR THE PIPELINE ROUTE (DE CASTRO AND BRITS, 2016D)

Unit number	Soil Form (Soil Complex)	Area (ha)	% of total area
1	Valsrivier	11.2	14.93
2	Arcadia/Valsrivier	16.6	22.13
3	Glenrosa/Mispah	0.4	0.53
4	Glenrosa/Mispah/Valsrivier	0.6	0.80
5	Sepane/ Glenrosa/Mispah	0.1	0.13
6	Shortlands	42.9	57.20
7	Acadia	2.9	3.87
8	Oakleaf/Mispah/Valsrivier	0.3	0.40
Total		75	100



Legend

Mine Layout

Proposed Pipeline

Soil Types

Ar1	E-Va2
Ar1-R	Exc
Ar1-S	Oa1
Bo1	R/Ms
E-Ar1	Sd-S
E-Oa1	Sd1
E-Oa2	Sd2
E-Sd-S	Va1
E-Sd1	Va2

Data Source: Rehab Green CC (2007)

Kilometers

0 0.5 1

Scale: 1:24 000 @ A4

SA Grid WGS84

SoilUnit	Dominant Soil Foramtion	Soil Description
Exc	-	Excavated areas where all topsoil has been removed.
Ar1	Arcadia 1100	Deep, dark coloured, strongly structured clay soils with shrink and expand properties underlain by highly weathered rock; Occurs on flat to gently slopes (1.5%).
Ar1-S	Arcadia 1100	Deep, dark coloured, strongly structured clay soils with shrink and expand properties underlain by highly weathered rock. Frequent small surface stones; flat to gently slope (1.5%)
Ar1-R	Arcadia 1100	Deep, dark coloured, strongly structured clay soils with shrink and expand properties underlain by highly weathered rock. Frequent small rock outcrops; flat to gently slopes (1.5%)
E-Ar1	Arcadia 1100	Highly eroded area with similar soil properties as unit Ar1
E-Ar1	Arcadia 1100	Highly eroded area with similar soil properties as unit Ar1
Bo1	Bonheim 1110	Deep, brown to dark coloured, strongly structured, clay loam to clay soils with somewhat shrink and expand properties; Occurs on gently slopes (1.5%).
R/Ms	Mispah 1100	Rock outcrops with 10-70% surface rock. Shallow, reddish brown, sandy clay loam soils within soil rock complex.
E-Oa1	Oakleaf 1220	Highly eroded drainage zone (deep narrow cutting) of which more than 90% of the topsoil has been removed. Have similar soil properties as unit Oa1.
E-Oa2	Oakleaf 1220	Very steep (10-38% slopes) and highly eroded northern edge of the Elandsriver with similar soil properties as unit Oa2.
Oa1	Oakleaf 1220	Deep, well-drained, reddish brown colluvial soils on gently slopes (1.5%). Weekly structured, sandy clay loam, characterised by many, black manganese concretions in the subsoil.
Sd-S	Shortlands 2210	Similar soil properties as unit Sd1 but slightly scattered to dense stone layers on the surface and in the soil profile. Stones are rounded river pebbles with 30-200 mm diameter.
E-Sd-S	Shortlands 2210	Highly eroded drainage zone with similar soil properties as unit Sd-S. Approximately 90% of the topsoil has been lost.
Sd1	Shortlands 2210	Deep, well drained, red, moderate to strongly structured, sandy clay loam soils with occasional surface stones and stone layers within the soil profile. Gently slopes (1.5%).
E-Sd1	Shortlands 2210	Highly eroded area with similar soil properties as unit Sd1.
Sd-S	Shortlands 2210	Similar soil properties as unit Sd1 but slightly scattered to dense stone layers on the surface and in the soil profile. Stones are rounded river pebbles with 30-200 mm diameter.
E-Sd-S	Shortlands 2210	Highly eroded drainage zone with similar soil properties as unit Sd-S. Approximately 90% of the topsoil has been lost.
Sd1	Shortlands 2210	Deep, well drained, red, moderate to strongly structured, sandy clay loam soils with occasional surface stones and stone layers within the soil profile. Gently slopes (1.5%).
Sd2	Shortlands 2210	A shallow phase of soil unit Sd1. Similar soil properties as unit Sd1 but with shallow underlying weathered or hard rock.
Va1	Valsrivier 1111	Deep, well-drained, brown, moderately structured, sandy clay loam to clay loam soils on gently slopes (1.5%).
E-Va2	Valsrivier 1221	Highly eroded areas with similar soil properties as unit Va2
Va2	Valsrivier 1221	Deep, well-drained, brown, strongly structured, sandy clay loam to clay loam soils on mild slopes (2-3%).

BAKUBUNG PLATINUM MINE (PTY) LTD

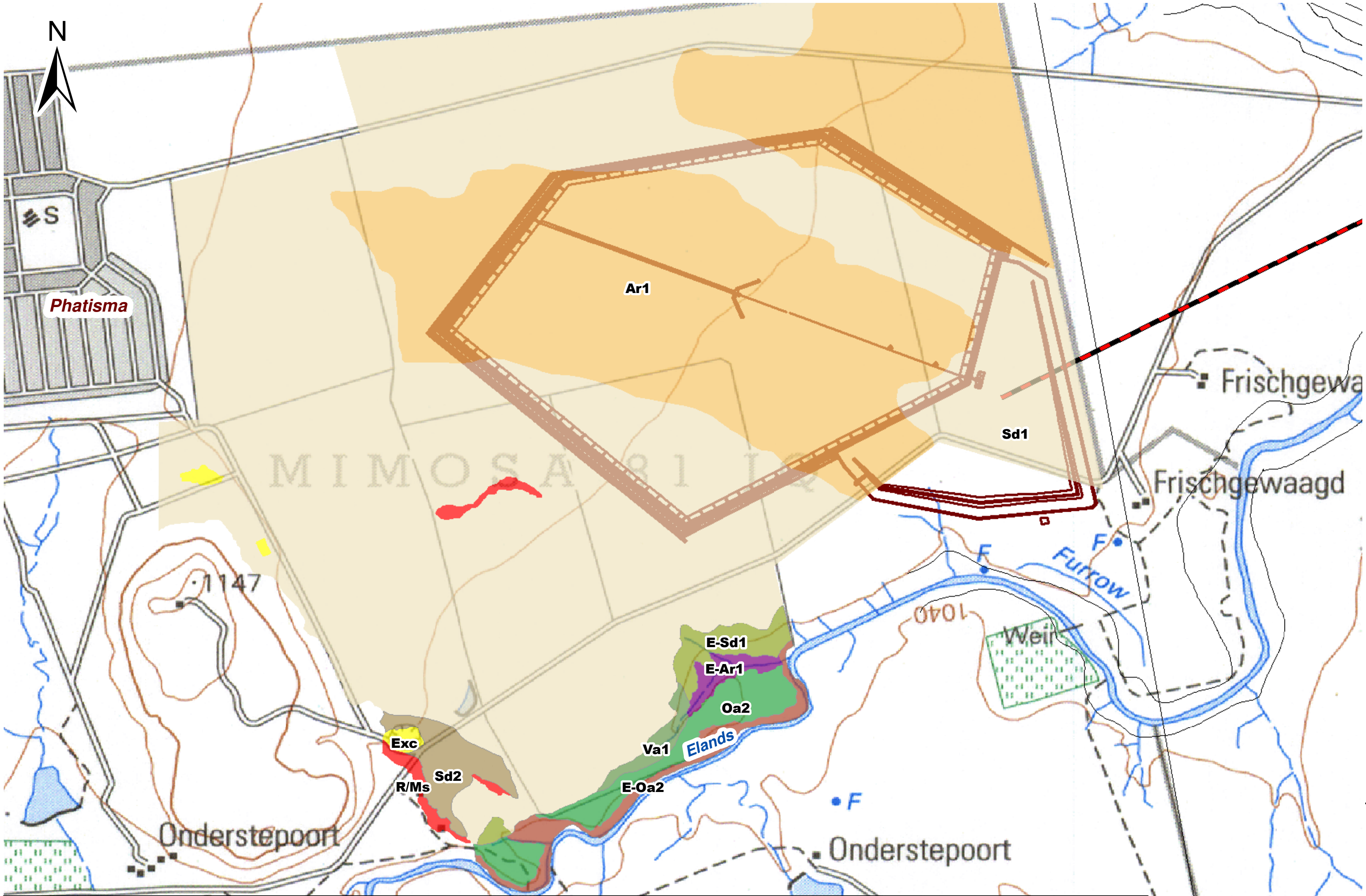
Figure 7.3

Soil Types in the Plant Area

SLR

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006 March 2016



Soil Unit	Dominant Soil Form	Soil Description
Ar1	Arcadia 1100	Deep, dark coloured, strongly structured clay soils with shrink and expand properties underlain by highly weathered rock; Occurs on flat to gently slopes (1.5%).
E-Oa2	Oakleaf 1220	Very steep (10-38% slopes) and highly eroded northern edge of the Elandsriver with similar soil properties as unit Oa2.
Oa2	Oakleaf 1110	Very deep, well-drained, brown, weakly structured, sandy loam to loam alluvial soils deposits on gently slopes (1.5%).
E-Ar1	Arcadia 1100	Highly eroded area with similar soil properties as unit Ar1
E-Sd1	Shortlands 2210	Moderately eroded areas on mild to slightly steep slopes (3-8%) with similar soil properties as unit Sd1. Mainly sheet erosion with occasional rills and gullies.
Va1	Valsrivier 1111	Deep, well-drained, brown, moderately structured, sandy clay loam to clay loam soils on gently slopes (1.5%).
E-Sd1	Shortlands 2210	Moderately eroded areas on mild to slightly steep slopes (3-8%) with similar soil properties as unit Sd1. Mainly sheet erosion with occasional rills and gullies.
Sd1	Shortlands 2210	Deep, well drained, red, moderate to strongly structured, sandy clay loam soils with occasional surface stones and stone layers within the soil profile. Gently slopes (1.5%).
R/Ms	Mispah 1100	Rock outcrops with 10-70% surface rock. Shallow, reddish brown, sandy clay loam soils within soil rock complex.
Exc	-	Excavated areas where all topsoil has been removed.
Sd2	Shortlands 2210	A shallow phase of soil unit Sd1. Similar soil properties as unit Sd1 but with shallow underlying weathered or hard rock.

Legend

Mine Layout

Proposed Pipeline

Soil Types

- Ar1
- E-Ar1
- E-Oa2
- E-Sd1
- Exc
- Oa2
- R/Ms
- Sd1
- Sd2
- Va1

Data Source: Rehab Green CC (2007)

Kilometers

0 0.5 1

Scale: 1:25 000 @ A4

SA Grid WGS84

BAKUBUNG PLATINUM MINE (PTY.) LTD

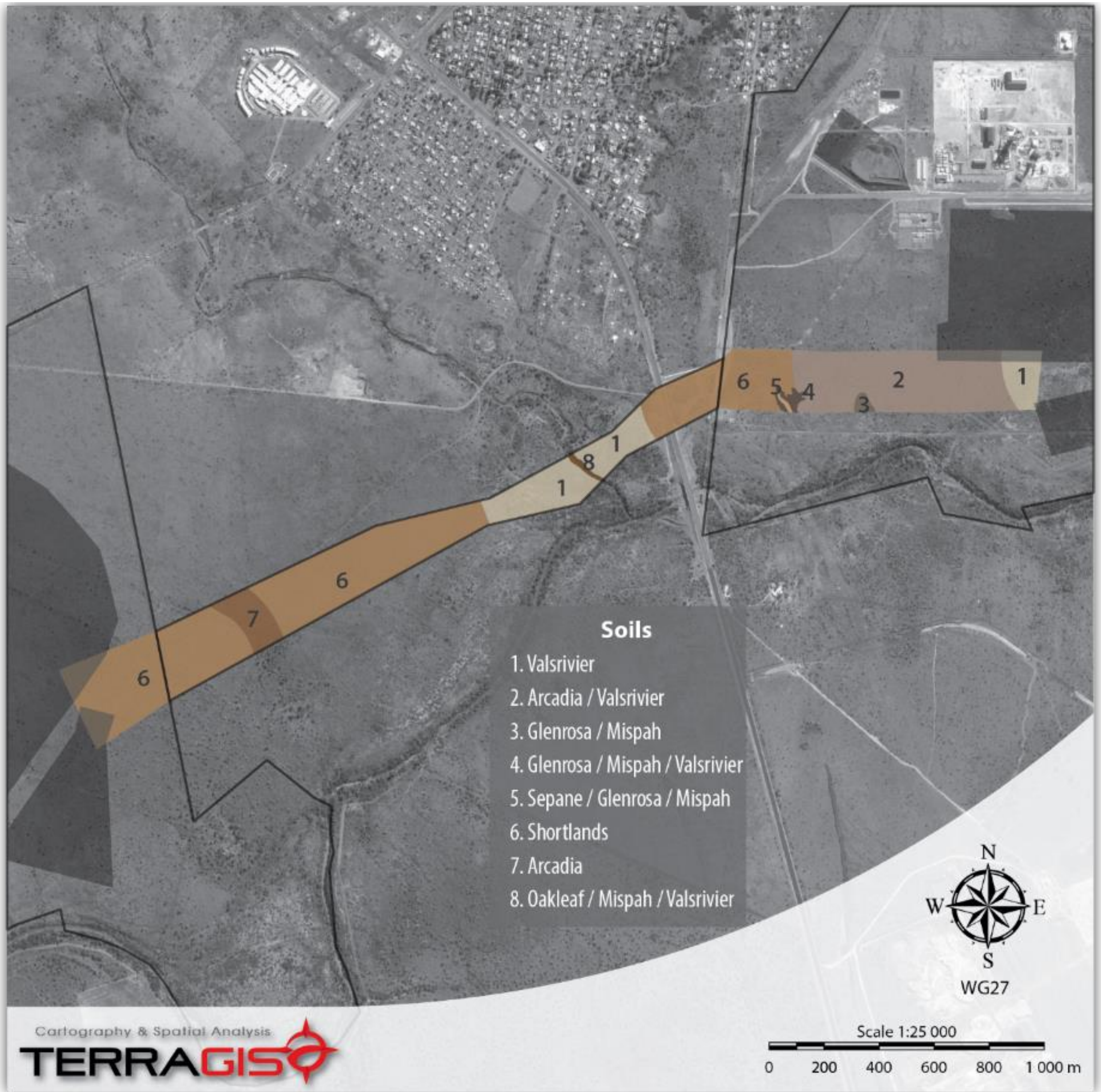
Figure 7.4

Soils Types in the TSF Area

SLR

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006 | March 2016



6
5
4
2
1
3
1
8
1
6
7
6
Soils
1. Valsrivier
2. Arcadia / Valsrivier
3. Glenrosa / Mispah
4. Glenrosa / Mispah / Valsrivier
5. Sepane / Glenrosa / Mispah
6. Shortlands
7. Arcadia
8. Oakleaf / Mispah / Valsrivier
N
W
E
S
WG27
Cartography & Spatial Analysis
TERRAGIS
Scale 1:25 000
0
200
400
600
800
1 000 m

Soil chemical properties

The general chemical properties of the soils located within the study area are discussed below.

From the 2007 soil assessment, the average pH values of the black clay soils (Arcadia form) varied from 7.1-8.4 indicating neutral to fairly alkaline conditions. Free lime was not found in the soil matrix during the field assessment although small lime nodules were frequently found at depths below 700 mm. The average pH values of the red, fine structured soils (Shortlands form) varied from 6.0-6.9 indicating slightly acid to neutral conditions. The average pH values of alluvial and colluvial soils along the Elands River (Oakleaf and Valsrivier forms) varied from 6.5-8.1, which indicated slightly acid to fairly alkaline conditions.

The average phosphorus values varied from 0.09-4.38 mg/kg indicating very low concentrations. The average cation values for K, Ca and Mg indicated moderate to high concentrations, thus moderate to high fertility. The average Na concentrations and calculated exchangeable sodium percentage was low and indicated the absence of sodic soils. The cation exchange capacity (CEC) values of the black clay soils were high (27.5-57.2 cmol(+)/kg) and indicated fairly unstable conditions which can lead to serious soil erosion in sensitive landscapes. The CEC values of the other soils varied from 6.2-18.2 cmol(+)/kg) which is fairly low to moderate and indicated low to moderate erodibility.

The 2016 assessment indicated that the soils of the study area do have the capacity to buffer chemical change. The soils are high in 2:1 swelling-shrinking clays which have the capacity to sorb high levels of cationic heavy metals, especially under near neutral to slightly alkaline pH values and oxidising conditions. However, these soils can reach a saturation point in terms of metal sequestration.

Sensitivity

High potential arable land, drainage lines and wetland soils prone to erosion are considered by the specialists to be sensitive soil resources. For the plant and TSF areas, the sensitive landscapes are near and around the drainage lines and the Eland River. For the pipeline route, the areas allocated as 3, 4 and 6 (Figure 7-5) were considered as having high sensitivity.

Land Use

The pipeline and TSF area is used for grazing. BPM is currently allowing cattle to graze within the TSF footprint until such time as construction of the TSF commences. Construction has already started at the plant area and thus is used for mining related activities. The surrounding land uses include mining, grazing, cultivation, natural vegetation, and residential (formal and informal).

Land capability and Agricultural potential

With reference to Table 7.5 and Table 7.6, four land capability classes were identified for the plant and TSF areas; these include arable, grazing, riparian and wilderness. At the TSF site, arable was the dominant land capability and at the plant area grazing was dominant. Along the pipeline route Table 7.7, the land capability includes arable, grazing and riparian areas (drainage complexes). Soils were grouped into the following land capability classes, high potential arable land, medium potential arable land, high potential grazing/low to medium potential arable land, low to medium potential grazing land/drainage complex, low potential grazing land/drainage complex and wetland/drainage line. High potential arable land was dominant.

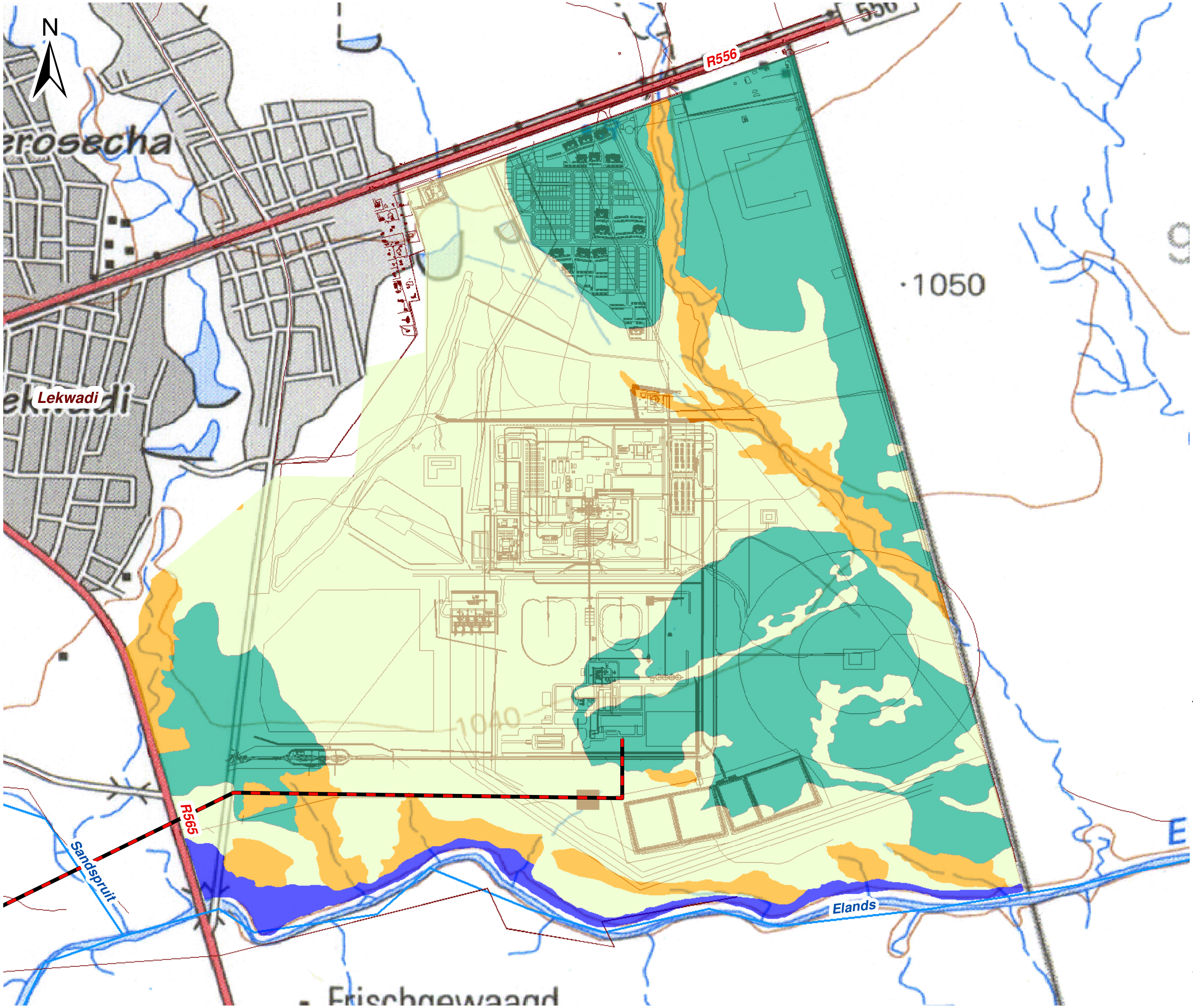
<u>Irrigation potential</u>

Three classes of irrigation potential were identified along the pipeline route:

- Class 1. Highly suitable for irrigation, few or no limitations and preconditions. Topography is flat, soils are well drained, of moderate permeability and deep, medium textured with a high water holding capacity.
- Class 3. Low suitability with moderately severe limitations, imperfect or somewhat excessively drained soils, slow or rapid permeability or shallow soils.
- Class 4. Not suitable for irrigation under most conditions with severe limitations.

With reference to Figure 7-8, the high potential arable land had soils suited to dry-land crop production and fell into Class 1. The medium potential arable land had soils suited to dry-land crop production and fell into Class 3. The high potential grazing/low to medium potential arable land had soils suited to dry-land crop production and fell into Class 4. The remaining areas along the pipeline route were not suitable for crop production as they fell within drainage complexes, the Eland River and/or a wetland system.

For the plant and TSF areas, Sd1 (Shortlands) and Oa1 (Oakleaf) were considered to have high irrigation potential (Figure 7-6 and Figure 7-7).



Legend

Mine Layout

Proposed Pipeline

Land Capability

Arable

Grazing

Riparian

Wilderness

Data Source: Rehab Green CC (2007)

Kilometers

0 0.4 0.8

Scale: 1:18 000 @ A4

SA Grid WGS84

BAKUBUNG PLATINUM MINE (PTY) LTD

Figure 7.6

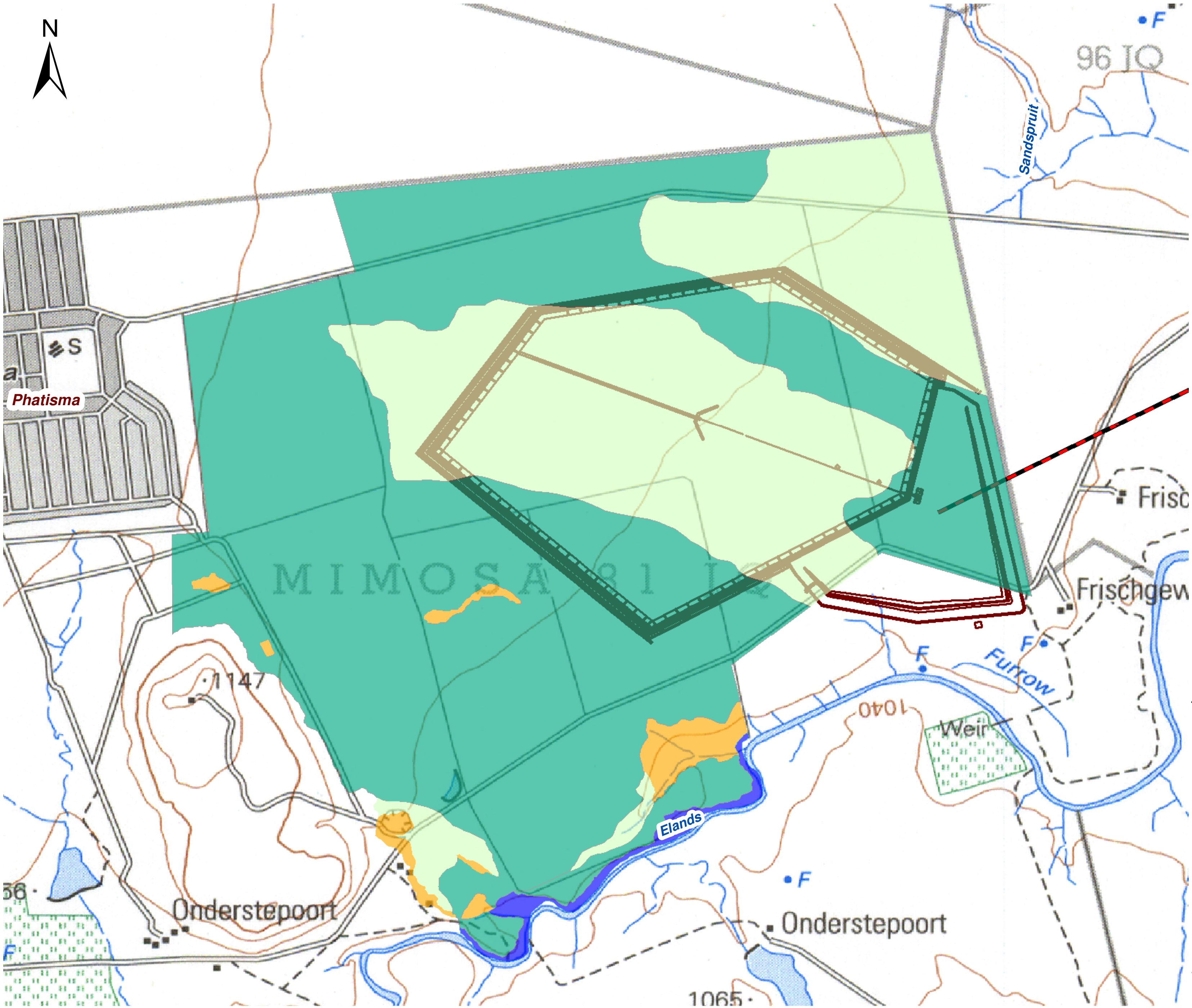
Land Capability in the Plant Area

SLR

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006

March 2016



Legend

Mine Layout

Proposed Pipeline

Land Capability

Arable

Grazing

Riparian

Wilderness

Data Source: Rehab Green CC (2007)

Kilometers

0 0.5 1

Scale: 1:24 000 @ A4

SA Grid WGS84

BAKUBUNG PLATINUM MINE (PTY) LTD

Figure 7.7

Land Capability in the TSF Area

SLR

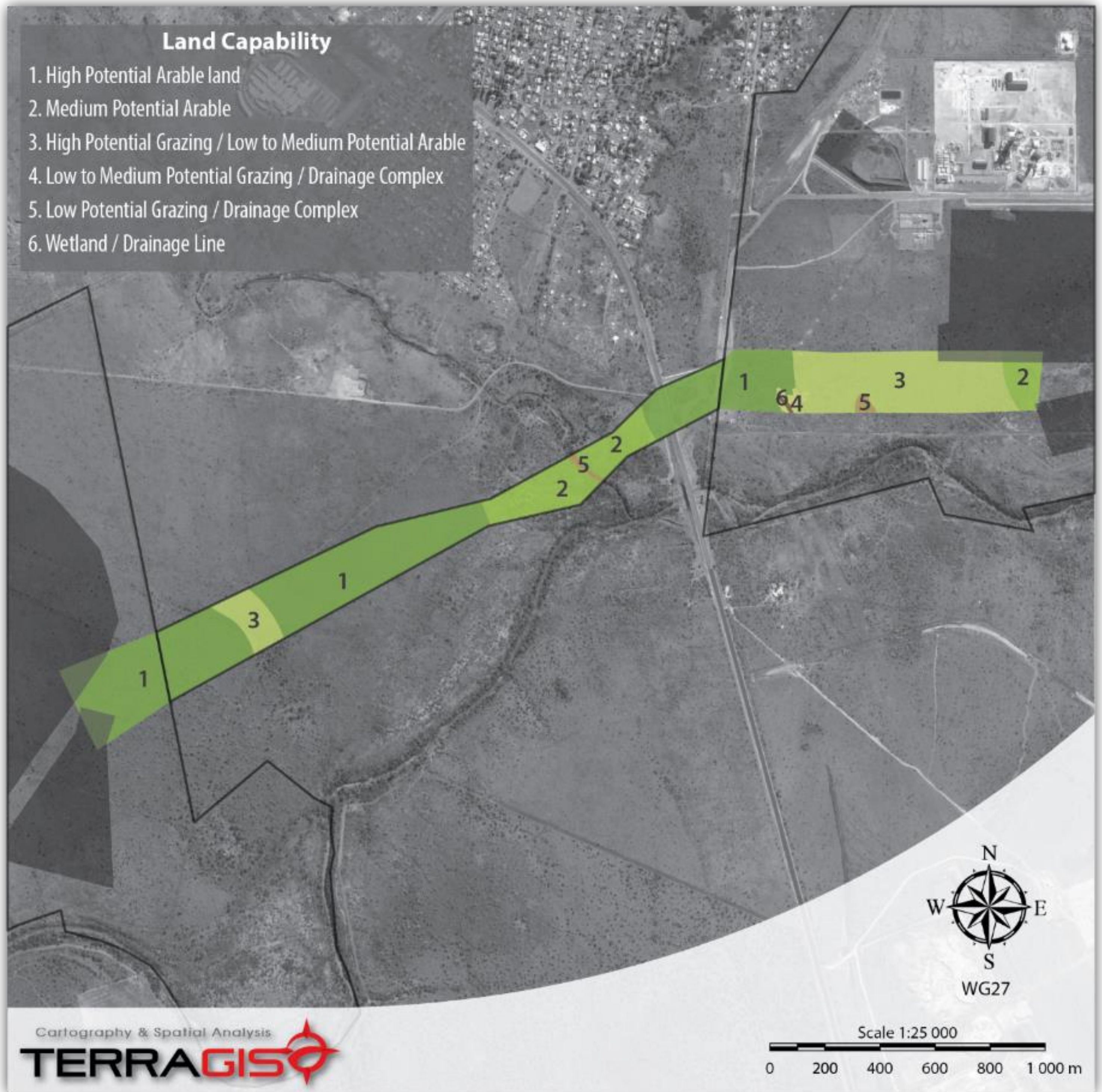
SLR Consulting (Africa) (Pty) Ltd

P O Box 1596,Cramerview, 2060, South Africa

Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006

March 2016



Land Capability
1. High Potential Arable land
2. Medium Potential Arable
3. High Potential Grazing / Low to Medium Potential Arable
4. Low to Medium Potential Grazing / Drainage Complex
5. Low Potential Grazing / Drainage Complex
6. Wetland / Drainage Line
N
W
E
S
WG27
Scale 1:25 000
0 200 400 600 800 1 000 m
Cartography & Spatial Analysis
TERRAGIS

CONCLUSION

The study area comprises a range of soil types with varying land capabilities. High potential arable land, drainage lines and wetland soils prone to erosion are considered by the specialists to be sensitive soil resources; these occur along the majority of the pipeline route, the eastern edge of the PCDs, and the southern edge of the Phase 1a mine housing. A re-alignment of a section of the pipeline near the plant area has been suggested by the specialist to avoid sensitive drainage areas. This has been taken into consideration in the final route alignment. Moving the other section of the pipeline won't have significant differences as similar soils are expected to be found. The soils on site also have high arable, grazing and irrigation potential, therefore increases in the overall footprint of the mine need to be carefully planned. Soils disturbed by the project will require appropriate management measures during construction and operation to minimise the loss of soil resources through pollution and physical disturbance including erosion, soil compaction and stripping.

7.4.1.5 Biodiversity

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

In the broadest sense, biodiversity provides value for ecosystem functionality, aesthetic, spiritual, cultural, and recreational reasons. The known value of biodiversity and ecosystems is as follows:

- soil formation and fertility maintenance
- primary production through photosynthesis, as the supportive foundation for all life
- provision of food and fuel
- provision of shelter and building materials
- regulation of water flows and water quality
- regulation and purification of atmospheric gases
- moderation of climate and weather
- control of pests and diseases
- maintenance of genetic resources.

The establishment of additional mining-related infrastructure and support facilities have the potential to result in the loss of vegetation, habitat and related ecosystem functionality through physical disturbance and/or contamination of soil, air and/or water resources.

As a baseline, this section provides an outline of the type of vegetation occurring in the project area and the status of the vegetation and highlights the occurrence of sensitive ecological environments including sensitive/endangered species (if present) that require protection and/or additional mitigation should they be disturbed. Some habitat has been removed/disturbed in the process of establishing the approved operations and the related surface infrastructure

DATA SOURCES

Information in this section is sourced from the approved EIA and EMP (TWP, 2008) (where relevant) and the following studies:

- Aquatic ecological assessment: Scientific Aquatic Services (2015) - Appendix M
- Vegetation assessment: De Castro and Brits (2016a) - Appendix K
- Watercourse assessment: De Castro and Brits (2016b) - Appendix I
- Faunal assessment: De Castro and Brits (2016c) - Appendix L

The specialist studies specified above covered areas applicable to both the approved and proposed project footprints. The information presented in the specialist report reflects a combination (in undisturbed areas) of the pre-mining state of the biodiversity in 2007 and in disturbed areas, the transformation that has occurred as a result of the mine development. According to the specialist, when comparing the vegetation findings of the two studies, there are correlations between the identified vegetation types with some differences (aside from name categories). For the purposes of this report, the more recent 2016 specialist findings have been used to inform the baseline. Further detail on the methodologies used is provided in the specialist reports.

RESULTS – NATIONAL GUIDELINES

<u>Importance of the project area according to National Guidelines</u>

The Mining and Biodiversity Guideline

According to the Mining and Biodiversity Guideline (DEA et al, 2013), the plant and shaft project area falls within the highest and high biodiversity categories and the TSF site falls within the high biodiversity category (Figure 7-9). This is described below:

- Highest biodiversity areas are generally areas with critically endangered ecosystems, critical biodiversity areas (CBAs), river and wetland freshwater ecosystem priority areas (FEPAs) and 1 km buffer zone around these areas, and RAMSAR sites. The implication for mining projects is that environmental assessments should focus on confirming the presence and significance of the biodiversity features and to provide site-specific basis on which to apply the mitigation hierarchy to inform regulatory decision making.
- High biodiversity areas generally comprise protected area buffer zones, transfrontier conservation areas, other identified areas from provincial spatial biodiversity plans, high water yield areas. The implication for mining projects is that environmental assessment should include an assessment of the optimum, sustainable land use and determine the impacts on biodiversity.

National Environmental Management: Biodiversity Act

The National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEMBA) provides for listing of threatened or protected ecosystems. Threatened ecosystems are listed in order to reduce the rate of ecosystem and species extinction by preventing further degradation and loss of structure, function and composition of threatened ecosystems. The purpose of listing protected ecosystems is primarily to conserve sites of exceptionally high conservation value. For the project area, approximately 45% of the land cover is

Marikana Thornveld (De Castro and Brits, 2016a) which is classified as vulnerable (Figure 7-10 and Figure 7-11).

National Protected Area Expansion Strategy

A National Protected Area Expansion Strategy (NPAES) has been developed by the South African National Botanical Institute (SANBI) and aims to achieve cost effective protected area expansion for ecological sustainability and adaptation to climate change. The NPAES sets targets for protected area expansion, provides maps of the most important areas for protected area expansion, and makes recommendations on mechanisms for protected area expansion. According to the NPAES database, the project area does not fall within an area earmarked for expansion of a National Protected Area.

Freshwater Ecosystem Priority Areas Project

The National Freshwater Ecosystem Priority Areas Project (NFEPA) was developed by SANBI, DWA and other stakeholders and organisations. This project was aimed at identifying strategic spatial priority areas for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. There are two wetlands indicated on the NFEPA wetland dataset to be within the project area. These are located near the Mine Housing Phase 1 but do not overlap with the infrastructure footprint. The wetland study confirmed that these wetlands are artificial wetlands in the form of dams and there are no other FEPA wetlands present within the project footprint (De Castro and Brits, 2016b; Figure 7-12).

Critical Biodiversity Areas (CBAs)

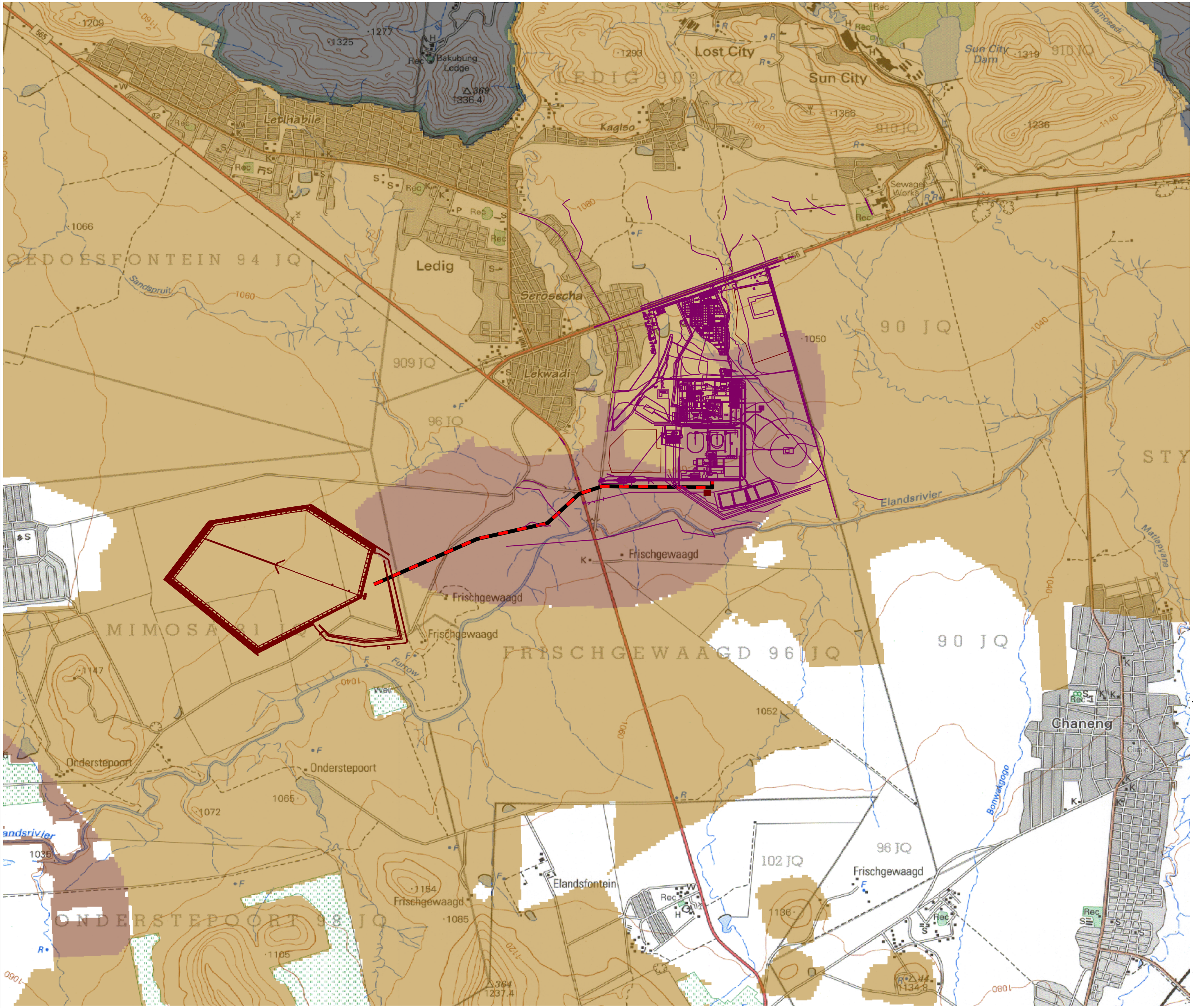
The North-West Province published a biodiversity conservation assessment report in 2009, which includes a list of CBAs. These areas are terrestrial and aquatic features that are critical for retaining biodiversity and supporting continued ecosystem functioning and services. The North West Biodiversity Sector Plan (NWBSP) 2015 has recently been completed which provides updated information on CBAs and Ecological Support Areas (ESAs). The NWBSP is not yet available on the SANBI or BGIS websites but a copy of the NWBSP and shapefiles for the CBAs was obtained by the vegetation specialist from the North West Department of Rural, Environment and Agricultural Development for this project (De Castro and Brits, 2016a).

The NWBSP showed that the majority of the project area falls within CBA 2 with small areas falling within ESA1 and ESA2 and small areas mapped as No Natural Habitat Remaining (Figure 7-13). The vegetation specialist indicated that based on the available GIS information for the NWBSP, the principal criteria for allocating CBA 2 status to the habitats of the study area is that the habitats are regarded as 'Natural Corridor Linkage' and 'Natural Protected Area Buffer' (within 5km of the Pilanesberg National Park) areas. The small area of ESA1 in Mimosa is based on the 'Natural Corridor Linkage' criteria and the small area of ESA2 in Mimosa is based on the 'Natural Corridor Linkage' criteria (De Castro and Brits, 2016a). Appendix K, the vegetation impact assessment provides a description of the land management objectives for each of these categories, extracted from Table 12 of the NWBSP 2015.

It should be noted that the vegetation specialist indicated that the NWBSP mapping for the study area is not accurate as CBA2 includes large areas of secondary vegetation of historically cultivated areas or permanently transformed areas (i.e. mine shaft complex and associated infrastructure). Approximately 42.9% of the area mapped as CBA2 within the study area comprises transformed habitats with secondary vegetation or no vegetation. The CBA and ESA land management

National Biodiversity Assessment

The National Biodiversity Assessment (NBA) conducted in 2011 was led by the SANBI in partnership with the Department of Environmental Affairs and a range of other organisations. The study provides an assessment of South Africa's biodiversity and ecosystems. This assessment also provides a summary of biodiversity priority areas that have been identified through systematic plans at national, provincial and local levels. The project area is not located within a formally or informally protected area in terms of this assessment, though the project area (and approved mine) falls within the 'Natural Protected Area Buffer' by being within 5 km of the protected Pilanesberg National Park (De Castro and Brits, 2016a).



Legend

- Mine Layout
- Proposed Pipeline

Mineguide Category

- A. Legally Protected - Mining Prohibited
- B. Highest Biodiversity Importance - Highest Risk for Mining
- C. High Biodiversity Importance - High Risk to Mining

Data Source:
South African National Biodiversity Institute (SANBI) 2012

Kilometers
0 1.5 3

Scale: 1:60 000 @ A4

SA Grid WGS84

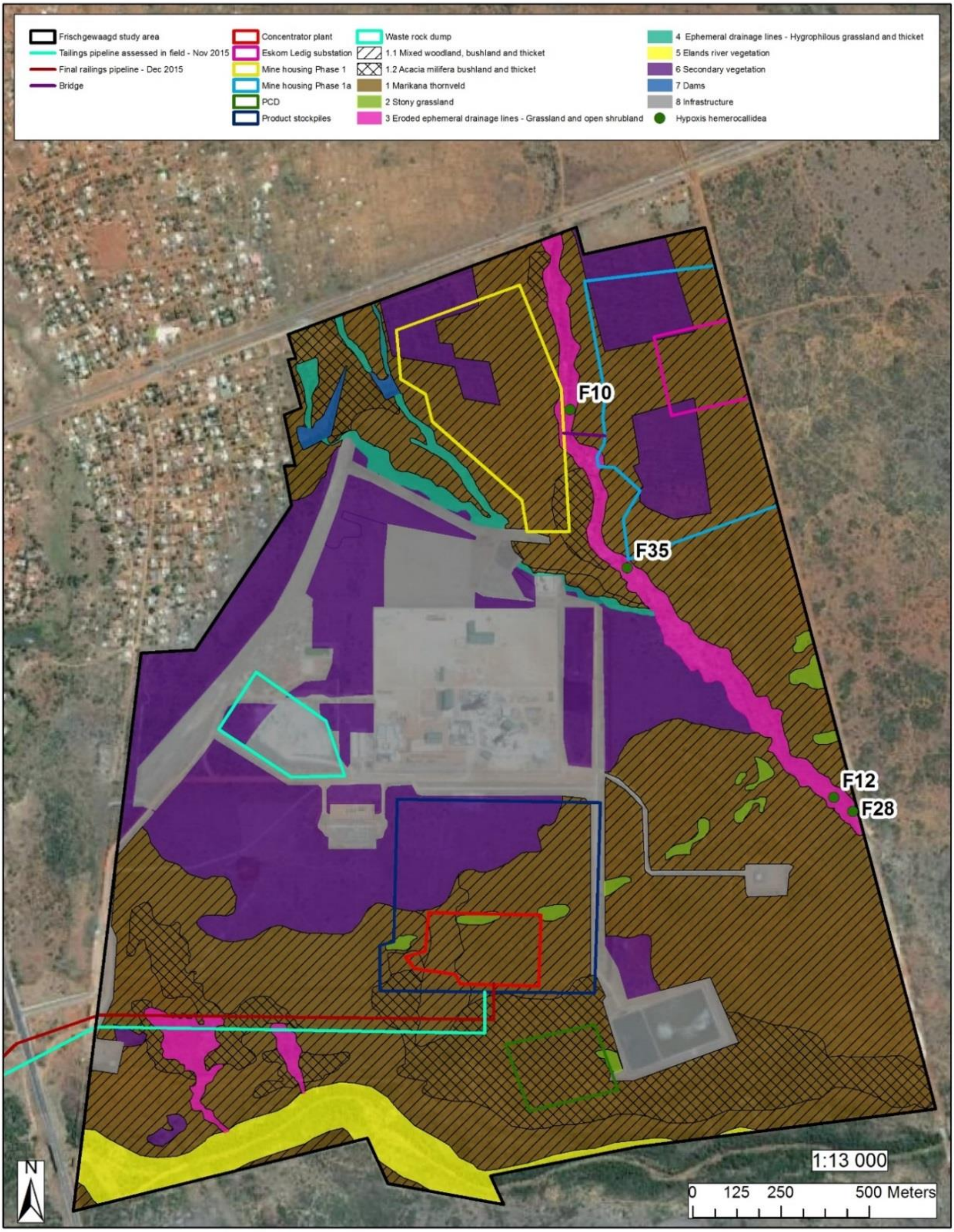
BAKUBUNG PLATINUM MINE (PTY) LTD

Figure 7.9

National Mining Biodiversity Priority Areas

SLR
SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

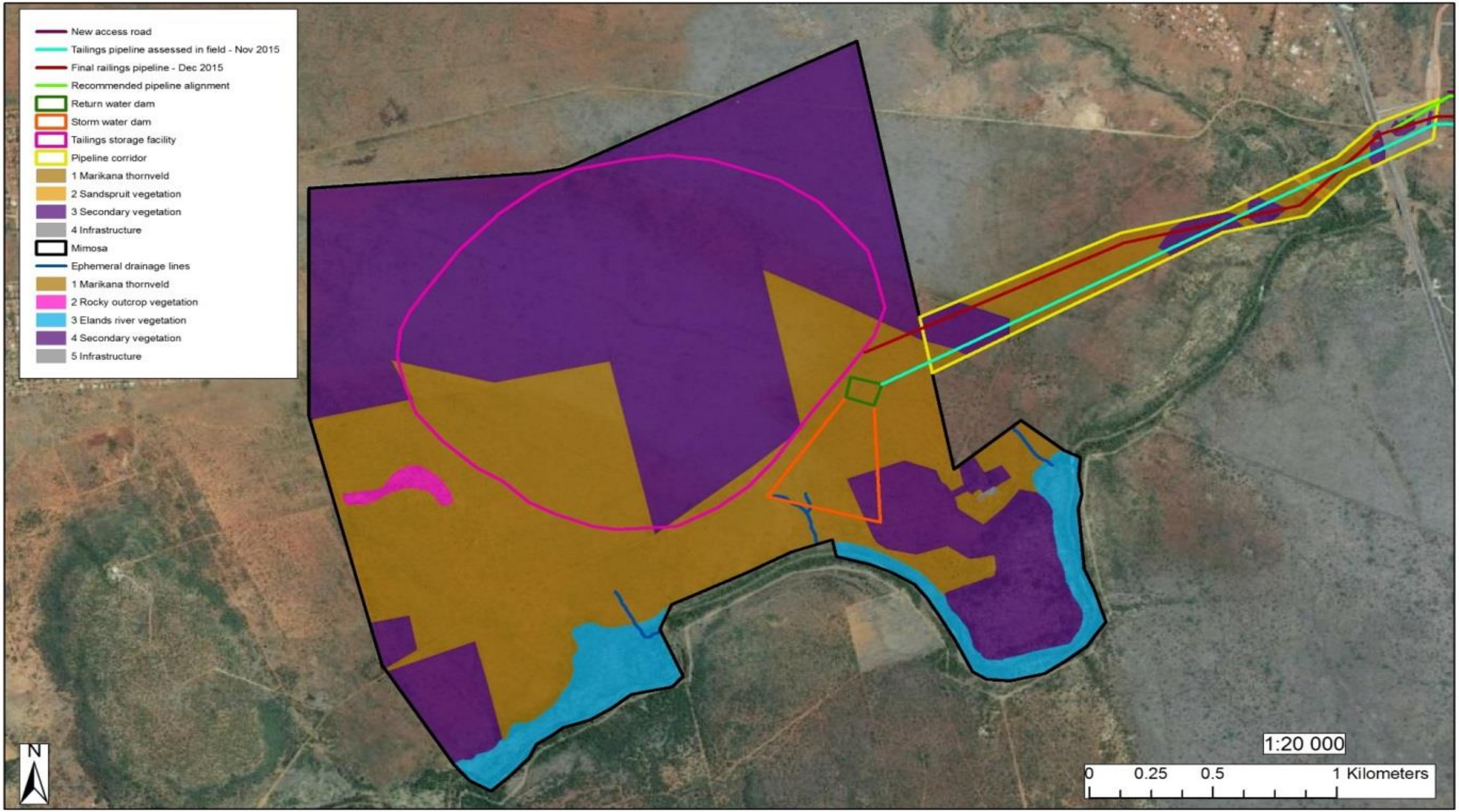
710.23001.00006 | March 2016



Vegetation map for Frischgewaagd

January 2016
Created by:

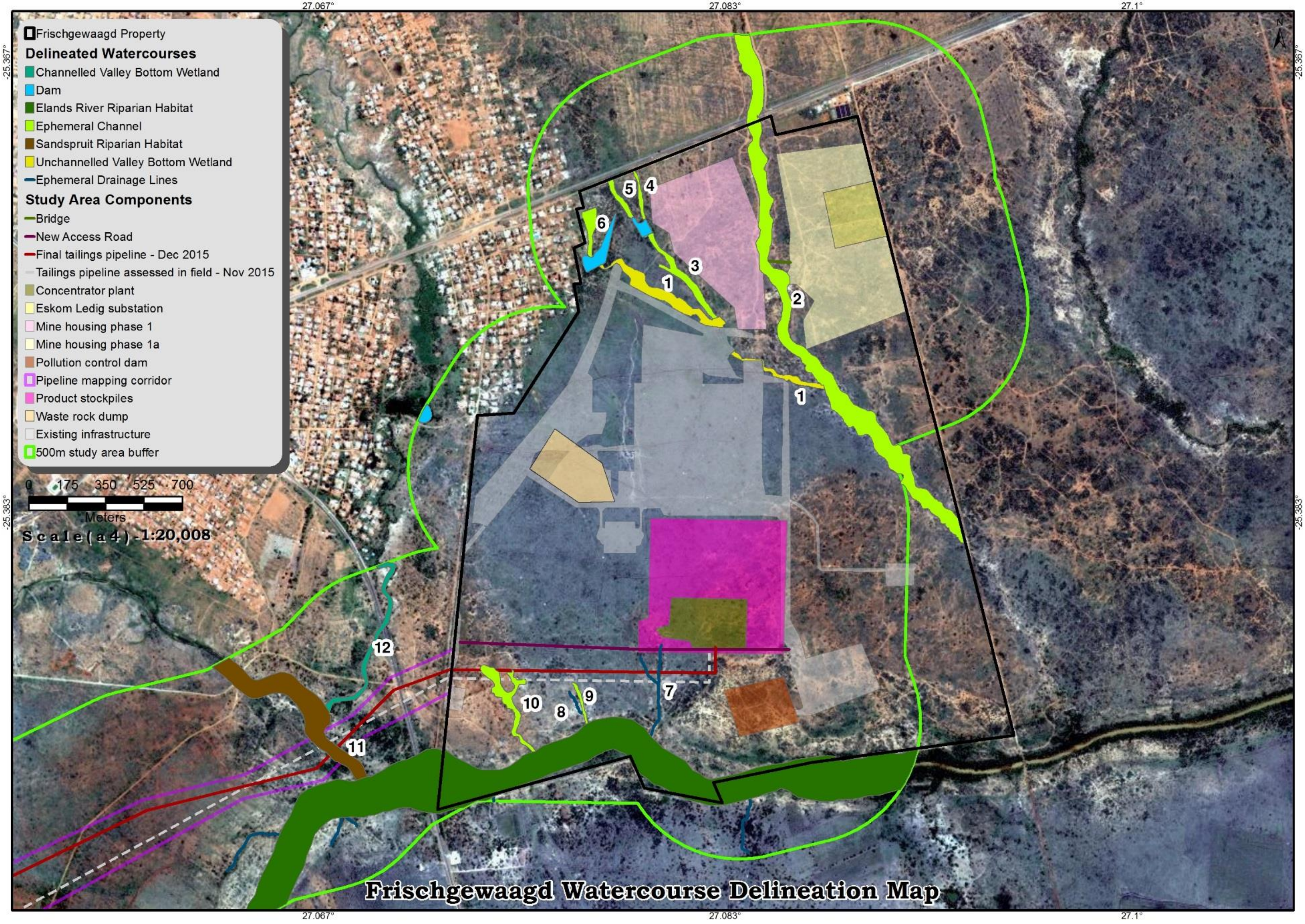
DE CASTRO & BRITS ECOLOGICAL CONSULTANTS

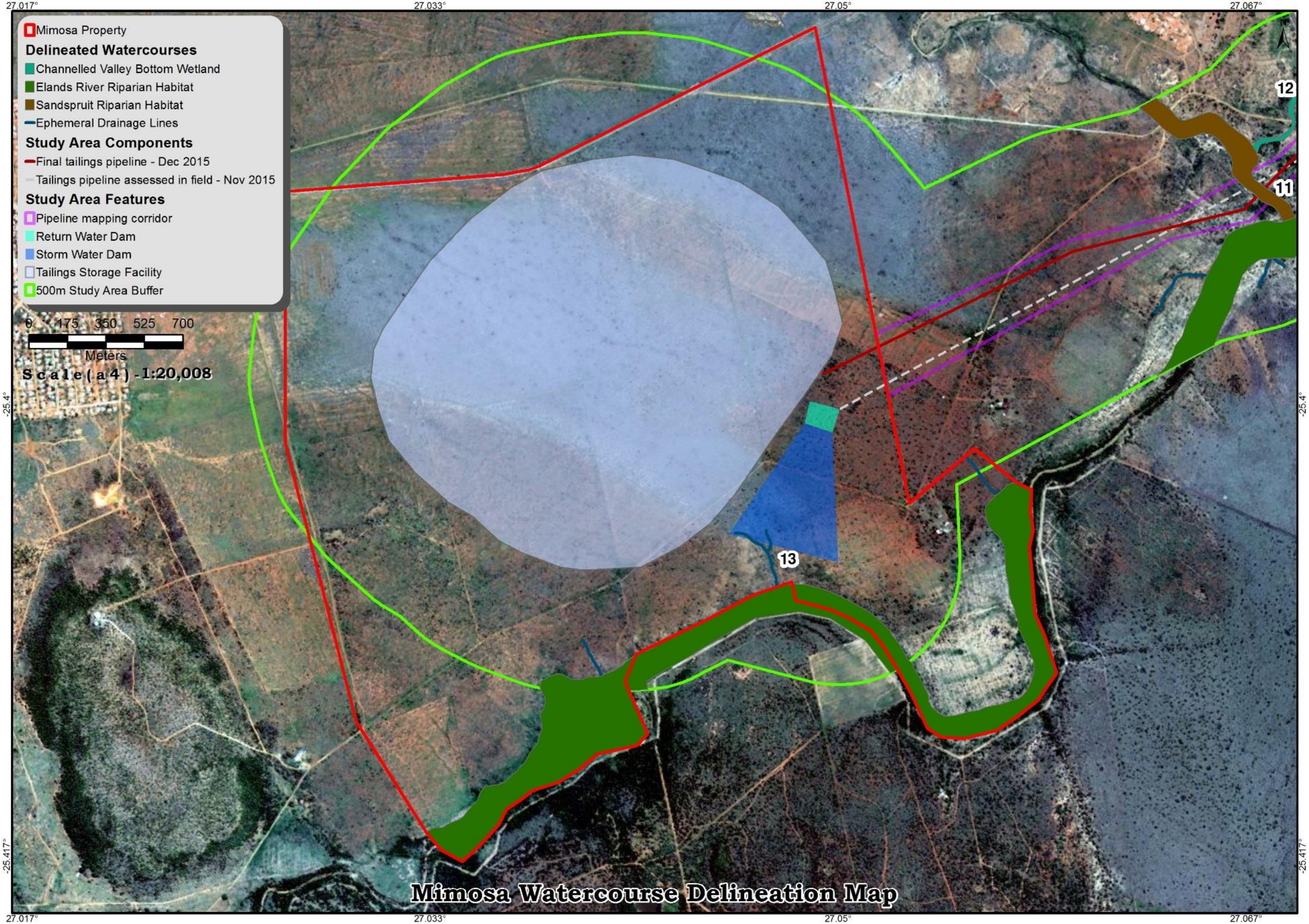


Vegetation map with proposed infrastructure for Mimosa and the Pipeline corridor

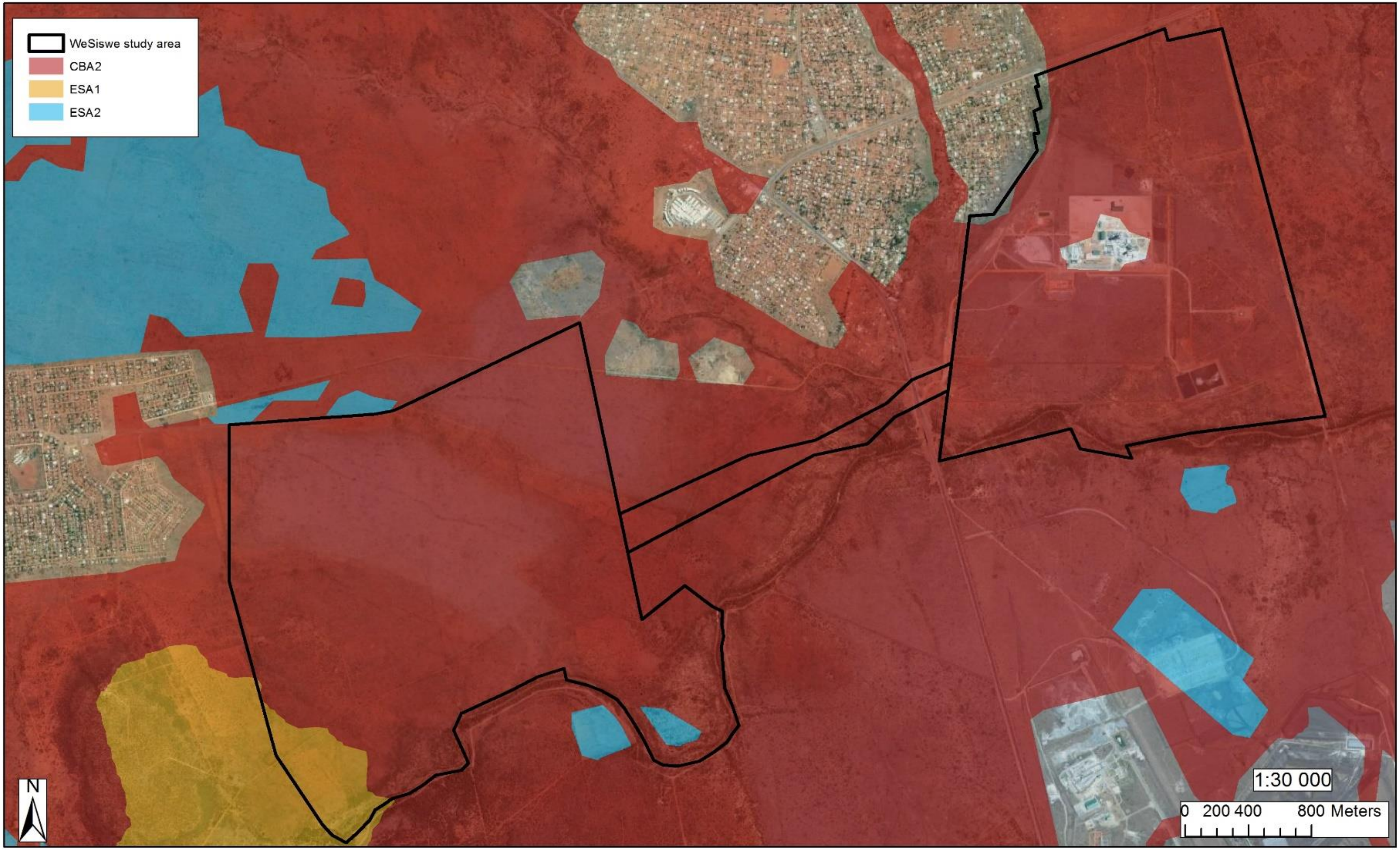
January 2016
Created by:

DE CASTRO & BRITS
ECOLOGICAL CONSULTANTS


Frischgewaagd Property
Delineated Watercourses
Channelled Valley Bottom Wetland
Dam
Elands River Riparian Habitat
Ephemeral Channel
Sandspruit Riparian Habitat
Unchannelled Valley Bottom Wetland
Ephemeral Drainage Lines
Study Area Components
Bridge
New Access Road
Final tailings pipeline - Dec 2015
Tailings pipeline assessed in field - Nov 2015
Concentrator plant
Eskom Ledig substation
Mine housing phase 1
Mine housing phase 1a
Pollution control dam
Pipeline mapping corridor
Product stockpiles
Waste rock dump
Existing infrastructure
500m study area buffer
0 175 350 525 700
Meters
Scale (a4) - 1:20,008
27.067°
27.083°
27.1°
-25.367°
-25.383°
1
2
3
4
5
6
7
8
9
10
11
12
Frischgewaagd Watercourse Delineation Map



27.017°
27.033°
27.05°
27.067°
-25.4°
-25.417°
Mimosa Property
Delineated Watercourses
Channelled Valley Bottom Wetland
Elands River Riparian Habitat
Sandspruit Riparian Habitat
Ephemeral Drainage Lines
Study Area Components
Final tailings pipeline - Dec 2015
Tailings pipeline assessed in field - Nov 2015
Study Area Features
Pipeline mapping corridor
Return Water Dam
Storm Water Dam
Tailings Storage Facility
500m Study Area Buffer
0 175 350 525 700
Meters
Scale (a4) - 1:20,008
11
12
13
Mimosa Watercourse Delineation Map



NWBSP 2015 Biodiversity classification for the Wesizwe study area

January 2016
Created by:

DE CASTRO & BRITS
ECOLOGICAL CONSULTANTS

RESULTS - NATURAL VEGETATION

Veld-type classification and conservation importance

The project area falls within the Central Bushveld Bioregion of the Savanna Biome. The NWBSP (2015) provides revised mapping of the national vegetation types (Mucina and Rutherford, 2006) within the North West Province. According to this revised mapping, six vegetation types occur within 3 km of the study area and four vegetation types occur within the study area, indicating that the study area is situated within a zone of transition. Although, according to the revised mapping, most of the study area is mapped as Zeerust Thornveld, with areas of Western Sandy Bushveld, Moot Plains Bushveld and Marikana Thornveld, the vegetation specialist is of the opinion that the study area conforms far more closely to the Mucina and Rutherford (2006) description of Marikana Thornveld in terms of species composition and dominance and therefore the vegetation type for the majority of the project area is regarded as Marikana Thornveld. The only other vegetation type identified within the project area is Gold Reef Mountain Bushveld, which is present near the western boundary of the farm Mimosa (De Castro and Brits, 2016a). These two vegetation types are described below.

Marikana Thornveld: This unit occurs across the North West province and northern part of Gauteng to the north of the Magaliesburg from Pretoria westwards. It has been categorised as Vulnerable, and less than 1% is statutorily conserved. This vegetation unit has been significantly transformed through cultivation and to a lesser extent residential and industrial development (De Castro and Brits, 2016a).

Gold Reef Mountain Bushveld: This unit is largely confined to rocky quartzitic ridges of the Magaliesburg and the parallel ridge to the south, and occurs in the North-West, Gauteng, Free State and Mpumalanga Provinces. It is categorised as least threatened and approximately 22% of this vegetation type is statutorily conserved mainly in the Magaliesburg Nature area and in smaller proportions in the Rustenburg, Wonderboom and Suikerbosrand Nature Reserves. There has been some transformation of this unit, which is attributed to cultivation and urbanization, though approximately 84% remains untransformed.

Vegetation based habitat zones

Nine vegetation/habitat zones were mapped within the mine area by Golder (2007). These included:

- Acacia mellifera Thicket
- Dichrostachys thicket
- Hillslope vegetation
- Open bushveld
- Riparian thicket
- Riparian woodland
- Rocky outcrop
- Secondary vegetation
- Wetland

For the 2016 study, De Castro and Brits (2016a) categorised the vegetation types as follows:

Frischgewaagd area:

- Marikana Thornveld
- Mixed Woodland and Thicket
- Acacia mellifera Bushland and Thicket
- Stony Grassland
- Ephemeral drainage lines - hygrophilous Grassland and Thicket
- Eroded ephemeral drainage lines - Grassland and Open Shrubland
- Secondary vegetation
- Elands River vegetation
- Dams

Mimosa:

- Marikana Thornveld - Mixed Thicket Bushland and Woodland
- Rocky outcrop vegetation
- Elands River vegetation
- Secondary vegetation
- Pipeline corridor:
- Marikana Thornveld
- Sandspruit vegetation
- Secondary vegetation

Descriptions of the habitat types as described in the 2016 vegetation study (Figure 7-10 and Figure 7-11) are provided below in Table 7.9, Table 7.10 and Table 7.11. The botanical biodiversity conservation value and sensitivity for each habitat is also provided.

TABLE 7.9 HABITAT TYPES IDENTIFIED AT THE PLANT AREA (DE CASTRO AND BRITS, 2016A)

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
1	Marikana Thornveld	Untransformed woody communities representative of the Marikana Thornveld vegetation type. Occurs mostly on deep red-brown to brown clay loam to sandy clay loam soils smaller areas on situated on black clay soils that have not been historically ploughed Two major plant communities occur within this unit, namely Mixed Thicket, Short/Low Woodland and Bushland on a variety of soil forms listed above (unit 1.1) and a less extensive community of Acacia mellifera Thicket and Bushland on soils of the Valsrivier form (unit 1.2)	High	See unit 1.1 and unit 1.2
1.1	Mixed Woodland & Thicket - on red clay loam soils	Thicket, Short/Low Woodland and Bushland communities of red-brown clay loam soils. Dominated by Searsia lancea, Zizphus mucronata and Acacia spp		Common trees include *Acacia caffra, Acacia robusta, Acacia karoo, Acacia tortilis, Searsia lancea* and *Ziziphus mucronata.* Dominant shrubs include *Acacia caffra* and *Acacia karoo*. Common shrubs include *Acacia erubescens, Carissa bispinosa, Diospyros lycioides, Grewia flava, Acacia tortilis, Searsia lancea* and *Searsia pyroides*. The dominant grasses are *Themeda triandra* and *Cymbopogon pospischilii*. Common grasses include *Aristida canescens, Aristida congesta subsp. barbicollis, Enneapogon scoparius, Eragrostis rigidior, Eragrostis trichophora, Eragrostis superba, Melinis repens, Panicum coloratum* and *Panicum maximum*. Common forbs and geoxylic suffrutices include *Aptosimum procumbens*, *Barleria macrostegia, Commelina africana, Crabaea angustifolia, Geigeria burkei, Felicia muricata, Hermannia depressa, Hibiscus pusillus, Vernonia oligicephala* and *Ziziphus zeyheriana.* The low shrub *Asparagus suaveolens* and the succulent *Aloe davyana* are also common.

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
1.2	Acacia mellifera Bushland and Thicket	Dense Acacia mellifera Thicket and Bushland and Acacia mellifera, Acacia tortilis and Tarchonanthus parvicapitulatus communities on red-brown clay to grey brown soils in southern parts of study area.		Common trees include *Acacia mellifera, Acacia karoo* and *Acacia tortilis*. The dominant shrub is Acacia mellifera, which usually constitutes the vast majority of woody cover. Common shrubs include *Diospyros lyciodes, Grewia flava, Gymnosporia buxifolia, Carissa bispinosa, Lycium cinereum* and *Tarchonathus parvicapitulatus*. Dominant grasses include *Panicum coloratum, Eragrostis chloromelas, Eragrostis curvula* and *Heteropogon contortus*. Common grasses include *Sporobolus fimbriatus, Aristida congesta subsp. barbicollis, Aristida congesta subsp. congesta, Digitaria eriantha, Eragrostis trichophora* and *Melinis repens.* Common forbs include *Blepharis integrifolia, Commelina africana, Corchorus aspleniifolius, Evolvulus alsinoides, Justicia betonica, Merremia plamata, Ruelliopsis setosa* and *Seddera capensis*. The low shrub *Asparagus suaveolens* and the succulent *Aloe davyana* are also common.
2	Stony Grassland	Grassland and Low Open Shrubland on red-brown, soils of the Shortlands form with alluvial pebbles scattered on surface. South-eastern parts of the study area.	High	The dominant grasses are *Trachypogon spicatus*, *Elionurus muticus* and *Schizachyrium sanguineum.* Common grasses include *Anthephora pubescens, Aristida canescens*, *Bewsia biflora, Brachiaria nigropedata, Diheteropogon amplectans, Enneapogon scoparius, Heteropogon contortus, Loudetia flavida* and *Urelytrum agropyroides*. Common forbs and low shrubs include *Aptosimum procumbens, Bulbostylis hispidula, Cyanotis speciosa, Dicoma anomala, Gnidia caffra, Ipomoea bathycolpos, Rhynchosia minima, Rotheca cf. hirsuta, Sida chrysantha, Silene sp., Triumfetta sonderi, Vernonia oligocephala* and *Ruellia patula*. This unit contains habitat that is considered suitable for one of the 'plant species of conservation' concern recorded or potentially occurring in the vicinity of the study area namely *Boophone disticha* (Declining).
3	Eroded ephemeral drainage lines - Grassland and Open Shrubland	Grassland and Shrubland along incised ephemeral drainage lines, with occasional, scattered trees. Includes small ephemeral drainage lines with shallowly incised channels surrounded by, stable eroded areas with exposed calcrete and rounded (probably alluvial) stones vegetated by Grassland and Shrubland in the southern parts of the study area, as well as a deeply incised larger ephemeral drainage line running from North to South through the north-eastern parts of the study area. No hygrophilous vegetation is present along the small southern drainage lines, but hygrophilous grassland is present along the active channel of the larger drainage	High	The central channel of the larger northern stream has distinct, narrow band of marginal vegetation. The vegetation can be described as marginal hygrophilous grassland with scattered riparian large shrubs and small trees, *Searsia lancea* is common. Other riparian shrubs and small trees include *Acacia karoo, Searsia pyroides* and *Ziziphus mucronata*. The dominant grasses include *Imperata cylindrica* and *Botriochloa insculpta*. Common to sub-dominant grasses include *Botriochloa bladhii, Eragrostis capensis, Hyparrhenia dregeana, Hyparrhenia filipendula, Hyparrhenia hirtaand* and *Themeda triandra.* Common forbs include *Berkheya radula, Cephalaria zeyheriana, Haplocarhpa lyrata, Lobelia thermalis, Nidorella resediifolia, Salvia runcinata* and *Vigna vexillata*. Small trees which occur scattered on the naturally eroded areas associated with these drainage lines include *Acacia karoo, Acacia mellifera, Maerua angolensis, Olea europaea subsp. africana* and *Searsia lancea*. Common shrubs include *Acacia mellifera, Dodonaea viscosa var. angustifolia, Euclea undulata, Grewia flava, Searsia lancea* and *Tarconanthus parvicapitulatus*.

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
		line in the north. These areas are characterised by various soils at different section along the drainage lines, including soils of the Oakley form, Valsrivier form, Shortlands form and Arcadia form.		The vegetation of the naturally eroded areas associated with the two smaller southern drainage lines and the lower reaches of the larger northern drainage line is Short Closed Grassland. The dominant grass is Aristida canescens and Trachypogon spicatus is sub-dominant. Common grasses include *Cymbopogon pospischilii, Diheteropogon spicatus, Enneapogon scoparius, Fingerhuthia africana, Melinis repens, Schmidtia pappophoroides* and *Schizachyrium sanguineum*. Common forbs include Ruelliopsis setosa, Bulbostylis hispidula, Chascanum cf. hederaceum, Dicoma anomala, Euphorbia davyi, Geigeria burkei, Indigofera heterotricha, Kohautia virgata, Oldenlandia cf. herbacea, Polygala krumaniana, and *Ptycholobium plicatum.*
4	Ephemeral drainage lines - hygrophilous Grassland and Thicket	Hygrophilous Grassland, Open Shrubland and Thicket of an indistinct ephemeral drainage line system in the north-western parts of the study area. The upper reaches of this drainage line comprise a series of small discontinuous swales, and the lower reaches a more distinctly incised channel. Periodically the upper reaches of this drainage line flood broad floodplains which may be over 50m wide. Most of the widely flooded areas are on black vertic clays.	High	Along the northern tributary of this drainage system dominant grasses include Botriochloa insculpta and Aristida bipartita. Common to locally dominant grasses include *Dicanthium annulatum, Ischaemum afrum, Botricochloa bladhii* and *Cynodon dactylon*. The margins of these swales and the periodically inundated soils adjacent to these swales are vegetated by Short Thicket. Dominant trees are *Searsia lancea* and *Acacia karoo*. Common trees include *Acacia tortilis* and *Ziziphus mucronata*. Dominant shrubs are *Acacia tortilis* and *Acacia karoo.* Common shrubs include *Acacia karoo, Aspargus laricinus, Searsia pyroides and Dichrostachys cinerea. Common grasses include Panicum maximum, Botriochloa insculpta* and *Sporobolus nitens*. Along the southern tributary of the drainage system common shrubs include *Acacia tortilis*, *Acacia karoo* and *Asparagus laricinus*. The dominant grasses are *Aristida bipartita* and *Dicanthium annulatum*. Common grasses include *Ischaemum afrum*, *Botriochloa insculpta*, *Brachiaria eruciformis* and *Eragrostis cf. micrantha*. The facultative hydrophytic geophyte *Crinum lugardiae* is abundant along the southern tributary (wetland) of this unit.
5	Elands River vegetation	Vegetation of the macro-channel bank and periodic floodplain of the Elands River. Includes marginal vegetation of the macro-channel bed vegetation, riparian Closed Woodland and Forest, and Low Bushland to Short Thicket of upper parts of macro-channel bank. The soils of this unit comprise deep, sandy loam to loam, alluvial soils of the Oakleaf form	High	The macro-channel bed comprises vegetation comprises dense reed beds of the megagraminoid Phragmites mauritianus, interspersed with herbaceous plant communities dominated by hygrophytic grasses and sedges, which include many alien weeds. Common small trees and shrubs include *Gomphostigma virgatum, Nicotiana glauca*, Salix mucronata, Searsia lancea, Eucalyptus camaldulensis** and *Sesbania punicea**. Common to dominant grasses, sedges and rushes include *Agrostis lachnantha, Cynodon dactylon, Echinochloa colona, Eragrostis rotifer, Hemarthria altissima, Imperata cylindrica, Paspalum dilatatum*, Paspalum distichum, Bulbostylis sp., Sporobolus fimbriatus, Cyperus fastigiatus, Cyperus marginatus, Cyperus eragrostis*, Cyperus sexangularis* and *Typha capensis.*

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				Common forbs include *Aster squamatus*, Juncus excertus, Ludwigia adscendens subsp. diffusa, Persicaria lapatifolia*, Persicaria senegalensis, Pulicaria scabra, Schkhuria pinnata*, Verbena bonariensis** and *Xanthium strumarium*.* On the lower macro-channel banks the dominant trees are *Acacia karoo, Combretum erythrophyllum* and *Searsia lancea*. Common trees include *Celtis africana, Melia azedarach*, Morus alba*, Searsia pyroides* and *Ziziphus mucronata.* The alien invasive trees include *Eucalyptus camaldulensis** and *Populus x canescens** are localised but together with *Melia azedarach** and *Morus alba** pose a significant threat of habitat transformation in this riparian woodland. Common shrubs include *Diospyros lyciodes, Gymnosporia buxifolia, Searsia pyroides* and *Ziziphus mucronata*. Dominants in the herbaceous layer include the grasses *Panicum maximum* and *Setaria megaphylla* and the forb *Hypoestes forskaolii.* Common grasses include *Cynodon dactylon, Ehrharta erecta* and *Urochloa mossambicensis*. Common forbs include *Ambrosia crataegifolia, Asparagus virgatus, Malvastrum coromandelianum** and *Pavonia burchellii*. The climber *Clematis brachiata* is common. On the upper parts of macro-channel bank common trees include *Acacia karoo, Melia azedarach*, Searsia lancea* and *Ziziphus mucronata*. Dominant shrubs include *Asparagus laricinus*, *Grewia flava, Diospyros lyciodes, Ziziphus mucronata.* Common shrubs include *Acacia tortilis, Gymnosporia buxifolia, Lycium cinereum* and *Tarchonanthus parvicapitulatus*. The dominant grasses include *Digitaria eriantha, Cynodon dactylon* and *Eragrostis rigidior.*
6	Secondary vegetation	Secondary vegetation of historically cultivated areas, borrow pits and scoured soils. Includes mostly secondary Bushland and Shrubland with smaller areas of secondary Thicket and patches of secondary Grassland on recently disturbed sites. Includes almost all areas on black turf soils classified as Arcadia as well as areas of red-brown soils of the Oakleef and Vlasrivier forms. Vegetation structure varies greatly in accordance with soil type, time elapsed since disturbance and the nature and duration of disturbance.	Moderate	On recently disturbed black clay soils the dominant grass is *Aristida bipartita*, and *Sorghum versicolor*, *Brachiaria eruciformis and Setaria sphacelata* are sub-dominant. Common forbs are *Zinnia peruviana**, *Bidens bipinnata** and *Schkhuria pinnata**. A low density of *Acacia mellifera* and *Acacia tortilis* saplings is present. In areas where succession has progressed further, the only common small tree is *Acacia tortilis.* The dominant shrub is also *Acacia tortilis* and common shrubs include *Acacia karoo*, *Asparagus laricinus, Diospyros lyciodes* and *Ziziphus mucronata*. The dominant grasses are *Aristida bipartita* and *Ischaemum afrum*, and common grasses include *Cymbopogon pospischilii*, *Eragrostis chloromelas* and *Brachiaria eruciformis*. On red-brown sandy clay loams (Oakleaf form) the dominant shrubs are *Acacia tortilis*

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				and *Dichrostachys cinerea*, and *Grewia flava is common*. The dominant grass is *Hyparrhenia filipendula* and common grasses include *Heteropogon contortus, Eragrostis superba, Eragrostis rigidior* and *Melinis repens*.
7	Dams	This unit comprises two old earth-walled farm dams built on ephemeral drainage lines and these dams therefore represent secondary drainage line habitat. Depending on the state of inundation, the floor of the full supply level either comprises bare, dry clays or is vegetated by stands of indigenous hygrophytic grasses and indigenous and alien forbs which often occur in disturbed areas.	Low	Dominant grasses are *Echinochloa colona* and *Cynodon dactylon.* Common grasses include *Botriochloa inscultpta, Dicanthium annulatum, Setaria sphacelata* and *Urochloa mossambicensis*. Common weedy forbs include *Ambrosia artemisiifolia**, *Aster squamatus*, Denekia capensis, Indigastrum parviflorum, Nidorella resedifolia, Persicaria senegalensis* and *Xanthium strumarium**. The alien biannual shrub **Sesbania bispinosa var. bispinosa* is common.
8	Infrastructure	The infrastructure comprising this unit was constructed mostly on soils of the Arcadia form. This unit comprises the mine shaft complex, discard dumps, steel water reservoirs, lined pollution control dams and linear infrastructure such as roads, canals and berms. The habitats of these areas have been completely transformed and the natural vegetation cleared.	Negligible	None

TABLE 7.10: HABITAT TYPES IDENTIFIED AT THE TSF AREA (DE CASTRO AND BRITS, 2016A)

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
1	Marikana Thornveld - Mixed Thicket Bushland and Woodland on red clay loam soils	Untransformed Thicket, Bushland and Woodland communities representative of Clay Thorn Bushveld. Mostly Short/Low Thicket and Bushland communities, with smaller areas of Closed Woodland, on red-brown clay loam soils. Dominated by Searsia lancea, Zizphus mucronata and Acacia spp. Unit also includes three small (longest 300m), indistinct 1st order ephemeral drainage lines near the Elands River.	High	Common trees include *Acacia caffra, Acacia karoo, Acacia tortilis, Searsia lancea* and *Ziziphus mucronata*. Dominant shrubs include *Acacia caffra* and *Acacia karoo*. Common shrubs include *Acacia erubescens, Grewia flava, Acacia tortilis, Searsia lancea* and *Searsia pyroides*. The dominant grasses are *Cymbopogon pospischilii*, *Heteropogon contortus* and *Themeda triandra*. Common grasses include *Aristida congesta subsp. barbicollis*, *Eragrostis chloromelas, Eragrostis superba, Eragrostis rigidior, Eragrostis trichophora*, *Eragrostis superba, Melinis repens, Panicum coloratum, Panicum maximum, Panicum coloratum, Setaria sphacelata* and *Tragus racemosa.* Common forbs include *Aptosimum procumbens, Barleria macrostegia, Commelina africana, Corchorus aspleniifolius, Crabaea angustifolia, Hermannia depressa, Hibiscus*

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				pusillus, Indigofera circinnata, Nidorella resediifolia, Ptycholobium plicatum and Ziziphus zeyheriana. The low shrub Asparagus suaveolens and the succulents Aloe davyana and *Aloe transvaalensis* are also common. The vegetation of the three small ephemeral drainage lines near the Elands River is very similar to the surrounding terrestrial vegetation but does display some differences. Common trees are *Acacia karoo, Olea europaea subsp. africana and Ziziphus mucronata*. The dominant shrub is *Acacia karoo*. Common shrubs include *Asparagus laricinus, Acacia erubescens, Combretum hereroense, Diospyros lycioides, Grewia flava, Gymnosporia buxifolia, Searsia pyroides, Tarchonanthus parvicapitulatus* and *Ziziphus mucronata*. Dominant grasses in the indistinct central channels include *Botriochloa insculpta* and *Setaria sphacelata*. Common grasses include *Cymbopogon pospischilii, Hyperthelia dissoluta, Ischaemum afrum* and *Themeda triandra*. Drimia sanguinea (Near Threatened), *Hypoxis hemerocallidea* (Declining) and a protected species *Sclerocarya birrea* were also recorded.
2	Rocky outcrop vegetation	This unit is entirely restricted to single low, linear rock (quartzite) outcrop situated near the western boundary of the section. The soils are shallow, reddish brown sandy clay loam soils of the Mispah soil form. The vegetation of this unit can be described as Open Shrubland which grades to Short Bushland and smaller patches of Short Thicket.	High	Common trees include *Acacia caffra, Acacia tortilis, Boscia albitrunca, Dombeya rotundifolia, Sclerocarya birrea, Searsia lancea, Strychnos pungens* and *Ziziphus mucronata*. The tree aloe, *Aloe marlothii*, is also common. The dominant shrub is *Acacia caffra*. Common shrubs include *Ehretia rigida, Elephantorrhiza burkei, Indigofera melanadenia subsp. melanadenia, Lannea discolor, Pavetta zeyheri, Searsia lancea, Searsia leptodictya, Vangueria infausta* and *Ximenia caffra*. Dominant grasses are *Schizachyrium jeffreysii, Loudetia flavida* and *Diheteropogon amplectans.* Common grasses include *Andropogon schirensis, Aristida congesta subsp. barbicollis Melinis repens, Trachypogon spicatus, Bewsia biflora, Elionurus muticus, Melinis repens, Themeda triandra, Trachypogon spicatus* and *Tricholaena monachne*. Common forbs include *Acalypha petiolaris, Bulbostylis hispidula, Chaetacanthus costatus, Chascanum cf. hederaceum, Dicoma anomala, Gnidia caffra, Ipomoea bathycolpos* and *Jamesbrittenia burkeana*. The succulent Aloe davyana and the woody climber/scrambler *Ancylobotrys capensis* are also common. The invasive large succulents *Cereus jamacuru** and *Agave Americana** are well established and pose a risk of significant habitat transformation within this unit. This unit contains habitat that is considered suitable for one of the 'plant species of conservation' concern recorded or potentially occurring in the vicinity of the study area, namely *Boophone disticha* (Declining).
3	Elands River vegetation	This unit comprises the vegetation of the	High	The macro-channel bed vegetation comprises dense reed beds of the megagraminoid

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
		Elands River macro-channel, including the active-channel banks, macro-channel bed and macro-channel banks, as well as a large floodplain of approximately 15ha directly downstream of the western boundary and a smaller floodplain with a floodplain lake on the eastern boundary. The soils of the vast majority of this unit comprise deep, sandy loam to loam, alluvial soils of the Oakleaf form, but small areas of sandy clay loam soils of the Valsrivier form occur on the upper edge of the floodplain		*Phragmites mauritianus*, interspersed with herbaceous plant communities dominated by hygrophytic grasses and sedges, which include many alien weeds. Frequent flooding by fact flowing waters largely precludes the establishment of mature trees other than rheophytes (e.g. *Salix mucronata*), but small trees and shrubs occur scattered on the macro-channel bed. Common small trees and shrubs include *Gomphostigma virgatum, Nicotiana glauca**, Salix mucronata, Searsia lancea, Eucalyptus camaldulensis** and *Sesbania punicea**. Common to dominant grasses, sedges and rushes include *Agrostis lachnantha, Cynodon dactylon, Echinochloa colona, Eragrostis rotifer, Hemarthria altissima, Imperata cylindrica, Paspalum dilatatum*, Paspalum distichum, Bulbostylis sp., Sporobolus fimbriatus, Cyperus fastigiatus, Cyperus marginatus, Cyperus eragrostis*, Cyperus sexangularis* and *Typha capensis*. Common forbs include *Aster squamatus*, Juncus excertus, Ludwigia adscendens subsp. diffusa, Persicaria lapatifolia*, Persicaria senegalensis, Pulicaria scabra, Schkhuria pinnata*, Verbena bonariensis** and Xanthium strumarium*. On the lower macro-channel the dominant trees are *Acacia karoo, Combretum erythrophyllum and Searsia lancea. Common trees include Celtis africana, Melia azedarach*, Morus alba*, Searsia pyroides* and *Ziziphus mucronata*. Common shrubs include *Diospyros lyciodes, Gymnosporia buxifolia, Searsia pyroides* and *Ziziphus mucronata*. Dominants in the herbaceous layer include the grasses *Panicum maximum* and *Setaria megaphylla* and the forb *Hypoestes forskaolii.* Common grasses include *Cynodon dactylon, Ehrharta erecta* and *Urochloa mossambicensis.* Common forbs include *Ambrosia crataegifolia, Asparagus virgatus, Malvastrum coromandelianum** and *Pavonia burchellii*. The climber *Clematis brachiata* is common. Patches of Tall Forest on the seldom activated upper parts of the macro-channel also have *Olea europaea subsp. africana* as a common tree, *Acalypha glabrata var. pilosior* as a common shrub, and a higher species richness in the herbaceous layer. The alien invasive trees *Eucalyptus camaldulensis** and *Populus x canescens** are localised but together with widespread *Melia azedarach** and *Morus alba** pose a significant threat of habitat transformation in this riparian woodland. There is also the alien invasive woody climber *Dolichandra unguis-cati**. On the upper parts of macro-channel common trees include *Acacia karoo, Melia azedarach*, Searsia lancea* and *Ziziphus mucronata*. Dominant shrubs include *Asparagus laricinus, Grewia flava, Diospyros lyciodes, Ziziphus mucronata.* Common shrubs include *Acacia tortilis, Gymnosporia buxifolia, Lycium cinereum* and

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				Tarchonanthus parvicapitulatus. The dominant grasses include *Digitaria eriantha, Cynodon dactylon* and *Eragrostis rigidior.* On the floodplains the only common tree is *Acacia karoo*. The dominant shrub is *Grewia flava*. Common shrubs include *Acacia karoo, Asparagus laricinus, Dichrostachys cinerea, Diospyros lycioides, Grewia bicolor, Gymnosporia buxifolia, Tarconanthus parvicapitulatus and Ziziphus mucronata. Dominant grasses include Botriochloa insculpta, Digitaria eriantha, Tragus racemosa* and *Urochloa mossambicenis*. Cenchrus *ciliaris* is a localised dominant. Common grasses include *Aristida cf. adscensionis, Aristida bipartita, Botriochloa radicans, Panicum coloratum, Panicum maximum* and *Heteropogon contortus*. Forb diversity is low. Common forbs include *Corchorus aspleniifolius, Talinum caffrum, Indigastrum parviflorum, Ledebouria sp., Nidorella resediifolia* and *Cullen tomentosum*. The low shrub *Asparagus suaveolens* is common as are the climbers *Asapagus cf. setaceus* and *Cyphostemma sulcatum*.
4	Secondary vegetation	This unit comprises vegetation of historically cultivated areas and scoured soils. It includes mostly secondary Bushland and Shrubland with a few small patches of secondary Thicket in areas where succession is more advanced. It covers the majority of the northern half of the study area as well as several patches in the south-eastern and south-western parts of the study area along the Elands River. It includes almost all areas on black turf soils classified as Arcadia as well as areas of red-brown soils of various soil forms. Vegetation structure and species composition varies greatly in accordance with soil type, time elapsed since disturbance and the nature and duration of the disturbance.	Moderate	In secondary Tall Closed Shrubland to Low Closed Bushland on red-brown sandy clay loams and clay loam soils common trees include *Acacia karoo, Acacia tortilis* and *Ziziphus mucronata*. The dominant shrub is *Acacia tortilis*. Common shrubs include *Acacia karoo, Acacia mellifera and Ziziphus mucronata*. The dominant grasses are *Aristida congesta subsp. barbicollis, Eragrostis rigidior* and *Urochloa mossambicensis*. Common grasses include *Cynodon dactylon, Eragrostis curvula, Eragrostis trichophora, Heteropogon contortus, Panicum maximum* and *Tragus racemosa*. Common forbs include *Berkheya carilinopsis subsp. magalismontanum, Boerhavia diffusa*, Corchorus aspleniifolius, Gomphrena celosiodes*, Indigofera circinnata. Indigofera melanadenia subsp. malacostachys, Kyphocarpha angustifolia, Nidorella resediifolia, Osteospermum muricatum, Pentarrhinum insipidum* and *Solanum eleagnifolium*.* In secondary In Tall Open Shrubland communities on heavy black clay soils, the vegetation is dominated by grasses. The only common small tree is *Acacia tortilis*, though small *Acacia karoo* trees are present in places. Common shrubs include *Acacia tortilis*, *Asparagus laricinus, Dichrostachys cinerea* and *Ziziphus mucronata. and Diospyros lycioide*s and common shrubs include *Acacia karoo*, *Asparagus laricinus, Diospyros lyciodes* and *Ziziphus mucronata*. The dominant grasses are Aristida bipartita, *Eragrostis chloromelas* and *Ischaemum afrum*, and common grasses include *Brachiaria eruciformis*, *Cymbopogon pospischilii*, *Setaria incrassate* and Themeda triandra. Common forbs include *Acalypha indica, Convolvulus sagittatus, Corchorus*

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				aspleniifolius, Elephantorrhiza elephantina (geoxylic suffrutex), Jamesbrittenia aurantiaca, Kouhautia virgate, Nidorella resediifolia, Rhynchosia minima and *Schkhuuria pinnata*.*
5	Infrastructure	Farm homesteads and guard huts.	Negligible	None

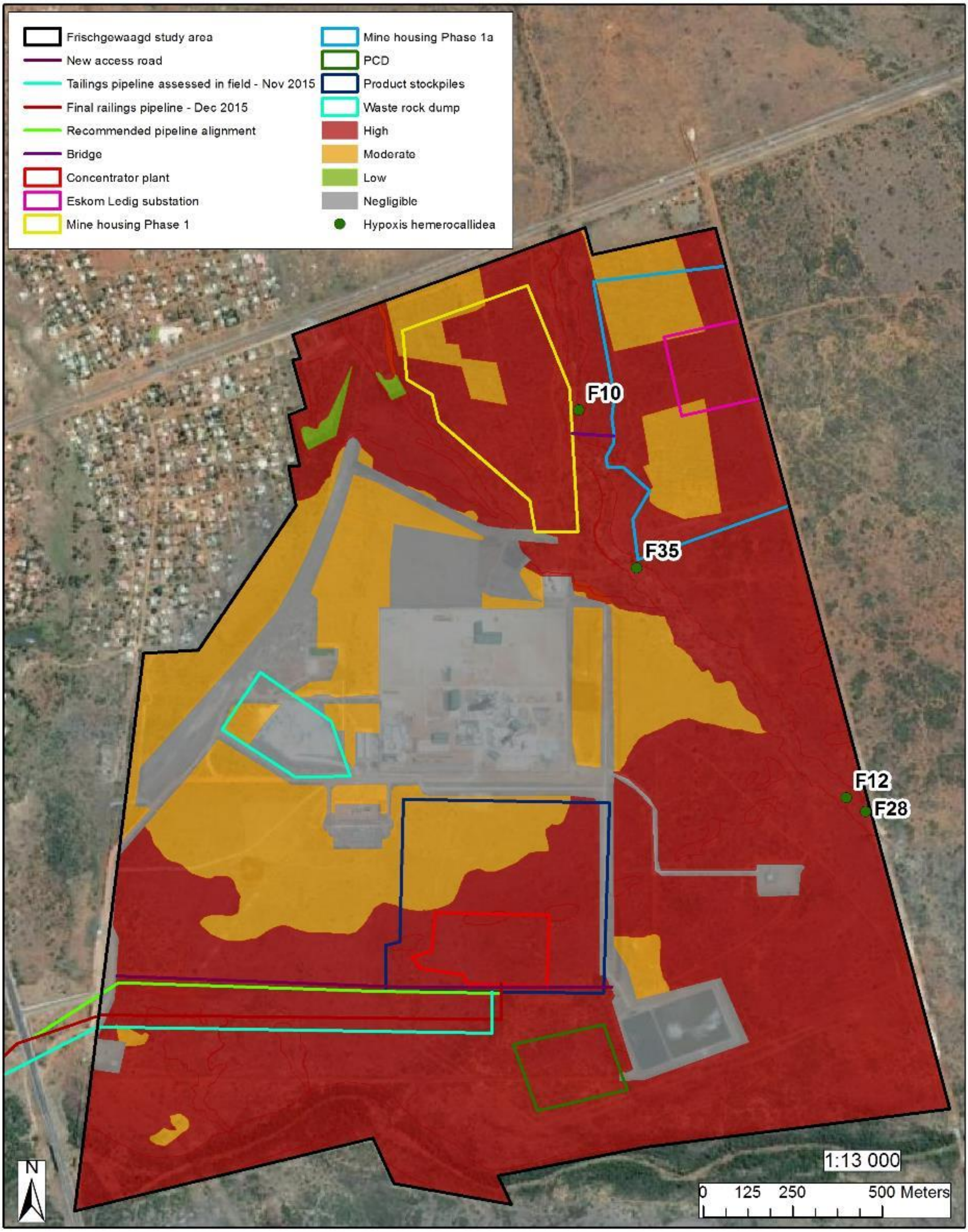
TABLE 7.11: HABITAT TYPES IDENTIFIED ALONG THE PIPELINE CORRIDOR (DE CASTRO AND BRITS, 2016A)

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
1	Marikana Thornveld	Refer to the descriptions provided in Table 7.9 and Table 7.10		
2	Sandspruit vegetation	This unit comprises the vegetation of the Sandspruit River macro-channel, including the macro-channel bed, active-channel banks (marginal zone) and the macro-channel banks. The Sandspruit is a weakly perennial stream. The soils of this unit comprise a mixture of sandy clay loam soils of the Oakleaf, Valsrivier and Mispah forms. The vegetation of this unit falls within a communal grazing area situated between Mimosa and Frischgewaagd, and is overgrazed and subjected to extensive cutting of trees for fuel and construction material.	High	Common shrubs at the exposed macro-channel bed include the rheophytes *Gomphostigma virgatum, Salix mucronata, and Sesbania punicea*.* Dominant grasses and rushes include *Cynodon dactylon* and *Juncus excertus*. Common grasses and sedges include *Agrostis lachnantha, Hemarthria altissima, Paspalum distichum, Cyperus eragrostis** and *Cyperus sexangularis*. Common forbs include *Aster squamatus*, Lobelia thermalis, Pulicaria scabra* and *Xanthium strumarium*.* On the lower macro-channel banks common small trees are *Salix mucronata* and *Morus alba*.* The dominant shrub is *Searsia lancea.* Common shrubs include *Conyza scabrida*, *Gymnosporia buxifolia, Salix mucronata* and *Sesbania punicea*.* The dominant species in the herbaceous layer are the sedge *Cyperus sexangularis* and the grass *Cynodon dactylon*. Common grasses include *Paspalum dilatatum*, Hemarthria altissima, Botriochloa* insculpta and *Sporobolus fimbriatus*. Common forbs include *Juncus excertus, Pulicaria scabra and Ranunculus multifidus*, *Verbena officinalis*. On the upper macro-channel banks, the dominant trees are *Searsia lancea* and *Acacia karoo*. Common trees include *Morus alba*, Olea europaea subsp. africana, Ziziphus mucronata*. The dominant shrubs are *Acacia karoo* and *Gymnosporia buxifolia*. Common shrubs include *Asparagus laricinus, Grewia flava, Searsia pyroides, Searsia lancea* and *Tarchonanthus parvipunctulatus*. The dominant species in the herbaceous layer is the grass *Panicum maximum*. Common forbs include *Hypoestes forskaolii* and *Pavonia burchellii.* Young plants of the alien invasive succulent *Agave americana** are locally abundant

Unit No.	Vegetation / land cover unit	Description	Conservation value and sensitivity	Species associated with vegetation / land cover unity Alien species are indicated by an asterisk.
				along the macro-channel banks.
3	Secondary vegetation	Refer to the descriptions provided in Table 7.9 and Table 7.10		
4	Infrastructure	Tar road, dog kennels for the mine and access roads	Negligible	None

Biodiversity Sensitive Habitats at Bakubung Mine

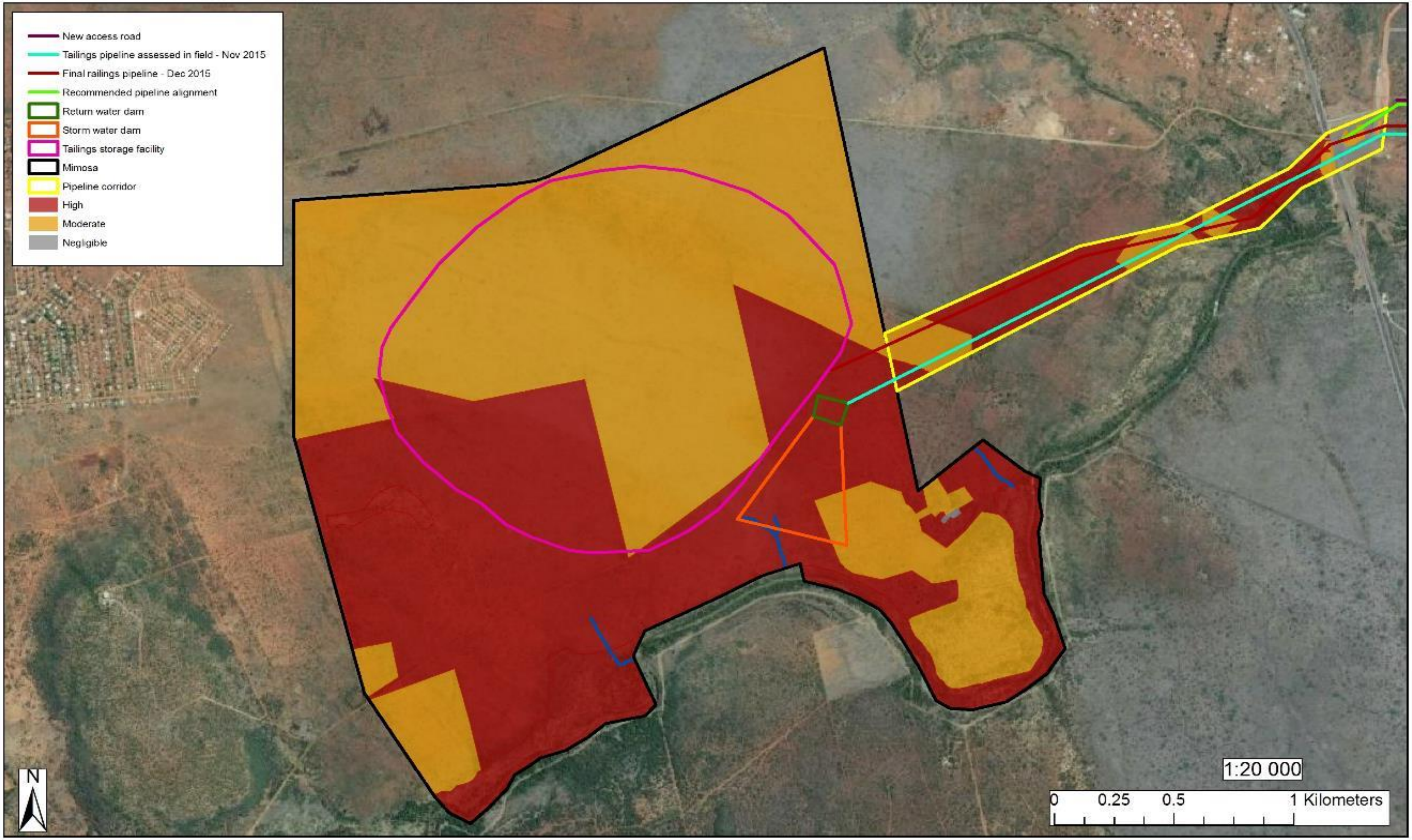
Areas of high, moderate, low and negligible botanical biodiversity sensitivity were mapped by the specialist (Figure 7-14 and Figure 7-15). All areas falling within Marikana Thornveld, the stony grasslands, watercourses, riparian areas and rocky outcrop were classified as having high sensitivity. All areas of secondary vegetation were classified as moderate. Areas with infrastructure had no sensitivity and the two dams were classified as having low sensitivity as described in Table 7.9, Table 7.10 and Table 7.11.



Senisitivity map with proposed infrastructure for Frischgewaagd

January 2016
Created by:

DE CASTRO & BRITS ECOLOGICAL CONSULTANTS



Sensitivity map with proposed infrastructure for Mimosa and the Pipeline corridor

January 2016
Created by:

DE CASTRO & BRITS ECOLOGICAL CONSULTANTS

Protected Tree Species and Species of conservation concern

Two protected species in terms of the National Forests Act (NFA; No. 84 of 1998) were recorded within the study area. These include *Boscia albitrunca* and *Sclerocarya birrea subsp*. *Africana*. A permit must be obtained from DAFF before these species may be removed from site.

The Pretoria Computer Information Systems lists of historically recorded species of conservation concern included nine plant species of conservation concern. Two additional species were also considered; Stenostelma umbelluliferum because it occurs in the eastern parts of the North West province in habitats similar to those found in the project area and was included as a potentially occurring species and Hypoxis hemerocallidea (Declining) because it was identified on site during the survey.

Table 7.12 provides the probability of occurrence of the 11 species discussed above. Only one of the eleven species listed has thus far been recorded within the study area. This species was recorded at four sites within Frischgewaagd. Hypoxis hemerocallidea is not a threatened species as defined by the IUCN criteria, but is categorised as Declining in the latest Red List of South African Plants.

TABLE 7.12: SPECIES OF CONSERVATION CONCERN AND THEIR PROBABILITY OF OCCURRENCE (DE CASTRO AND BRITS, 2016A).

Species	Conservation Status Category*	Habitat	Probability of occurrence	
			Frischgewaagd	Mimosa
Frithia pulchra	Rare	Coarse, shallow, quartzitic soils on sandstones.	Low	Low
Boophone disticha	Declining	Dry grassland and woodland, particularly in rocky areas.	Low	Medium
Stenostelma umbelluliferum	Near Threatened	Deep black turf in open woodland mainly in the vicinity of drainage lines.	Medium	Low
Ilex mitis var. mitis	Declining	Along rivers and streams in forests and thickets, sometimes in the open. Found from sea level to inland mountain slopes.	Low	Low
Aloe peglerae	Endangered	Grassland, in shallow, gravely quartzitic soils on rocky, north-facing slopes or summits of ridges.	Negligible	Negligible
Adromischus umbraticola subsp. umbraticola	Near Threatened	South-facing rock crevices on ridges, restricted to Gold Reef Mountain Bushveld in the northern parts of its range, and Andesite Mountain Bushveld in the south	Negligible	Negligible
Gunnera perpensa	Declining	In marshy, cold or cool, continually moist localities, mainly along upland streambanks. From coast to 2400m.	Negligible	Negligible
Drimia sanguinea	Near Threatened	Open veld and scrubby woodland in a variety of soil types.	Medium	Medium
Hypoxis hemerocallidea	Declining	Grassland and mixed woodland, including secondary grassland of historically cultivated soils. Usually in moist situations.	Recorded	High
Rapanea melanophloeos	Declining	Coastal, swamp and mountain forest, on forest margins and in bushclumps, often in damp areas from coast to mountains.	Negligible	Negligible
Prunus africana	Vulnerable	Evergreen forests near the coast,	Negligible	Negligible

Species	Conservation Status Category*	Habitat	Probability of occurrence	
			Frischgewaagd	Mimosa
		inland mistbelt forests and afromontaone forests up to 2100m.		

Medicinal species

Two medicinal plants could occur on site and are species of conservation concern. The Declining medicinal plant Hypoxis hemerocallidea was recorded on site and Boophone disticha has a moderate probability of occurring as described above. Boophone disticha is not under any immediate threat of extinction, and has been categorised as Declining as it is a popular and fairly heavily utilised medicinal plant. It is long-lived and slow growing, and thus there are concerns that the long-term over-utilisation of wild plants will lead to a decline in many of the sub-populations of this species.

Alien and Invasive Species

Scattered alien and invasive plant species are located throughout the project area. The most important species in terms of habitat transformation that were recorded on site include, Agave americana. Cereus jamacuru, Dolichandra anguis-cati, Eucalyptus camaldulensis, Melia zedarach, Morus alba, Nicotiana glauca, Opuntia ficus-indica, Populus x canescens and Sesbania punicea These species pose a significant threat to the indigenous vegetation of the study area and its immediate surrounds and should be controlled as a matter of urgency. This list does not include all the species identified, for a full list refer to the vegetation study (Appendix K).

RESULTS - TERRESTRIAL ANIMAL LIFE

Commonly occurring faunal species

While the study area is generally untransformed, large portions to the west and south are intensively settled or mined and the specialist is of the opinion that the fauna of the site is as a consequence lacking. However, the Pilanesberg National Park, is situated a 2 km north of the site and contains large numbers of vertebrate fauna, including many Red Data listed species (De Castro and Brits, 2016c).

Mammals

The savanna biome is a region with high diversity of mammals, a low number of endemics and a high number of Red Data species.

Much of the area surrounding the project area has been transformed and extensively disturbed through mining, agriculture and urban spread. This habitat transformation, together with elevated human presence and impacts such as disturbance and hunting, has negatively impacted on large mammal occurrence, particularly ungulates and predators. As a result, mammals remaining in the study area are mostly small, cryptic and often nocturnal species that are adapted to live in close proximity to transformed ecosystems such as cultivated fields or urban developments (De Castro and

Brits, 2016b). Ten mammal species were confirmed to occur within the development footprint, one being a species of conservation concern, the Serval (*Leptailurus serval*). All the remaining species located during fieldwork are common and widespread mammals of the savanna and grassland biomes of South Africa and include herbivores such as Steenbok (*Raphicerus campestris*), Grey Duiker (*Sylvicapra grimmia*), Springhare (*Pedetes capensis*) and Scrub Hare (*Lepus saxatilis*) and carnivores such as Caracal (*Caracal caracal*), Black-backed Jackal (*Canis mesomelas*) and Water Mongoose (*Atilax paludinosus*) (De Castro and Brits, 2016c).

Twenty three conservation-important mammal species potential occur within the general vicinity of the project area; Table 7.13 provides the likelihood of their occurrence. Of the 23 species, 21 are Red Data species and five are protected under NEMBA. No mammals potentially occurring within the study area are endemic to South Africa (De Castro and Brits, 2016c).

TABLE 7.13: POTENTIALLY OCCURRING MAMMALS IN THE PROJECT AREA (DE CASTRO AND BRITS, 2016C).

Species	Scientific Name	Red Data	Protected	Likelihood
African Clawless Otter	*Aonyx capensis*	NT*		Moderate
Southern African Hedgehog	*Atelerix frontalis*	NT		Moderate
Reddish-grey Musk Shrew	*Crocidura cyanea*	DD		Moderate
Swamp Musk Shrew	*Crocidura mariquensis*	DD		Moderate
Tiny Musk Shrew	*Crocidura fuscomurina*	DD		Moderate
Lesser Red Musk Shrew	*Crocidura hirta*	DD		Moderate
Peters' Musk Shrew	*Crocidura silacea*	DD		Moderate
Short-snouted Elephant-shrew	*Elephantulus brachyrhynchus*	DD		Moderate
Black-footed Cat	*Felis nigripes*		NEMBA (PR)	Low
Spotted-necked Otter	*Hydrictis maculicollis*	NT		Moderate
Single-striped Grass-Mouse	*Lemniscomys rosalia*	DD		Moderate
Serval	*Leptailurus serval*	NT	NEMBA (PR)	Confirmed
Honey Badger	*Mellivora capensis*	NT		Moderate
Forest Shrew	*Myosorex varius*	DD		Moderate
Brown Hyaena	*Hyaena brunnea*	NT	NEMBA (PR)	Moderate
Rusty Bat	*Pipistrellus rusticus*	NT		Moderate
African Weasel	*Poecilogale albinucha*	DD		Moderate
Ground Pangolin	*Smutsia temminckii*	VU	NEMBA (VU)	Low
Least Dwarf Shrew	*Suncus infinitesimus*	DD		Moderate
Greater Dwarf Shrew	*Suncus lixus*	DD		Moderate
Lesser Dwarf Shrew	*Suncus varilla*	DD		Moderate
Cape Fox	*Vulpes chama*		NEMBA (PR)	Low
Bushveld Gerbil	*Tatera leucogaster*	DD		Moderate

* = IUCN classification; DD = Data Deficient; NT = Near-threatened; EN = Endangered; VU = Vulnerable

<u>Birds</u>

The savanna regions of South Africa support the highest diversity of bird species but also the lowest number of endemics.

The quarter-degree grid 2527AC, within which the project area is located, has had a high total of 365 bird species recorded so far in the ongoing second South African Bird Atlas (SABAP2). This is primarily due to high observer coverage in the Pilanesberg National Park, which is located within this grid (De Castro and Brits, 2016c). One-hundred and twelve bird species have been confirmed to occur in the project area (Table 7.14).

TABLE 7.14: BIRD SPECIES CONFIRMED TO OCCUR IN THE PROJECT AREA (DE CASTRO AND BRITS, 2016C)

Common Name	Scientific name
Common Myna	*Acridotheres tristis*
Egyptian Goose *	*Alopochen aegyptiacus*
Thick-billed Weaver	*Amblyospiza albifrons*
Red-billed Teal *	*Anas erythrorhyncha*
African Darter	*Anhinga rufa*
African Pipit	*Anthus cinnamomeus*
Little Swift	*Apus affinis*
White-rumped Swift	*Apus caffer*
Black-headed Heron	*Ardea melanocephala*
Marsh Owl	*Asio capensis*
Chinspot Batis	*Batis molitor*
Marico Flycatcher	*Bradornis mariquensis*
Cattle Egret	*Bubulcus ibis*
Steppe Buzzard	*Buteo vulpinus*
Barred Wren-Warbler	*Calamonastes fasciolatus*
Sabota Lark	*Calendulauda sabota*
Fiery-necked Nightjar	*Caprimulgus pectoralis*
Familiar Chat	*Cercomela familiaris*
White-browed Scrub-Robin	*Cercotrichas leucophrys*
Kalahari Scrub-Robin	*Cercotrichas paena*
Dideric Cuckoo	*Chrysococcyx caprius*
Klaas's Cuckoo	*Chrysococcyx klaas*
Marico Sunbird	*Cinnyris mariquensis*
White-bellied Sunbird	*Cinnyris talatala*
Desert Cisticola	*Cisticola aridulus*
Rattling Cisticola	*Cisticola chiniana*
Neddicky	*Cisticola fulvicapilla*
Zitting Cisticola	*Cisticola juncidis*
Great Spotted Cuckoo	*Clamator glandarius*
Jacobin Cuckoo	*Clamator jacobinus*
White-backed Mousebird	*Colius colius*
Speckled Mousebird	*Colius striatus*
Speckled Pigeon	*Columba guinea*
Pied Crow	*Corvus albus*
Grey Go-away-bird	*Corythaixoides concolor*
Black-throated Canary	*Crithagra atrogularis*
Yellow Canary	*Crithagra flaviventris*
Yellow-fronted Canary	*Crithagra mozambica*
Black Cuckoo	*Cuculus clamosus*
African Palm-Swift	*Cypsiurus parvus*
Fulvous Duck *	*Dendrocygna bicolor*
Crested Francolin	*Dendroperdix sephaena*
Fork-tailed Drongo	*Dicrurus adsimilis*
Black-shouldered Kite	*Elanus caeruleus*
Golden-breasted Bunting	*Emberiza flaviventris*
Cinnamon-breasted Bunting	*Emberiza tahapisi*

Common Name	Scientific name
Chestnut-backed Sparrowlark	*Eremopterix leucotis*
Common Waxbill	*Estrilda astrild*
Yellow-crowned Bishop	*Euplectes afer*
White-winged Widowbird	*Euplectes albonotatus*
Southern Red Bishop	*Euplectes orix*
Red-knobbed Coot *	*Fulica cristata*
Violet-eared Waxbill	*Granatina granatina*
Woodland Kingfisher	*Halcyon senegalensis*
Wahlberg's Eagle	*Hieraaetus wahlbergi*
Lesser Striped-Swallow	*Hirundo abyssinica*
White-throated Swallow *	*Hirundo albigularis*
Greater Striped-Swallow	*Hirundo cucullata*
Rock Martin	*Hirundo fuligula*
Barn Swallow	*Hirundo rustica*
Red-breasted Swallow	*Hirundo semirufa*
Red-billed Firefinch	*Lagonosticta senegala*
Cape Glossy Starling	*Lamprotornis nitens*
Crimson-breasted Shrike	*Laniarius atrococcineus*
Southern Boubou	*Laniarius ferrugineus*
Common Fiscal	*Lanius collaris*
Red-backed Shrike	*Lanius collurio*
Lesser Grey Shrike	*Lanius minor*
Red-crested Korhaan	*Lophotis ruficrista*
Black-collared Barbet	*Lybius torquatus*
Pale-chanting Goshawk	*Melierax canorus*
European Bee-eater	*Merops apiaster*
Little Bee-eater	*Merops pusillus*
Rufous-naped Lark	*Mirafra africana*
Cape Wagtail	*Motacilla capensis*
Spotted Flycatcher	*Muscicapa striata*
Southern Pochard *	*Netta erythrophthalma*
Helmeted Guineafowl	*Numida meleagris*
Namaqua Dove	*Oena capensis*
Red-winged Starling	*Onychognathus morio*
Black-headed Oriole	*Oriolus larvatus*
African Quailfinch	*Ortygospiza atricollis*
Chestnut-vented Tit-Babbler	*Parisoma subcaeruleum*
Southern Greyheaded Sparrow	*Passer diffusus*
House Sparrow	*Passer domesticus*
Cape Sparrow	*Passer melanurus*
White-browed Sparrow-Weaver	*Plocepasser mahali*
Southern Masked-Weaver	*Ploceus velatus*
Black-chested Prinia	*Prinia flavicans*
Tawny-flanked Prinia	*Prinia subflava*
Swainson's Spurfowl	*Pternistis swainsonii*
Dark-capped Bulbul	*Pycnonotus tricolor*
Green-winged Pytilia	*Pytilia melba*
Red-billed Quelea	*Quelea quelea*
Scaly-feathered Finch	*Sporopipes squamifrons*
Cape Turtle Dove	*Streptopelia capicola*
Red-eyed Dove	*Streptopelia semitorquata*
Laughing Dove	*Streptopelia senegalensis*
Common Whitethroat	*Sylvia communis*
Long-billed Crombec	*Sylvietta rufescens*
Little Grebe *	*Tachybaptus ruficollis*
Brown-crowned Tchagra	*Tchagra australis*
African Grey Hornbill	*Tockus nasutus*

Common Name	Scientific name
Acacia Pied Barbet	*Tricholaema leucomelas*
Blue Waxbill	*Uraeginthus angolensis*
Red-faced Mousebird	*Urocolius indicus*
Blacksmith Lapwing *	*Vanellus armatus*
Crowned Lapwing	*Vanellus coronatus*
Pin-tailed Whydah	*Vidua macroura*
Long-tailed Paradise-Whydah	*Vidua paradisaea*
Shaft-tailed Whydah	*Vidua regia*
Cape White-eye	*Zosterops virens*

* = Recorded from adjacent habitat in 2015

The Pilanesberg National Park is considered an Important Bird Area and supports a number of threatened large raptors such as White-backed and Cape Vultures, Secretarybird, Verreaux's, Tawny and Martial Eagles, Bateleur and African Marsh Harrier. Additional wetland birds include White-backed Night Heron and African Finfoot. All of these birds are scarce outside protected areas in South Africa and no breeding habitat is present within the project area. No species of conservation concern were located during fieldwork, though Black Stork was confirmed on an adjacent property in May 2015 during another survey. An additional 22 Red Data species have been recorded from other pentads (unit of measurement - five minutes of latitude by five minutes of longitude, squares with sides of roughly 9 km) within 2527AC. Of the potentially occurring Red Data species, six have a moderate chance of occurring within the study area (Table 7.15) (De Castro and Brits, 2016c).

TABLE 7.15: POTENTIALLY OCCURRING BIRDS IN THE PROJECT AREA (DE CASTRO AND BRITS, 2016C).

Species	Scientific Name	Red Data	Protected	Likelihood
Half-collared Kingfisher	*Alcedo semitorquata*	NT		Moderate
Kori Bustard	*Ardeotis kori*	NT	NEMBA (PR)	Low
Pallid Harrier	*Circus macrourus*	NT		Low
Abdim's Stork	*Ciconia abdimii*	NT		Moderate
African Marsh-Harrier	*Circus ranivorus*	EN		Low
Black-winged Pratincole	*Glareola nordmanni*	NT		Low
Black Stork	*Ciconia nigra*	VU		Moderate
European Roller	*Coracias garrulus*	NT		Moderate
Lanner Falcon	*Falco biarmicus*	VU		Moderate
White-backed Vulture	*Gyps africanus*	EN	NEMBA (EN)	Low
Cape Vulture	*Gyps coprotheres*	EN	NEMBA (EN)	Low
Marabou Stork	*Leptoptilos crumeniferus*	NT		Low
Yellow-billed Stork	*Mycteria ibis*	EN		Low
Pink-backed Pelican	*Pelecanus rufescens*	VU		Low
Lesser Flamingo	*Phoenicopterus minor*	NT		Low
Greater Flamingo	*Phoenicopterus ruber*	NT		Low
Verreaux's Eagle	*Aquila verreauxii*	VU		Low
Martial Eagle	*Polemaetus bellicosus*	EN	NEMBA (EN)	Low
Secretarybird	*Sagittarius serpentarius*	VU		Low
Yellow-throated Sandgrouse	*Pterocles gutturalis*	NT		Moderate
Greater Painted-Snipe	*Rostratula benghalensis*	VU		Low
Bateleur	*Terathopius ecaudatus*	EN	NEMBA (EN)	Low
Lappet-faced Vulture	*Torgos tracheliotus*	EN	NEMBA (EN)	Low
African Grass Owl	*Tyto capensis*	VU		Low
Tawny Eagle	*Aquila rapax*	EN	NEMBA (EN)	Low
Bateleur	*Terathopius ecaudatus*	VU	NEMBA (EN)	Low

* = IUCN classification; DD = Data Deficient; NT = Near-threatened; EN = Endangered; VU = Vulnerable

Reptiles and amphibians

Four reptile and four frog species are confirmed to occur in the study area, all being common and widespread in the savanna biome in South Africa and not species of conservation-concern. The North West Province does not have high numbers of threatened or near threatened reptiles, and no Red Data reptile species potentially occur. The only additional frog species of conservation concern that potentially occurs in the study area is the Giant Bullfrog (Pyxicephalus adspersus) which has been assessed as Near Threatened and is protected under the NEMBA. There are no seasonal pan-wetlands in the study area which could provide suitable breeding sites for the Giant Bullfrog and its presence within the study area is unlikely (De Castro and Brits, 2016c).

TABLE 7.16: REPTILES AND AMPHIBIANS RECORDED ON SITE (DE CASTRO AND BRITS, 2016C)

Common name	Scientific name
Reptiles	
Puffadder	*Bitis arietans*
Mozambique Spitting Cobra	*Naja mossambica*
Striped Skink	*Trachylepis striata*
Variable Skink	*Trachylepis varia*
Amphibians	
Common River Frog	*Amietia angolensis*
Gutteral Toad	*Amietophrynus gutteralis*
Raucous Toad	*Amietophrynus rangeri*
African Bullfrog	*Pyxicephalis edulis*

Invertebrates

A total of 72 arthropods were recorded during the site investigations for the approved EIA and EMP; 37 species of Lepidoptera and 35 species of other arthropods. The specialist indicated that the dry summer and degradation and low floristic diversity of the area could play a part in low arthropod diversity. Five lepidoptera identified have medium conservation status, these include False Swift (*Borbo fallax*), Barber's Acraea (*Acraea (Acraea) Barberi*), Purple Gem (*Chloroselas mazoensis*), Darker Commodore (*Junonia antelope*) and Ragged Skipper (*Caprona pillaana*). A potentially occurring red data species (low probability) is the Rossouw's Copper (*Aloeides rossouw*) which is Vulnerable. A list of the species identified is included in Table 7.17. All of the species recorded during the survey were common savanna species and are not restricted in terms of habitat or distribution (Golder, 2007).

TABLE 7.17: ARTHROPOD SPECIES RECORDED ON SITE (GOLDER, 2007)

Order	**Scientific Name**
Isoptera	*Trinervitermes*
Isoptera	*Amitermis hastatus*
Mantodea	*Harpagomantis tricolor*
Mantodea	*Sphodromantis gastrica*
Dermaptera	*Labidura riparia*
Orthoptera	*Hetrodes pupus*
Orthoptera	*Phaneroptera*

Order	Scientific Name
Orthoptera	*Gryllus bimaculatus*
Orthoptera	*Hoplolopha*
Orthoptera	*Phymateus morbillosus*
Orthoptera	*Acrida acuminata*
Orthoptera	*Locustana pardalina*
Hemiptera	*Etrichodia crux*
Hemiptera	*Mirperus faculus*
Hemiptera	*Scantius fosteri*
Hemiptera	*Nemia costalis*
Coleoptera	*Passalidius fortipes*
Coleoptera	*Acanthoscelis ruficornis*
Coleoptera	*Melyris*
Coleoptera	*Psammodes striatus*
Coleoptera	*Stenocara dentata*
Diptera	*Tabanus taeniatus*
Diptera	*Exoprosopa*
Diptera	*Chrysomya chloropyga*
Diptera	*Chrysomya albiceps*
Hymenoptera	*Apis mellifera*
Hymenoptera	*Tetraponera*
Hymenoptera	*Messor capensis*
Hymenoptera	*Camponotus fulvopilosus*
Scorpiones	
Araneae	
	Centipede
	Millipede
Lepidoptera	*Bunaea alcinoe*
Lepidoptera	*Delta hottentottum*
Lepidoptera	*Axiocerses tjoane tjoane*
Lepidoptera	*Aloeides Molomo molomo*
Lepidoptera	*Danaus (Anosia) chrysippus aegyptius*
Lepidoptera	*Hyalites (Auracraea) rahira rahira*
Lepidoptera	*Iolaus (Stugeta) bowkeri tearei*
Lepidoptera	*Acraea (Acraea) anemosa*
Lepidoptera	*Acraea (Stephenia) aglaonice*
Lepidoptera	*Ypthima impure paupera*
Lepidoptera	*Physcaeneura panda*
Lepidoptera	*Melanitis leda helena*
Lepidoptera	*Tirumala petiverana*
Lepidoptera	*Hyalites (Hyalites) encedon encedon*
Lepidoptera	*Junonia ceryne ceryne*
Lepidoptera	*Lachnocnema durbani*
Lepidoptera	*Hypolimnas misippus*
Lepidoptera	*Hamanumida daedalus*
Lepidoptera	*Leucochitonea levubu*
Lepidoptera	*Metisella willemi*
Lepidoptera	*Gegenes niso niso*
Lepidoptera	*Gegenes pumilio gambica*
Lepidoptera	*Pelopidas thrax inconspicua*
Lepidoptera	*Parosmodes morantii morantii*
Lepidoptera	*Kedestes macomo*
Lepidoptera	*Spialia dromus*
Lepidoptera	*Spialia colotes transvaaliae*
Lepidoptera	*Kedestes lepenula*
Lepidoptera	*Zizeeria knysna*
Lepidoptera	*Eurema (Eurema) brigitta brigitta*
Lepidoptera	*Azanus moriqua*

Order	Scientific Name
Lepidoptera	*Catopsilia florella*
Lepidoptera	*Azanus ubaldus*
Lepidoptera	*Azanus jesous jesous*
Lepidoptera	*Borbo fallax*
Lepidoptera	*Acraea (Acraea) barberi*
Lepidoptera	*Chloroselas mazoensis*
Lepidoptera	*Junonia antilope*
Lepidoptera	*Caprona pillaana*

RESULTS - AQUATIC ECOLOGY

The project area is located within the Crocodile (West) and Marico Water Management Area (WMA) and Eland Sub Water Management Area (sub WMA), which falls within Quaternary Catchment A22F. The portion of Quaternary Catchment A22F located where the project area is located increasingly being transformed by urban and mining development, although the upper margins of the catchment located within the Pilanesberg Nature Reserve is more natural.

The site survey confirmed the presence of different watercourse types within the study area, (Figure 7-16) (De Castro and Brits, 2016b). These include:

- 1 Unchannelled valley bottom wetland
- 1 Channelled valley bottom wetland
- 7 Ephemeral Channels (these are clearly defined drainage lines)
- 3 Ephemeral drainage lines (these are poorly defined drainage lines)
- 3 Dams
- Riparian habitat along the Sandspruit, including the active channel
- Riparian habitat along the Elands River, including the active channel

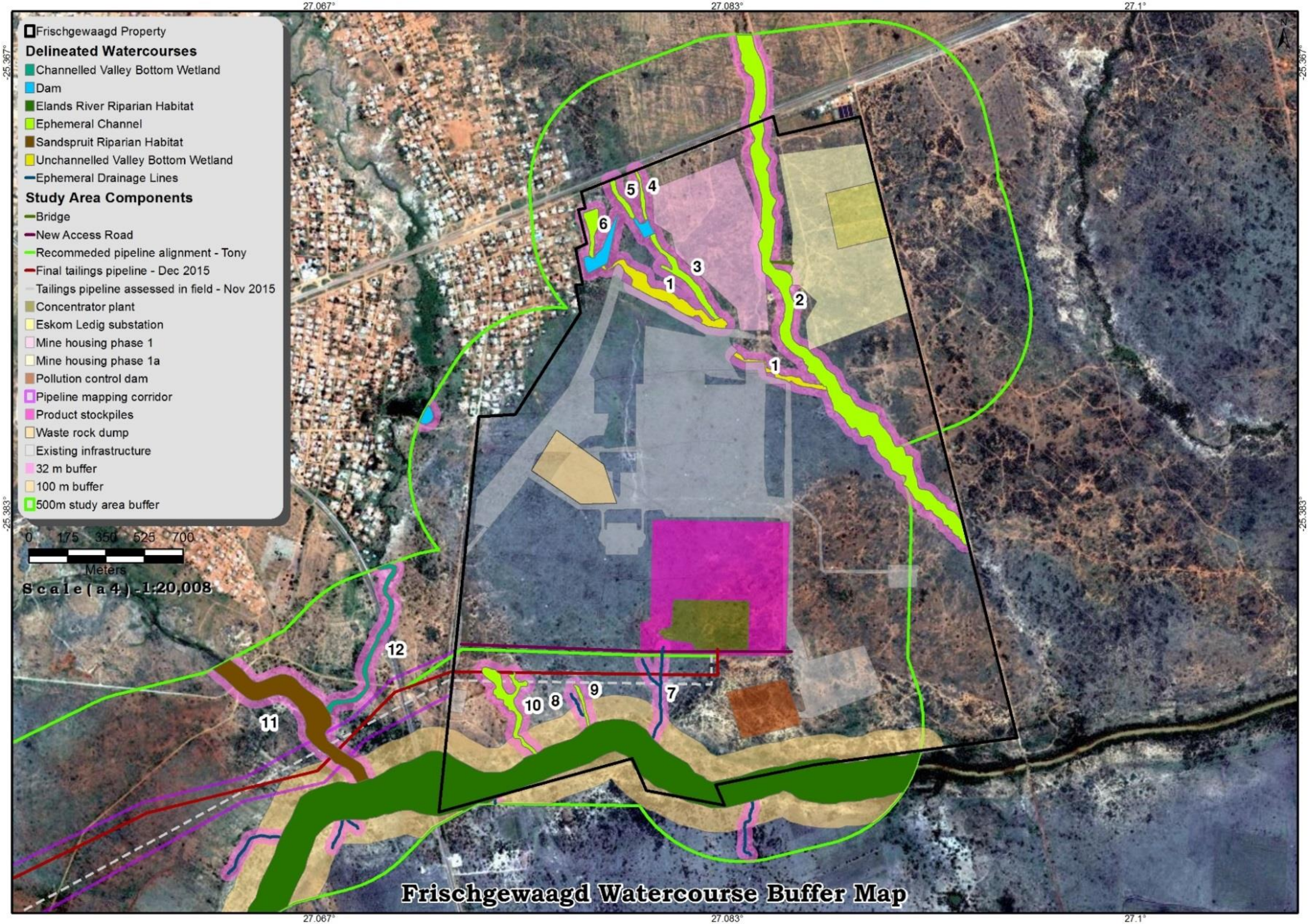
The present ecological state (PES) and the ecological importance and sensitivity (EIS) of each delineated watercourse are presented in Table 7.18.

TABLE 7.18: WATERCOURSES DELINEATED WITHIN THE PROJECT AREA (DE CASTRO AND BRITS, 2016B)

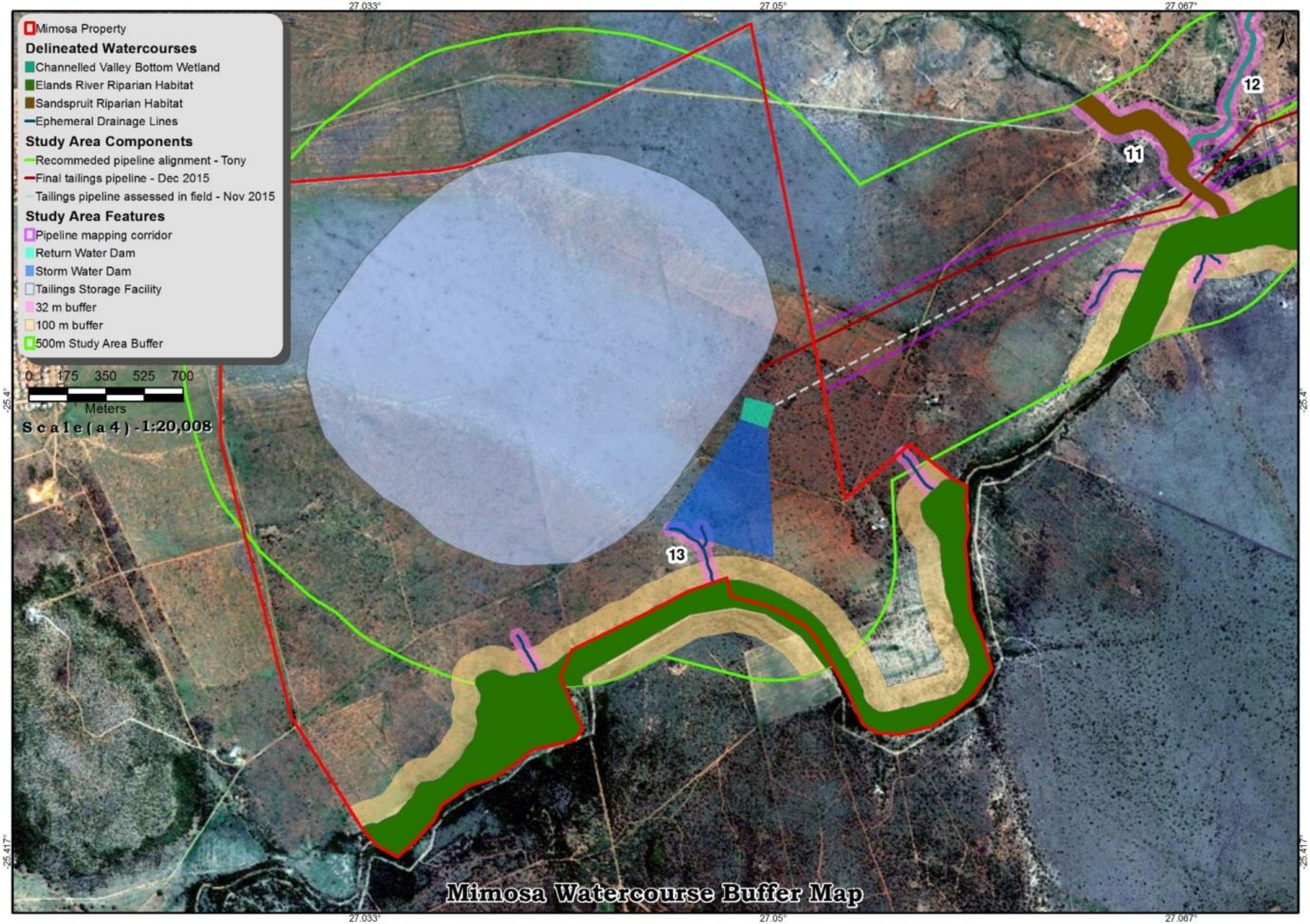
Watercourse Number	Watercourse Type	Present Ecological state*	Ecological importance and sensitivity
1	Unchannelled valley bottom wetland	D	High
2	Ephemeral channel	C	High / Very High
3	Ephemeral channel	B	High
4	Ephemeral channel	C	High
5	Ephemeral channel	C	High
7	Ephemeral drainage line	B	High
8	Ephemeral drainage line	B	High
9	Ephemeral channel	B	High
10	Ephemeral channel	B	High
11	Sandspruit River and riparian habitat	C	Moderate
12	Channelled valley bottom wetland	C	Moderate / High
13	Ephemeral drainage line	B	High

* Category B is largely natural, Category C is moderately modified and Category D is largely modified

SAS (2015) indicated that the Sandspruit and unnamed tributary of the Elands River had a PES Category C and a moderate EIS.



27.067°
27.083°
27.1°
-25.367°
-25.383°
Frischgewaagd Property
Delineated Watercourses
Channelled Valley Bottom Wetland
Dam
Elands River Riparian Habitat
Ephemeral Channel
Sandspruit Riparian Habitat
Unchannelled Valley Bottom Wetland
Ephemeral Drainage Lines
Study Area Components
Bridge
New Access Road
Recommeded pipeline alignment - Tony
Final tailings pipeline - Dec 2015
Tailings pipeline assessed in field - Nov 2015
Concentrator plant
Eskom Ledig substation
Mine housing phase 1
Mine housing phase 1a
Pollution control dam
Pipeline mapping corridor
Product stockpiles
Waste rock dump
Existing infrastructure
32 m buffer
100 m buffer
500m study area buffer
0 175 350 525 700
Meters
Scale (a4) - 1:20,008
N
1
2
3
4
5
6
7
8
9
10
11
12
Frischgewaagd Watercourse Buffer Map



Mimosa Property
Delineated Watercourses
Channelled Valley Bottom Wetland
Elands River Riparian Habitat
Sandspruit Riparian Habitat
Ephemeral Drainage Lines
Study Area Components
Recommeded pipeline alignment - Tony
Final tailings pipeline - Dec 2015
Tailings pipeline assessed in field - Nov 2015
Study Area Features
Pipeline mapping corridor
Return Water Dam
Storm Water Dam
Tailings Storage Facility
32 m buffer
100 m buffer
500m Study Area Buffer
0 175 350 525 700
Meters
Scale(a4) - 1:20,008
27.033°
27.05°
27.067°
-25.4°
-25.417°
11
12
13
Mimosa Watercourse Buffer Map

River health

The Sandspruit and unnamed tributary of the Elands River are considered by the specialist as systems of reduced Ecological Importance and Sensitivity due to limited provision of refugia and limited support for the aquatic ecology of the area. However, the systems are important for the provision of services to the terrestrial fauna of the area and have a fair importance from a socio-cultural point of view (SAS, 2015).

The large instream impacts to the Sandspruit are from flow modification and water quality modification. The moderate impacts include water abstraction, bed modification and channel modification. The largest riparian zone impacts included bank erosion, indigenous vegetation removal, flow modification and water abstraction. The Sandspruit was found to be moderately modified. The habitat conditions at the sites sampled were regarded as inadequate for supporting a diverse and sensitive aquatic macro-invertebrate community due to lack of strong flowing water and the absence of marginal vegetation (SAS, 2015).

The unnamed tributary of the Elands River has also been impacted. Instream, large impacts are from flow modification and water quality modification. Moderate impacts include water abstraction, bed modification and channel modification. In the riparian zone the impacts include bank erosion, indigenous vegetation removal and water abstraction. The unnamed tributary of the Elands River was found to be moderately modified. Habitat conditions upstream were regarded as inadequate for supporting a diverse and sensitive aquatic macro-invertebrate community due to sedimentation from a collapsed road crossing further upstream. The downstream habitat was considered to be adequate for supporting a diverse and sensitive aquatic macro-invertebrate community (SAS, 2015).

Aquatic macroinvertebrates

Monitoring of macro-invertebrates is useful as they are good indicators of localised conditions over the short-term. Benthic macro-invertebrates (bottom dwellers) are an important part of monitoring the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localised disturbances. The South African Scoring System, Version 5 (SASS5), was used to provide an indication of the quality of the aquatic environment at four sites sampled. The aquatic macro-invertebrates (to family level) recorded in terms of SASS5 are in Table 7.19 and the location of the sites sampled is in Figure 7-17.

Bak2 is downstream from Bak1 and Bak4 is downstream of Bak3, therefore any impact on the aquatic resources as a result of the proposed tailings pipeline will be evident at Bak2 and Bak4.

TABLE 7.19: AQUATIC MACRO-INVERTEBRATES (SAS, 2015)

Order	Family
Ephemeroptera	*Caenidae*
Annelida	*Oligochaeta*

Order	Family
Ephemeroptera	*Baetidae*
Ephemeroptera	*Caenidae*
Diptera	*Ceratopogonidae*
Diptera	*Chironomidae*
Diptera	*Culicidae*
Diptera	*Simuliidae*
Diptera	*Muscidae*
Pelecypoda	*Sphaeriidae*
Coleoptera	*Dytiscidae*
Coleoptera	*Gyrinidae*
Coleoptera	*Hydrophilidae*
Odonata	*Corduliidae*
Odonata	*Libellulidae*
Odonata	*Coenagrio nidae*
Hemiptera	*Veliidae*
Hemiptera	*Corixidae*

Following the SASS5 scoring, the biotic integrity of the sites can be classified as follows (the location of points is in Figure 7-17) (SAS, 2015):

- BAK5, an ephemeral pan, was dry at the time of the sampling;
- The aquatic macro-invertebrate community integrity of the Sandspruit at both the Bak1 and Bak2 sites was considered to be seriously impaired (Class E);
- The aquatic macro-invertebrate community integrity of the unnamed tributary was considered as critically impaired (Class F) at the upstream Bak3 site and as seriously impaired (Class E) at the downstream Bak4 site.

Diatoms

Diatoms are useful in providing an overall picture of the trends that are occurring in an aquatic system as they provide a rapid response to specific physico-chemical conditions in water and are often the first indication of change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinisation and changes in pH. The sampling in the Sandspruit found high values of pollution tolerant diatoms, indicative of artificial inputs of organic material. The upstream site of the unnamed tributary of the Elands River also found a high number of pollution tolerant diatoms, while the downstream site has a low percentage. This indicates that organic pollution is entering the unnamed tributary at the upper reaches of the system. This is likely due to the locality of the sampling site being close to the R556 and downstream of a rural settlement (SAS, 2015).

Ichthyofauna

While invertebrate communities are good indicators of localised conditions in a river over the short-term, fish, which are relatively long lived, mobile and feed on lower trophic levels, are good indicators of long-term influences and general habitat conditions (SAS, 2015). The approved EIA and EMP indicated that 16 indigenous fish species are expected to occur in the Elands River; eight are of low conservation importance, seven have medium conservation importance and one has high conservation importance. From sampling conducted in 2007 nine were recorded in the sample area. The species identified had low and medium conservation importance, the species of medium conservation importance included the Papermouth (*Barbus matozzi*) and the River sardine (*Mesobola brevianalis*) (Table 7.20).

TABLE 7.20: EXPECTED FISH ASSEMBLAGES FOR THE ELANDS RIVER (GOLDER, 2007)

Scientific Name	Common Name	Conservation Status	Recorded / Expected
Labeobarbus marequensis	Largescale yellowfish	Medium	Expected
Barbus mattozi	Papermouth	Medium	Recorded
Barbus paludinosus	Straightfin barb	Low	Recorded
Barbus trimaculatus	Threespot barb	Low	Recorded
Barbus unitaeniatus	Longbeard barb	Low	Recorded
Labeo cylindricus	Redeye labeo	Medium	Expected
Labeo molybdinus	Leaden labeo	Medium	Expected
Mesobola brevianalis	River sardine	Medium	Expected
Chiloglanis pretoriae	Shortspine suckermouth	High	Expected
Synodontis zambezensis	Brown squeaker	Medium	Expected
Clarias gariepinus	Sharptooth catfish	Low	Recorded
Oreochromis mossambicus	Mozambique tilapia	Low	Recorded
Pseudocrenilabrus philander	Southern mouthbrooder	Low	Recorded
Tilapia rendalli	Redbreast tilapia	Low	Expected
Tilapia sparrmanii	Banded tilapia	Low	Recorded
Schilbe intermedius	Silver catfish	Medium	Expected

Bak3
Bak5
Bak4
Bak1
Bak2

CONCLUSION

The project area falls mainly within the Marikana Thornveld which is classified as Vulnerable and thus an important vegetation type that requires careful consideration when developing mining projects. The probability of species of conservation concern occurring in the project area overall is moderate for floral and faunal species with three species having been confirmed on site in the current survey (one mammal and two plant species). For mammals and fish, there is a moderate likelihood, for plant there is a low to moderate likelihood, for birds, amphibian and arthropods it is mainly low. The approved mine and project area falls entirely within a CBA2 (in terms of the 2015 NWBSP) which has a management objective to maintain it in a natural or near natural state that maximises the retention of biodiversity pattern and ecological process. Important in this area are the natural corridor linkages and natural protected area buffer of the Pilanesberg National Park. It is important to note that these national guidelines and assessments were published after the mine was approved in 2009.

Areas of high, moderate and low botanical biodiversity sensitivity were mapped by the specialist. Some project footprints fall within areas of high botanical biodiversity sensitivity. Some areas have been transformed by agricultural and mining activities (both on the project sites and in the surrounding areas). The river systems have also shown some deterioration and further deterioration should be minimised. There are however aquatic systems that are still considered to be in a natural state and a large portion of the undeveloped area is the Marikana Thornveld. Thus, there are aquatic and terrestrial habitats that still exist within the project area which are suitable for fauna and flora species, including some Red Data and protected species.

7.4.1.6 Hydrology

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

Surface water resources include rivers, drainage lines, paths of preferential flow of storm water runoff as well as the channelling and/or collection of water on the surface such as dams. Mining projects have the potential to alter the drainage of surface water flow across a site and/or result in the contamination of the surface water resources through the placement of infrastructure and seepage and/or spillage of substances, non-mineralised and mineralised wastes.

Key to understanding the hydrology of the site is understanding the climatic conditions of the site (see Section 7.4.1.3) and topographical features (see Section 7.4.1.1). As a baseline, this section identifies hydrological catchments that could be affected by the project and the status of surface water features in the mining area.

DATA SOURCES

The information for this section was sourced from the approved mine EIA and housing BAR, the annual surface water monitoring report (SLR, 2015a), the September 2015 and December 2015 quarterly reports (SLR, 2015b and 2015c) (the Elands River was dry during the most recent quarterly and monthly sampling), the aquatic biomonitoring report (SAS, 2015b), the social impact assessment (Desai, 2016; Appendix P) and the wetland assessment report (De Castro and Brits, 2016d).

RESULTS

<u>Surface Drainage</u>

The project area is located within the Crocodile (West) and Marico Water Management Area and is located in Eland Sub Water Management Area, which falls within Quaternary Catchment A22F (De Castro and Brits, 2016d). The project area is located along the Elands River which is a tributary of the Crocodile River and forms part of the Limpopo River primary drainage system. The project area falls within the Bushveld-Basin Aquatic Ecoregion (SAS, 2015b).

There are various water courses and drainage lines within and around the project area. There are three main river reaches which includes the Elands River, an unnamed tributary of the Elands River and the Sandspruit. The Elands River flows south of the project area, is the receiving water body and flows into the Vaalkop Dam. The unnamed tributary of the Elands River flows through Frischgewaagd between Phase 1 and Phase 1a of the Gabonewe Estate mine housing. The Sandspruit flows to the west of the R565 and is between the TSF and plant/shaft area. The watercourses present within the project area are shown in Figure 7-12 (De Castro and Brits, 2016b).

An unchannelled valley bottom wetland is present to the north of the shaft complex and is bisected by a noise berm that has been constructed between the mine housing and the plant area. A channelled valley bottom wetland is east of and connected to the Sandspruit just north of the TSF/return water pipeline route. Clearly defined ephemeral channels are located to the west of the Phase 1 Gabonewe Estate mine housing and south of the TSF pipeline route on the Farm Frischgewaagd linking to the Elands River. Poorly defined ephemeral drainage lines feeding into the Elands River are present south of the TSF pipeline route on the Farm Frischgewaagd and south of the return water dam. There are also two artificial wetlands in the form of dams located west of the Phase 1 Gabonewe Estate mine housing area (De Castro and Brits, 2016b).

Mean Annual Runoff

The upslope sub-catchment referred to as Part of A22F North has been subdivided into five drainage areas corresponding to the drainage lines draining from or past the farms Frischgewaagd and Mimosa Figure 7-18). The sub-catchments of concern are the Sandspruit (I), Matlhogaabone (II), an unnamed north drainage line (III), the part of A22F south of the site (IV) and the Phatsima/Mimosa area (V). The sub-catchment area totals approximately 303 km^2 (TWP, 2008).

The annual runoff expected from the Elands basin area is 10 to 20 mm. The Mean Annual Runoff (MAR) is the long-term average river flow derived from the relevant catchment under virgin conditions, i.e. in its pristine state prior to any changes brought about by anthropogenic land-use (TWP, 2008).

The total MAR in the catchment upstream of the project area is 54 million cubic meters (mcm) with A22F contributing 4.8 million cubic meters (8.9% of the total MAR). The approved mine and proposed project lies within sub-catchments that contribute approximately 1.8 % of MAR (i.e. II + III + V) for the Elands upstream of the site (Table 7.21). The Elands upstream of the site contributes approximately 48 % of MAR of the total Elands Catchment (TWP, 2008).

TABLE 7.21: MEAN ANNUAL RUNOFF FOR RELEVANT SUB-CATCHMENT AREAS NEAR THE PROJECT AREA (PRISTINE CONDITIONS) (TWP, 2008)

Sub-Catchment	Sub-Catchment Area (km^2)	MAR (106 m^3)	MAR % of Total
I	172	2.75	56.7
II	28	0.45	9.3
III	11	0.18	3.7
IV	70	1.12	23.1
V	22	0.35	7.2
Total for Sub-Catchments	**303**	**4.85**	**100**

Legend

- Perennial Rivers
- Non-Perennial Rivers

Quatenary Catchments

- A22D
- A22E
- A22F
- A22H
- A22J
- A24D
- A24E

Kilometers

0 5 10

Scale: 1:236 000 @ A4

SA Grid WGS84

BAKUBUNG PLATINUM MINE (PTY) LTD

Figure 7.18

Catchments

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006 | March 2016

Normal dry weather flow

The normal dry weather flow for perennial streams is regarded as the average monthly flow that is expected during the three driest months. The three driest months include June, July and August.

The sub-catchments areas (I, II, III, IV and V) contribute to normal dry weather flow at a rate totalling approximately 108 l/hour or 2.6 m^3 per day. These drainage lines which are ephemeral in nature are dry during most of the dry months as the available volume of runoff is virtually zero during these periods. The normal dry weather flows in the sub-catchment areas are shown in Table 7.22. Note that the average expected flow is a long-term average and for arid areas such as Elands, the variance could also be large (TWP, 2008).

TABLE 7.22: NORMAL DRY WEATHER FLOW FOR THE RELEVANT SUB-CATCHMENT AREAS NEAR THE PROJECT AREA (PRISTINE CONDITIONS) (TWP, 2008)

Sub-Catchment	Jun (million cubic meters (mcm))	Jul (mcm)	Aug (mcm)	Average (mcm)	Average (l/hour)
I	0.055	0.044	0.036	0.045	61
II	0.009	0.007	0.006	0.007	10
III	0.004	0.003	0.002	0.003	4
IV	0.022	0.018	0.015	0.018	25
V	0.007	0.006	0.005	0.006	8
Total	0.097	0.078	0.063	0.079	108

Flood Peaks and volumes

Flood peaks for the 1:20, 1:50, 1:100 and 1:200 year storm events were calculated for the Elands River. Various methods were used to calculate the peak floods, these included the Franco Rodier method, the Standard Design Flood method and the Unit Graph (UG) method. The UG method of calculation was considered to be applicable in this case. The peak flow rates are summarised below in Table 7.23.

TABLE 7.23: FLOOD PEAK ESTIMATES FOR THE ELANDS RIVER ACCORDING TO THE UG METHOD (TWP, 2008)

Return Period	1:20	1:50	1:100	1:200
UG (m3/s)	520	800	980	1 150
Flood volume (106 m3)	35.5	54.6	66.9	78.5

Floodlines

Floodlines were determined for the project area as part of the mine EIA and housing BAR. Input data included the 1:100 flood peak, flood plain slopes, vegetation and general roughness of the river and overbanks areas.

Disturbance of drainage systems

The portion of Quaternary Catchment A22F located around the project area is increasingly being transformed by urban and mining development, although the upper margins of the catchment located within the Pilanesberg National Park is more natural (TWP, 2008).

At desktop level, the project area was found to be deteriorated from what be expected. The large instream impacts to the Sandspruit are from flow modification and water quality modification. The moderate impacts include water abstraction, bed modification and channel modification. The largest riparian zone impacts included bank erosion, indigenous vegetation removal, flow modification and water abstraction. The Sandspruit was found to be moderately modified (SAS, 2015b).

The unnamed tributary of the Elands River has also been impacted. Instream, large impacts are from flow modification and water quality modification. Moderate impacts include water abstraction, bed modification and channel modification. In the riparian zone the impacts include bank erosion, indigenous vegetation removal and water abstraction. The unnamed tributary of the Elands River was found to be moderately modified (SAS, 2015b).

Ongoing aquatic biomonitoring in the project area has indicated that the Elands River has also been moderately modified from anthropogenic activities within the larger project area (SAS, 2015a).

Water Quality

The pre-mining water quality was determined through 11 surface water sampling points along the Elands River.

Monthly surface water monitoring has been taking place since 2010 at BPM, with a more detailed set of parameters assessed every quarter.

Surface water monitoring takes place at the evaporation dam (SW4) on site and along three of the original sampling points in the Elands River:

- Upstream: Elands River, south of the proposed TSF area, upstream of tributary from the south on Onderstepoort 98 JQ (SW1)
- Midstream: Elands River intersection with the R565, downstream of the confluence of the Sandspruit on Frischgewaagd 96 JQ (SW2); and
- Downstream: Elands River downstream of proposed shaft and plant area along the intersection of the river with the communal boundary between Frischgewaagd 96 JQ and Styldrift 90 JQ (SW3).

During the winter months there is no water flow in the Elands River thus sampling occurs sporadically mainly during the rainy season.

The pre-mining water quality is shown in Table 7.24. The three monitoring points included in the monthly surface water monitoring programme along the Elands River are indicated as SW1, SW2 and SW3. The results were compared to SANS 241:2011 water quality guidelines. Exceedances for Class II (maximum allowable) are bold and exceedances for Class II (limits exceeded) are shaded grey.

The following parameters exceeded one or more of the guideline values: aluminium (Class II limits exceeded), fluoride (Class II limits exceeded), iron (Class II maximum allowable), manganese (Class II maximum allowable) and turbidity (Class II limits exceeded). Possible reasons for the elevated parameters were not indicated. There were no traces of faecal coliforms in the samples analysed.

TABLE 7.24: PRE-MINING SURFACE WATER QUALITY (FEBRUARY, 2008) (TWP, 2008)

Variable	S1	S3	S4 (SW1)	S6	S7	S8	S9 (SW2)	S10 (SW3)	S12	S13	S15	Class I (Rec. Ops. Limit)	Class II (Max. allow.)	Class II Limits Exceeded
% Ion Difference	9.24	9.8	10.17	9.95	7.79	6.79	8.34	8.7	8.85	8.75	8.78			
Aluminium (mg/l)	0.06	1.03	0.97	0.24	0.04	0.03	2.34	2.42	1.88	2.31	2.55	0 - 0.3	0.3 - 0.5	> 0.5
Ammonia (mg/l) as N	<0.01	<0.01	0.014	<0.01	0.103	0.036	<0.01	0.047	0.057	0.018	0.042	0 - 1.0	1.0 - 2.0	> 2.0
Arsenic (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0 - 0.01	0.01 - 0.05	> 0.05
Boron (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Ca Hardness (mg/l)	44.9	26	22.6	28.9	68.9	110	50.2	43.4	43.4	39.7	42.7			NS
Cadmium (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0 - 0.005	0.005 - 0.01	> 0.01
Calcium (mg/l)	18	10.4	9.04	11.6	27.6	43.9	20.1	17.4	17.4	15.9	17.1	0 - 150	150 - 300	> 300
Chloride (mg/l)	7.03	5.45	6.68	5.93	15.5	28.6	12	10.2	8.24	6.72	7.64	0 - 200	200 - 300	> 300
Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0 - 0.1	0.1 - 0.5	> 0.5
Copper (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0 - 1	1.0 - 2.0	> 2.0
Corrosion Ratio	7.3	7.76	8.55	8	5.82	5.86	6.61	6.24	6.06	6.18	6.46			
EC (mS/m)	17.3	13.8	13.3	12.8	36.4	59.6	27.1	22.7	21	20.3	20.8	0 - 150	150 - 370	> 370
Fluoride (mg/l)	0.12	0.12	0.1	0.11	1.16	1.64	0.89	0.92	0.88	0.73	0.74	0 - 1.0	1.0 - 1.5	> 1.5
Hexavalent Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0 - 0.01	0 - 0.01	> 0.01
Iron (mg/l)	0.08	1.23	1.41	0.25	0.05	0.01	1.85	1.84	1.35	1.79	2.11	0 - 0.2	0.2 - 2.0	> 2.0
Lead (mg/l)	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0 - 0.02	0.02 - 0.05	> 0.05
Magnesium (mg/l)	13.4	9.76	10.5	9.44	18.6	28.5	14.5	11.6	10.5	10.9	11.6	0 - 70	70 - 100	> 100
Manganese (mg/l)	0.07	<0.01	<0.01	<0.01	0.06	0.01	0.02	0.057	0.23	0.053	0.102	0 - 0.1	0.1 - 1.0	> 1.0
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0 - 0.001	0.001 - 0.005	> 0.005
Mg Hardness (mg/l)	55.2	40.2	43.4	38.9	76.6	117	59.7	47.8	43.2	44.9	47.8			
Nickel (mg/l)	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0 - 0.15	0.15 - 0.35	> 0.35
Nitrate (mg/l) as N	0.49	0.47	0.16	0.17	0.48	0.92	0.97	0.75	0.47	0.36	0.54	0 - 10	10.0 - 20.0	> 20
Ortho Phosphate (mg/l) as P	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
pH	7.51	7.64	7.4	7.43	7.85	8.01	7.81	7.77	7.69	7.85	7.74	5.0 - 9.5	4.0 - 10.0	< 4 or > 10
Potassium (mg/l)	3.04	3.8	3.41	3.39	1.08	1.03	4.09	4.66	4.89	4.33	4.75	0 - 50	50- 100	> 100

Variable	S1	S3	S4 (SW1)	S6	S7	S8	S9 (SW2)	S10 (SW3)	S12	S13	S15	Class I (Rec. Ops. Limit)	Class II (Max. allow.)	Class II Limits Exceeded
Ryznar Index	0.54	0.63	0.76	0.69	0.33	0.31	0.39	0.41	0.37	0.32	0.37			
Selenium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0 - 0.02	0.02 - 0.05	> 0.05
Silicon (mg/l)	9.04	9.69	6.78	8.95	12.2	14.9	11.8	6.5	7.14	18.3	8.13			
Sodium (mg/l)	7.61	8.99	9.41	6.83	23.8	46.1	18.9	13.5	11.8	10.7	10.5	0 - 200	200 - 400	> 400
Sodium Absorption Ratio	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01			
Sulphate (mg/l)	35.4	35.7	42.5	36.2	21.9	19.1	28.6	21.7	19.4	20.1	24	0 - 400	400 - 600	> 600
Suspended Solids (mg/l)	10	66	189	12	32	806	39	23	30	6	21			
T.Alk. as CaCO3 (mg/l)	70.5	53.8	53.9	51.7	168	295	126	97.7	89	90.9	92.7			
TDS (mg/l)	126	107	114	102	212	349	179	142	127	125	134	0 - 1 000	1 000 - 2 400	> 2 400
TDS to EC Ratio	0.33	0.48	0.5	0.36	0.85	1.33	0.78	0.61	0.55	0.5	0.48			
Total Chlorine mg Cl2/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0 - 200	200 - 600	> 600
Total Hardness (mg/l)	100	66.2	65.9	67.8	146	227	110	91.2	86.7	84.6	90.5			
Turbidity NTU	185	340	377	232	205	1273	120	97.1	87.1	77	84.9	0 - 1	1.0 - 5.0	> 5
Vanadium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0 - 0.2	0.2 - 0.5	> 0.5
Zinc (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0 - 5.0	5.0 - 10.0	> 10.0

The water quality from the surface water monitoring programme has been compared to the previous monitoring events as well as the following guidelines (SLR, 2015):

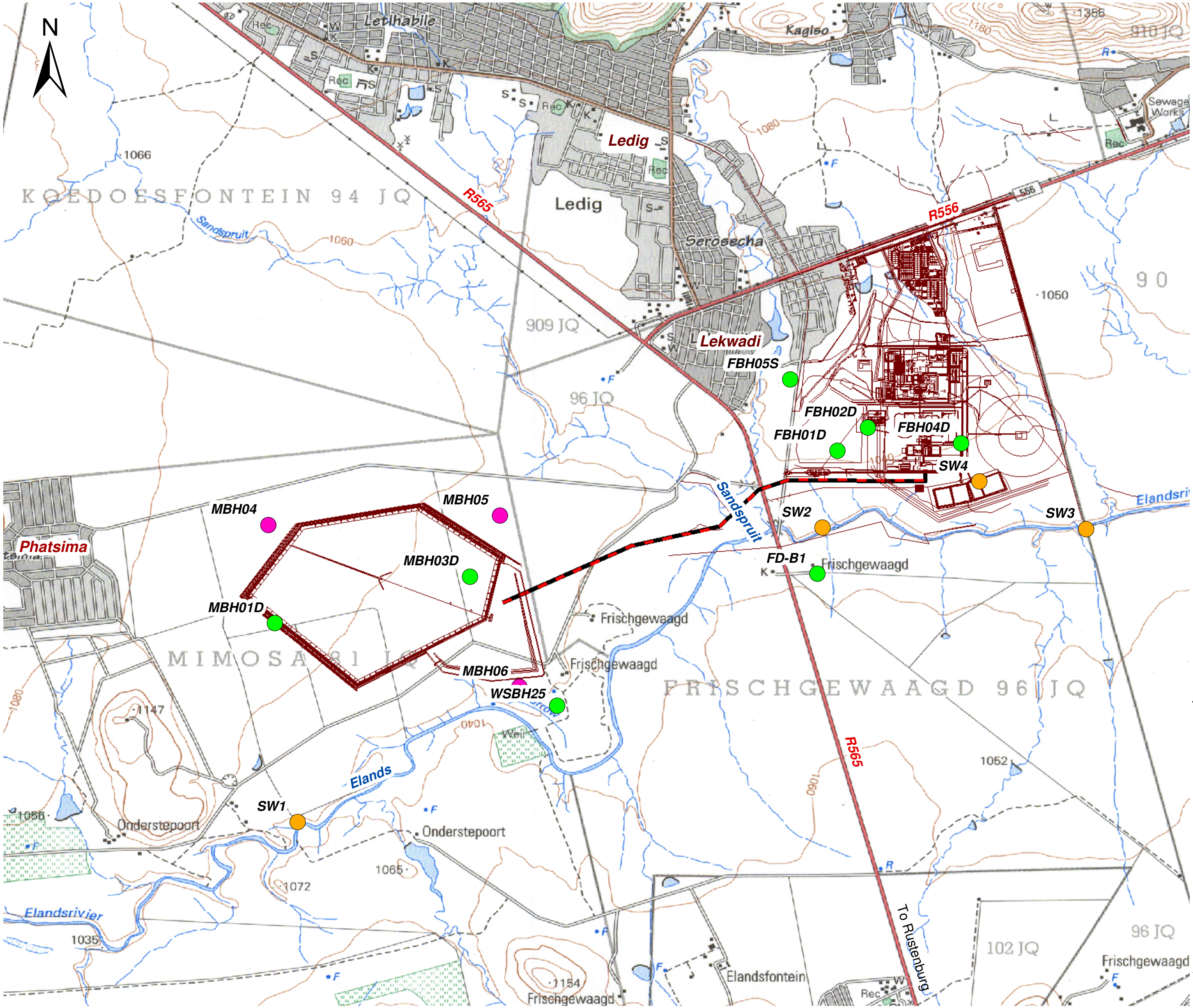
- South African National Standard for Drinking water (SANS 241:2011 and SANS 241: 2015 (for December 2015 data))
- South African DWAF Water Quality Guidelines for Livestock Watering

The most recent quarterly surface water sampling in the Elands River only took place in September and December 2014 as the river was dry during the quarterly winter monitoring runs (SLR, 2015a). Sampling locations are shown in Figure 7-19. The most recent quarterly monitoring for SW4 (evaporation dam) took place in September 2015 (SLR, 2015b) and December 2015 (SLR, 2016a). Review of the available data showed the following:

- The EC recorded from SW1, SW2 and SW3 was low, ranging from 22.4 mS/m (SW3, December 2014) to 81.8 mS/m (SW1, December 2014). The EC recorded in SW4 (December 2015) remained low (≤46.7 mS/m). Concentrations are consistent with previous monthly monitoring events.
- The TDS concentrations recorded in the river samples were low, averaging between 158 mg/l (SW3) and 432 mg/l (SW1). The concentration recorded in SW4 for December was 256 mg/l remaining low. Concentrations are consistent with previous monitoring events.
- Concentrations of nitrate identified in the pre-mining water quality data as being of concern were all below DWAF limits for Livestock Watering in the Elands River.
- Nitrate concentrations at SW4 continued the previous year's trend of being elevated above the SANS 241: 2011 standard up to December 2014. This was compared to 0.8 mg/l in December 2013. Nitrate levels decreased substantially to 1.5 mg/l in December 2015. It was indicated that it is unclear if birds which frequent the dam are contributing to nitrate contamination. It is likely that ammonium nitrate fuel oil (ANFO) explosive residue collected from the dirty water containment area runoff is the source of contamination.
- E.coli counts per 100 ml were elevated above the SANS 241: 2011 standard on at least one occasion during the 2014/2015 annual monitoring period at the following surface water monitoring points:
  - SW1; 4 & 15 /100 ml (September and December 2014)
  - SW2; 25 & 490 /100 ml (September and December 2014)
  - SW3; 120 /100 ml (December 2014)
  - SW4; 100 & 2 /100 ml (December 2014 and March 2015)
- E. coli contamination within the Elands River is likely due to the use of the river for livestock watering. E. coli contamination within the evaporation dam (SW4) was indicated to be likely due to birds which frequent the pond.
- Aluminium concentrations exceeded the SANS 241: 2011 standard of 300 µg/l at SW2 and SW3 in December 2014 and for SW4 in September 2015 and December 2015. No spillages at BPM have been reported during the December 2014 period. Aluminium concentrations are likely due to

the high sediment loads present within the Elands River, however due to the ephemeral nature of the Elands River it is difficult to determine trends.

- Trace amounts of Iron and Manganese were detected in the Elands River in December 2014 at SW2 and SW3. This represents an aesthetic impact on water quality in terms of the SANS 241: 2011 guidelines. Elevated levels of Iron that exceeded the SANS 241: 2015 standard were found in SW4 in December 2015.



Legend

- Main Roads
- Secondary Roads
- Other Access Roads
- Power Line
- Rivers and Streams
- 20m Contour Lines
- Cultivated Areas
- Built-up Areas
- Mine Layout
- Proposed Pipeline

Sampling Points

- Groundwater
- Surface Water
- Newly Drilled Groundwater

Kilometers

0 1 2

Scale: 1:48 000 @ A4

SA Grid WGS84

BAKUBUNG PLATINUM MINE (PTY) LTD

Figure 7.19

SW and GW Sampling Points

SLR

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596,Cramerview, 2060, South Africa
Tel: +27 (11) 467-0945 Fax: +27 (11) 467-0978

710.23001.00006 | March 2016

<u>Surface Water Use</u>

There are various water users for the Elands sub-area of the Crocodile (West) Water Management Area, which include mainly agricultural irrigation, followed by mining, industrial (urban) and industrial (non-urban) purposes (TWP, 2008). The approved EIA and EMP also indicated that around the project area cattle drinking from the Elands River and fishing were observed. Observations on site in December 2015 (Desai, 2016) confirmed that there is still cattle grazing on site and fishing taking place in the river.

CONCLUSION

There are a number of surface water systems within the mine and project area including the Elands River, a tributary of the Elands River, the Sandpsruit and various ephemeral drainage lines, channels and wetlands. Use of the water from these systems has been observed on site. The water systems are deteriorated from what would be expected at desktop level and the systems have been modified through water abstraction, bed and channel modification, bank erosion and vegetation removal among others.

The pre-mining water quality showed elevated concentration of certain parameters. The water quality monitoring shows that the water quality has remained consistent for most parameters when compared to pre-mining water quality. There were instances of elevated E. Coli counts found at the sampling sites, which is likely from livestock and avifauna.

The facilities that part of this project will influence surface water runoff on the site, which in turn will influence the storm water management system on site. The proximity of project components to drainage lines needs careful consideration in the assessment of impacts and design of mitigation measures.

7.4.1.7 Geohydrology

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

Groundwater is a valuable resource and is defined as water that is located beneath the ground surface in rock pore spaces and in the fractures of lithologic formations. Understanding the geology of the area (see Section 7.4.1.2) provides a basis from which to understand the occurrence of groundwater resources. Project related activities have the potential to contaminate groundwater and result in a reduction of groundwater resources available to both the environment and third party users.

As a baseline, this section provides an understanding of the groundwater conditions (quality, quantity and use) and the potential for changes in groundwater as a result of project-related activities in the mining area.

DATA SOURCES

The information for this section was sourced from the approved EIA, BAR and EMPs, the annual ground water monitoring report (SLR, 2015a), the most recent quarterly (SLR, 2016a) and monthly (SLR, 2016b) groundwater monitoring reports and the groundwater modelling report (DTM, 2016, Appendix H).

RESULTS

Aquifer Classification

As discussed in the geology baseline, the area under investigation is underlain by the Rustenburg Layered Suite of the Bushveld Complex. Numerous faults and north-south striking dykes cut through and across the area. Groundwater occurs in secondary aquifers and is mainly associated with deeply weathered and fractured mafic rocks. This characteristic, in association with north-south striking dykes that cut through and across the norite, has formed groundwater compartments (TWP, 2008).

Two aquifers have been identified, an upper weathered aquifer and a lower fractured aquifer.

- Upper weathered aquifer: The weathered aquifer extends to a depth of 10 metres below ground level (mbgl). The weathered material forms due to vertical infiltration of recharging rainfall into the anorthosites/norites. The weathered aquifer was found to be partially saturated to unsaturated. This can be attributed to the fact that evaporation in the area is greater than rainfall for all months of the year resulting in a marked moisture deficit. Hence little or no recharge occurs (DTM, 2016).
- Lower fractured aquifer: The competent anorthosite/norite/gabbro-norites are subjected to fracturing associated with tectonic movements, and layering of the rock suites. The primary porosity does not allow significant groundwater flow, except where the porosity has been increased by formation of secondary structures. Groundwater flow in the fractured aquifer is mostly associated with these secondary fracture zones, provided that they are open and have not been filled with secondary mineralization (DTM, 2016).

The approved EIA and EMP indicated that the average yield in the area was approximately 1.7 l/s (6120 l/hour). These yields are based on blow yields and it was assumed that the actual yields would be much less. A realistic average yield for the area was indicated to be approximately 1-1.5 l/s.

The permeability tests conducted within the footprint of the TSF found that groundwater movement in the clayey turf was regarded as "slow" (TWP, 2008), with recharging water being retarded by the lower permeability of the overlaying clay material (DTM, 2016), with permeability being 0.08m/day (TWP, 2008). Rainwater and surface run-off will thus have a slow infiltration rate into the saturated turf (TWP, 2008).

The aquifer system in the project area was classified according to "A South African Aquifer System Management Classification (1995)". Following a hydrocensus and according to the abovementioned system, the aquifer system was classified as a minor aquifer system. Minor aquifer systems can have fractured or potentially fractured rocks which do not have a high permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality may be variable. While these aquifers seldom produce large quantities of water they are important for local supplies and in supplying base flow for rivers. The aquifer was found to be important for supplying base flow to the Elands River (TWP, 2008).

Groundwater Recharge

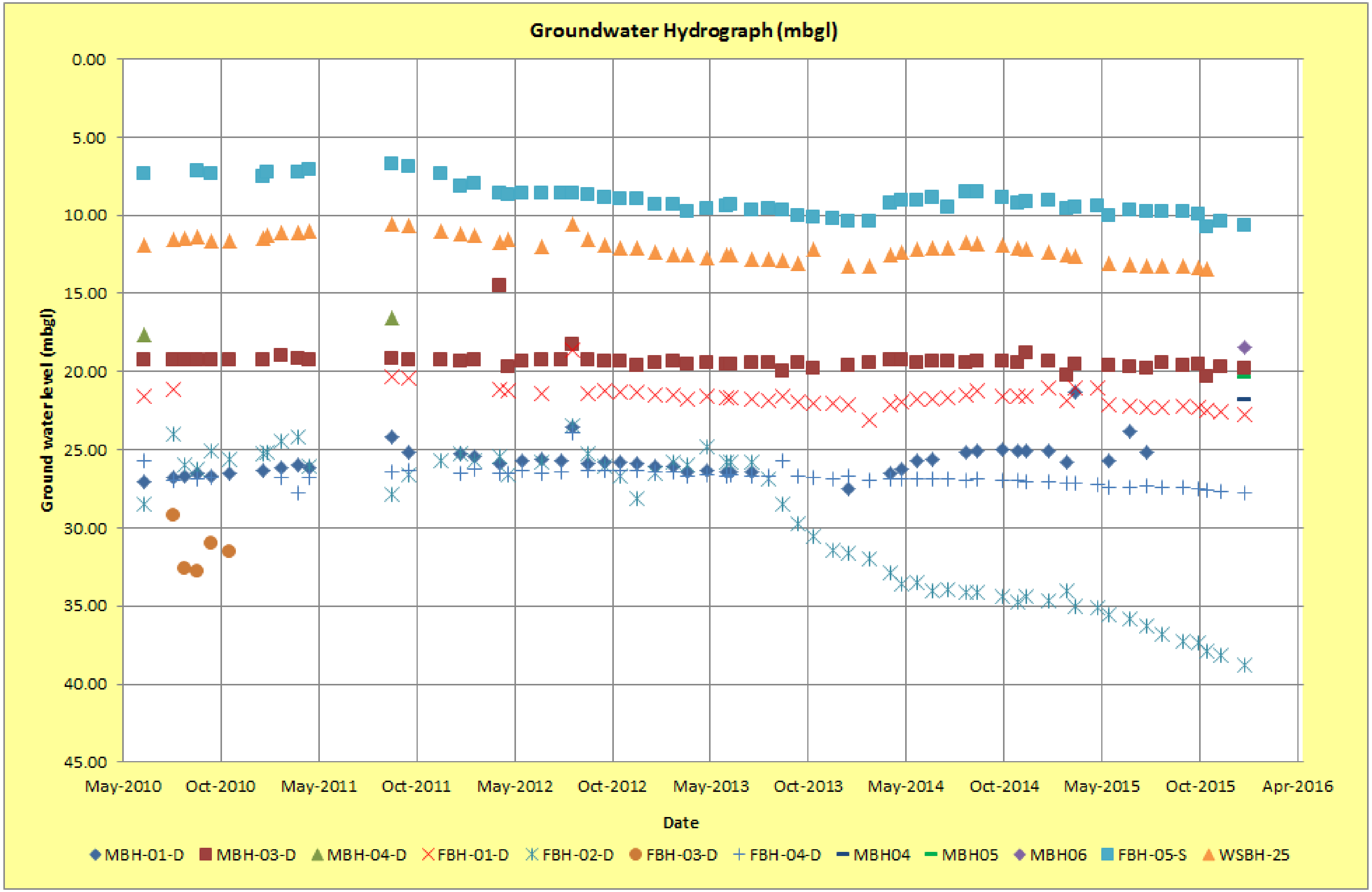
With evaporation being greater than rainfall in the area, there is a marked moisture deficit, thus little or no recharge to the aquifer occurs (DTM, 2016). Rainfall recharge is the only water source for groundwater recharge in the project area, with it being specified between 3% and 5% of the average annual precipitation. Natural drainage canals were seen as near surface groundwater sinks. The Elands River is a gaining river, receiving groundwater from the adjacent aquifer systems. Groundwater (especially the shallow aquifer systems) will therefore flow towards the river where it either daylights as springs or is recovered through evapotranspiration by vegetation (TWP, 2008).

Groundwater Flow, Levels and Use

The regional groundwater flow is closely related to the topography, and groundwater flows from higher lying ground in the north towards lower lying areas in the south and towards watercourses, which occur in lower lying areas. Of major importance for groundwater flow in the area is the presence of a relatively impermeable interface between the upper shallow weathered aquifer and the deeper, fractured aquifer. This semi- to impermeable interface prevents rapid vertical drainage of the shallow aquifer on a regional scale, thus permitting lateral groundwater flow in the shallow aquifer driven by groundwater gradients related to local topography.

The groundwater contours follow the surface topography, indicating that the groundwater flow is from high ground towards the Elands River. Groundwater will generally flow from north to south towards the Elands River (TWP, 2008).

The approved EIA and EMP indicated that the majority of the groundwater levels were between 20 to 30 mbgl. The results from groundwater monitoring suggest that groundwater levels generally range between 8.48 mbgl and 35.81 mbgl with groundwater flow towards the Elands River (SLR, 2015b). A hydrograph showing the changes in groundwater levels since 2010 (when on site groundwater monitoring started) is shown in Figure 7-20.



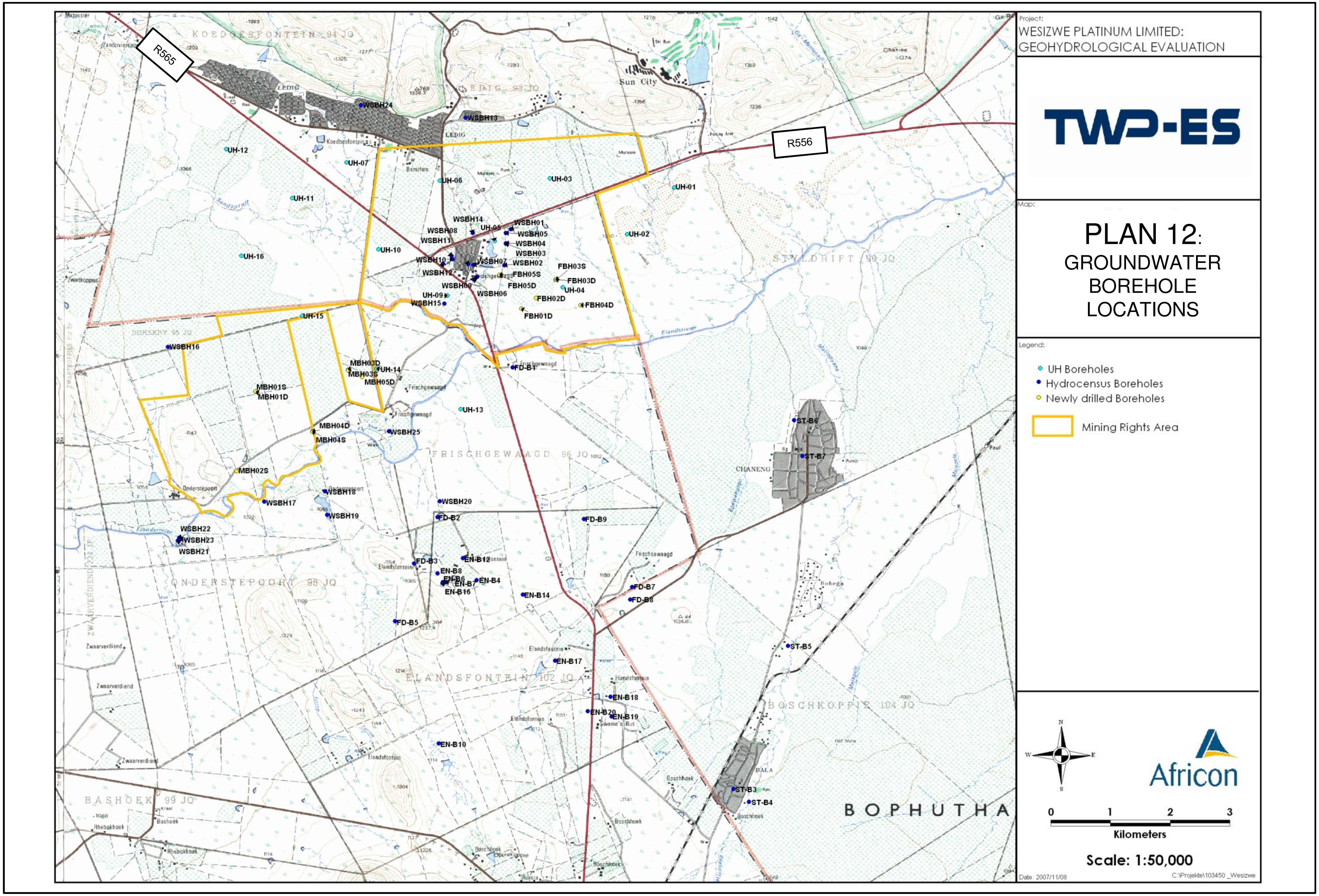
Groundwater Hydrograph (mbgl)
Ground water level (mbgl)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
May-2010
Oct-2010
May-2011
Oct-2011
May-2012
Oct-2012
May-2013
Oct-2013
May-2014
Oct-2014
May-2015
Oct-2015
Apr-2016
Date
MBH-01-D
MBH-03-D
MBH-04-D
FBH-01-D
FBH-02-D
FBH-03-D
FBH-04-D
MBH04
MBH05
MBH06
FBH-05-S
WSBH-25

The figure shows that there are fluctuations with groundwater over time around the site. The water level in borehole FBH02D has been falling over time. FBH02D is located south of the waste rock dump, east of the Concentrator Complex; the decrease in water levels may be as a result of mine operations.

Groundwater in the area is used for domestic, agriculture and irrigation purposes (SLR, 2016b). A map showing the boreholes that were identified in the 2008 EIA and EMP is contained in Figure 7-21 Figure 7-22. It should be noted that some of these may no longer exist and new ones may have been developed since the previous EIA.

BH nr.	Latitude/Longitude		Address	Owner	Tel nr.	Date drilled	Depth (m)	Collar height	Waterlevel (mbgl)	Date measured	Waterlevel (mbgl)	Date measured	Equipment	Yield (l/s)	Waterstrikes	User application
WSBH01	25.37354	27.07414	Kagiso Section 1	Municipality		1981	Unknown	0.00	~	9/7/2007			Hand pump	No info	No info	Domestic
WSBH02	25.37947	27.07296	Kagiso Section 1, Stand 2788	Mr Malebo	0736334295	1991	Unknown	0.00	~	9/7/2007			Hand pump	No info	No info	Domestic & Irrigation
WSBH03	25.37593	27.07326	Kagiso Section 1, Stand 2766	Me J. M. Moalusi	0836850106	1989	Unknown	0.33	~	9/7/2007			Hand pump	No info	No info	Domestic
WSBH04	25.37583	27.07328	Kagiso Section 1, Stand 2773	Me J. A. Ramotshudi	0764719970	Not Known	Unknown	0.40	~	9/7/2007			Hand pump	No info	No info	Domestic
WSBH05	25.37411	27.0733	Kagiso Section 1, Stand 2768	Me M. Masimo	0722674297	Not Known	Unknown	0.21	5.25	9/7/2007			Submersible	No info	No info	Domestic & Irrigation
WSBH06	25.38178	27.06792	Kagiso Section 1	Municipality	~	Not Known	Unknown	0.10	3.84	9/7/2007			Hand pump	No info	No info	None
WSBH07	25.3794	27.06786	Lekwadi Section, Stand 2425	Mr A. P. Mthembu	0787085422	28/07/1983	Unknown	0.26	7.30	9/7/2007			Submersible	No info	No info	Domestic
WSBH08	25.37936	27.06698	Lekwadi Section, Stand 2429	Me J. B. Motshoane	0834969112	1997	Unknown	0.25	8.05	9/7/2007			Submersible	No info	No info	None
WSBH09	25.38137	27.06849	Lekwadi Section	Municipality	~	Not Known	Unknown	0.20	4.44	9/7/2007			Hand pump	No info	No info	Domestic
WSBH10	25.37853	27.0644	Lekwadi Section, Stand 2138	Me M. V. Mbanjwa	0726611682	1989	Unknown	0.15	~	9/7/2007			Submersible	No info	No info	Domestic
WSBH11	25.37794	27.06423	Lekwadi Section, Stand 2063	Me J. Tlapu	0145510754	1984	72	0.13	~	9/7/2007			Mono pump	No info	No info	Domestic
WSBH12	25.37921	27.06283	Lekwadi Section, Stand 2050	Mr S. M. Gaborone	0826872267	1990	Unknown	0.17	~	9/7/2007			Mono pump	No info	No info	Domestic
WSBH13	25.35495	27.06662	Bagatleng Section , Stand 2834	Mr M. T. Nkosi	0724521593	30 years ago	Unknown	0.17	7.90	10/7/2007			Submersible	No info	No info	Domestic & Irrigation
WSBH14	25.37408	27.06784	Bagatleng Section , Stand 2465	Mr T. Dmoeti	0836952512	Not Known	Unknown	0.35	7.70	10/7/2007			Submersible	No info	No info	Domestic
WSBH15	25.38588	27.06298	Casablanca Sect, Stand TKK00181	Mr Masisi	0735334862	Dec-06	30	0.12	10.30	10/7/2007			Submersible	0.8	No info	Domestic
WSBH16	25.39315	27.01692	Phatsima Village	Municipality	~	Not Known	Unknown	0.06	31.29	11/7/2007			None	No info	No info	Domestic
WSBH17	25.41888	27.03298	Onderstepoort	Mr J. C. Grobbelaar	~	Not Known	50	0.06	12.00	11/7/2007			None	No info	No info	None
WSBH18	25.41721	27.04314	Onderstepoort	Mr J. C. Grobbelaar	~	Not Known	50	0.24	25.41	11/7/2007			Wind mill	No info	No info	None
WSBH19	25.42112	27.04349	Onderstepoort	Mr J. C. Grobbelaar	~	Not Known	50	0.13	~	11/7/2007			Mono pump	No info	No info	Domestic & Agricultural
WSBH20	25.41882	27.06227	Frischgewaagd	Mr J. C. Grobbelaar	~	Not Known	Unknown	0.22	32.35	11/7/2007			None	No info	No info	None
WSBH21	25.42541	27.01866	Phatsima Village	Municipality	~	Not Known	Unknown	0.58	9.42	11/7/2007			None	No info	No info	None
WSBH22	25.42491	27.01883	Phatsima Village	Municipality	~	Not Known	Unknown	0.25	11.06	11/7/2007			None	No info	No info	None
WSBH23	25.42511	27.01897	Phatsima Village	Municipality	~	Not Known	Unknown	0.79	10.51	11/7/2007			None	No info	No info	None
WSBH24	25.3528	27.0491	Ledig Section 3, Stand 1247	Me P. M. Tekela	0732442215	1985	54	0.20	17.02	11/7/2007			Submersible	No info	No info	Domestic
WSBH25	25.40709	27.05377	Frischgewaagd	No info	~	Not Known	Unknown	0.24	12.41	11/7/2007			None	No info	No info	None
UH-01	25.36652	27.10137	Styldrift	Anglo Platinum	~	7/7/2007	130	~	15.02	24/07/2007			None	7.5	22, 67	Seismic survey (destroyed?)
UH-02	25.3743	27.09349	Styldrift	Anglo Platinum	~	8/7/2007	100	~	14.34	24/07/2007			None	7.5	25	Seismic survey (destroyed?)
UH-03	25.36498	27.0806	Ledig	Anglo Platinum	~	5/7/2007	64	~	18.96	24/07/2007			None	0.4	31	Seismic survey (destroyed?)
UH-04	25.38315	27.08278	Frischgewaagd	Anglo Platinum	~	9/7/2007	90	~	11.03	23/07/2007			None	Dry	~	Seismic survey (destroyed?)
UH-05	25.37543	27.07146	Frischgewaagd	Anglo Platinum	~	12/7/2007	100	~	1.43	24/07/2007			None	0.6	25	Seismic survey (destroyed?)
UH-06	25.36536	27.06224	Ledig	Anglo Platinum	~	10/7/2007	110	~	8.16	24/07/2007			None	3.8	40	Seismic survey (destroyed?)
UH-07	25.36234	27.0467	Koedoesfontein	Anglo Platinum	~	17/7/2007	100	~	10.33	23/07/2007			None	5	28	Seismic survey (destroyed?)
UH-09	25.38452	27.06354	Frischgewaagd	Anglo Platinum	~	11/7/2007	100	~	10.01	23/07/2007			None	12.5	18	Seismic survey (destroyed?)
UH-10	25.3768	27.05201	Ledig	Anglo Platinum	~	7/7/2007	100	~	10.78	23/07/2007			None	6.2	18, 55	Seismic survey (destroyed?)
UH-11	25.36831	27.03767	Koedoesfontein	Anglo Platinum	~	7/6/2007	100	~	16.57	23/07/2007			None	Dry	~	Seismic survey (destroyed?)
UH-12	25.36015	27.02667	Koedoesfontein	Anglo Platinum	~	7/6/2007	85	~	26.09	23/07/2007			None	Dry	~	Seismic survey (destroyed?)
UH-13	25.40344	27.06572	Frischgewaagd	Anglo Platinum	~	13/7/2007	100	~	24.30	24/07/2007			None	0.6	59	Seismic survey (destroyed?)
UH-14	25.39671	27.05168	Onderstepoort	Anglo Platinum	~	11/7/2007	95	~	21.71	24/07/2007			None	Dry	~	Seismic survey (destroyed?)
UH-15	25.38789	27.03936	Onderstepoort	Anglo Platinum	~	3/7/2007	100	~	18.00	24/07/2007			None	1.2	67	Seismic survey (destroyed?)
UH-16	25.37788	27.0292	Koedoesfontein	Anglo Platinum	~	4/7/2007	75	~	23.01	24/07/2007			None	0.2	41	Seismic survey (destroyed?)
FBH01D	25.38671	27.07588	Frischgewaagd	Wesizwe Platinum	~	11/7/2007	72	0.66	21.63	15/08/2007	21.77	4/3/2008	None	0.5	26, 61	Monitoring
FBH02D	25.38494	27.0783	Frischgewaagd	Wesizwe Platinum	~	10/7/2007	72	0.74	29.42	15/08/2007	22.81	4/3/2008	None	Dry	~	Monitoring
FBH03D	25.38187	27.08158	Frischgewaagd	Wesizwe Platinum	~	10/7/2007	60	0.86	29.29	15/08/2007	25.33	4/3/2008	None	Dry	~	Monitoring
FBH03S	25.38188	27.0817	Frischgewaagd	Wesizwe Platinum	~	10/7/2007	12	0.83	Dry	15/08/2007	Dry	4/3/2008	None	Dry	~	Monitoring
FBH04D	25.38612	27.08576	Frischgewaagd	Wesizwe Platinum	~	10/7/2007	60	0.69	26.68	15/08/2007	26.91	4/3/2008	None	0.01	33	Monitoring
FBH05D	25.38105	27.07224	Frischgewaagd	Wesizwe Platinum	~	9/7/2007	60	0.65	8.88	14/08/2007	8.12	4/3/2008	None	0.01	34	Monitoring
FBH05S	25.38104	27.07218	Frischgewaagd	Wesizwe Platinum	~	9/7/2007	12	0.40	9.40	14/08/2007	8.69	4/3/2008	None	Dry	~	Monitoring
MBH01D	25.40057	27.03158	Mimosa	Wesizwe Platinum	~	9/7/2007	60	0.72	27.72	14/08/2007	28.09	4/3/2008	None	0.2	51	Monitoring
MBH01S	25.40048	27.03153	Mimosa	Wesizwe Platinum	~	9/7/2007	12	0.82	Dry	14/08/2007	Dry	4/3/2008	None	Dry	~	Monitoring
MBH02S	25.41379	27.02837	Mimosa	Wesizwe Platinum	~	13/7/2007	43	0.77	23.70	14/08/2007	23.82	4/3/2008	None	0.1	25-35	Monitoring
MBH03D	25.39688	27.04694	Mimosa	Wesizwe Platinum	~	11/7/2007	60	0.60	19.22	14/08/2007	19.28	4/3/2008	None	Dry	~	Monitoring
MBH03S	25.39699	27.04699	Mimosa	Wesizwe Platinum	~	12/7/2007	12	0.44	Dry	14/08/2007	Dry	4/3/2008	None	Dry	~	Monitoring
MBH04D	25.40718	27.04103	Mimosa	Wesizwe Platinum	~	12/7/2007	60	0.70	18.58	14/08/2007	18.09	4/3/2008	None	5	23, 32	Monitoring
MBH04S	25.40723	27.041	Mimosa	Wesizwe Platinum	~	12/7/2007	12	0.73	Dry	14/08/2007	Dry	4/3/2008	None	Dry	~	Monitoring
MBH05D	25.39805	27.0493	Mimosa	Wesizwe Platinum	~	13/7/2007	44		Dry	14/08/2007	Dry	4/3/2008	None	Dry	~	Monitoring
EN-B4	25.43204	27.06845	Sundown Ranch	L Coetzer	083 633 4905	No info	85	0.12	55.20	10/7/2007			Submersible	0.17	No info	Domestic
EN-B6	25.43229	27.06278	Sundown Ranch	L Coetzer	083 633 4905	No info	100	0.90	51.60	10/7/2007			Submersible	0.42	No info	Domestic
EN-B7	25.43231	27.06330	Sundown Ranch	L Coetzer	083 633 4905	No info	96	0.30	53.37	10/7/2007			Submersible	0.10	No info	Domestic
EN-B8	25.43077	27.06190	Sundown Ranch	L Coetzer	083 633 4905	No info	86	0.15	65.18	10/7/2007			Submersible	0.13	No info	Domestic
EN-B10	25.45928	27.06215	Sundown Ranch	L Coetzer	083 633 4905	No info	100	0.46	43.37	10/7/2007			Submersible	0.31	No info	Domestic

BH nr.	Latitude/Longitude		Address	Owner	Tel nr.	Date drilled	Depth (m)	Collar height	Waterlevel (mbgl)	Date measured	Waterlevel (mbgl)	Date measured	Equipment	Yield (l/s)	Waterstrikes	User application
EN-B12	25.42832	27.06614	Sundown Ranch	L Coetzer	083 633 4905	No info	100	0.11	45.92	10/7/2007			Submersible	0.12	No info	Domestic
EN-B14	25.43437	27.07611	Sundown Ranch	L Coetzer	083 633 4905	No info	100	0.29	54.47	10/7/2007			Submersible	1.66	No info	Domestic
EN-B16	25.43251	27.06266	Sundown Ranch	L Coetzer	083 633 4905	No info	100	0.47	54.06	10/7/2007			Submersible	1.11	No info	Domestic & Agricultural
EN-B17	25.44540	27.08155	Sherwood house	G Du Plessis	072 450 4541	No info	65	0.28	32.91	11/7/2007			None	No info	No info	None
EN-B18	25.45153	27.09073	Elandsfontein	S Palmer	072 777 1104	No info	55	0.08	37.05	11/7/2007			Submersible	2.78	No info	Domestic & Agricultural
EN-B19	25.45485	27.09093	Elandsfontein	S Palmer	072 777 1104	No info	78	0.22	37.42	11/7/2007			None	2.78	No info	None
EN-B20	25.45395	27.08686	Elandsfontein	S Palmer	072 777 1104	No info	60	0.21	34.45	12/7/2007			None	2.22	No info	None
WN-B1	25.35412	27.17532	Haartbeesspruit	Sauva Englezakis	076 845 5544	No info	0	0.11	5.92	11/7/2007			Mono pump	0.23	No info	Domestic & Agricultural
FD-B1	25.39650	27.07441	Frischgewaagd	Andre van Vuuren	073 721 4265	No info	25	0.48	9.63	10/7/2007			Mono pump	0.14	No info	Domestic & Agricultural
FD-B2	25.42147	27.06195	Frischgewaagd	Wiitkrans Trust	082 922 1579	No info	80	0.22	32.57	11/7/2007			None	0.63	No info	None
FD-B3	25.42923	27.05800	Frischgewaagd	Wiitkrans Trust	082 922 1579	No info	100	0.30	42.40	11/7/2007			None	0.25	No info	None
FD-B5	25.43876	27.05483	Frischgewaagd	Wiitkrans Trust	082 922 1579	No info	130	0.26	51.76	11/7/2007			Submersible	0.19	No info	Domestic & Agricultural
FD-B7	25.43312	27.09435	Frischgewaagd	J J Stols	072 988 6863	No info	73	0.21	17.44	10/7/2007			None	0.83	No info	None
FD-B8	25.43515	27.09402	Frischgewaagd	J J Stols	014-573 3327	No info	40	0.31	20.24	10/7/2007			Submersible	0.83	No info	Domestic & Agricultural
FD-B9	25.42178	27.08632	Sundown Ranch	L Coetzer	083 633 4905	No info	44	0.49	21.92	11/7/2007			None	No info	No info	None
ST-B2	25.46773	27.71113	Rasimone Village	MRS S MORAKE	~	No info	0	0.27	4.77	11/7/2007			Submersible	0.42	No info	Domestic & Irrigation
ST-B3	25.46690	27.11123	Rasimone Village	MRS M THBEDI	073 508 0656	No info	0	0.07	8.71	11/7/2007			Submersible	0.42	No info	Domestic & Agricultural
ST-B4	25.46898	27.11381	Rasimone Village	BAFOKENG PROPETY	~	No info	0	0.00	4.14	11/7/2007			None	No info	No info	None
ST-B5	25.44294	27.12029	Boschkoppie	No info	~	No info	0	0.00	13.15	11/7/2007			None	No info	No info	None
ST-B6	25.40526	27.12133	Chaneng Village, Plot B683	MRS R M MAGOBE	083 997 6112	No info	0	0.00	12.23	11/7/2007			Powerhead	0.01	No info	Domestic & Agricultural
ST-B7	25.41127	27.12271	Chaneng Village	MR L TEEKE	082 951 2772	No info	40	0.13	16.64	11/7/2007			Submersible	0.01	No info	Domestic & Agricultural



G:\070660 WESIZWE BFS\8.DRAWINGS\TWP ES 070660 0024 REV A

<u>Groundwater Quality</u>

For the pre-mining groundwater quality, chemical results were compared with the SANS Drinking Water Standards (SANS 241:2006). The majority of boreholes showed a Ca-Mg-HCO3 signature indicating recently recharged or recharging water. The pre-mining groundwater quality in the area was generally good with most of the water samples fit for human consumption (SLR, 2015b). Class I is the recommended operational limit and Class II is the maximum allowable concentration for short term use only. The results are shown in Table 7.25. Elevated levels above Class I are shown in bold.

Of the 26 boreholes sampled, 16 fell into Class I. Information on elevated concentrations and pollution indicators normally associated with platinum mining is indicated below (TWP, 2008):

- Nitrate: Nitrate concentrations exceeding the Class i concentration of 10 mg/l were present in 3 boreholes. These boreholes were all located within 40 m of a pit latrine, which is a potential source of nitrate pollution.
- Fluoride: Fluorides were high in 6 boreholes, exceeding the Class I concentration of 1 mg/l. The study indicated that high fluoride occurrences in the Pilanesberg area and the Rustenburg Layered Suite as confirmed by McCaffrey (1993) and Barnard (2000). According to McCaffrey (1993) the fluoride can be associated with the Red Foyaite in the Pilanesberg Complex and high values are encountered on the margins of the Pilanesberg, at or near the contact with the country rocks.
- Iron: Iron concentrations in 3 boreholes exceeded the Class I limit of 0.2 mg/l. The concentrations in 2 of the boreholes would only have aesthetic (taste) effects but no health effects. The concentration in the third borehole could have had slight health effects in children and sensitive individuals and pronounced aesthetic effects.
- Magnesium: The magnesium concentration in 1 borehole exceeded the Class I limit of 70 mg/l. The magnesium gives water a slight bitter taste and diarrhoea may occur in sensitive users.
- Electrical Conductivity: Electrical conductivity is an indicator of the total amount of dissolved solids in water, and thus serves as a useful indicator of groundwater pollution. The electrical conductivity of all the samples was low compared to the Class I drinking water standard of 150 mS/m.
- pH: The normal pH range of groundwater tends to be between 6 and 8, depending on the specific soil and rock composition through which it has percolated. All of the samples fell within this range and had a pH of greater than 7. The water had an alkaline character that is typical of water present in the occurring geology in the area.
- Sulphate: All the samples had sulphate concentrations that were within the Class 1 drinking water standards of 400mg/l.

The approved EIA and EMP indicated that as part of the social survey that was conducted in August 2007 in Ledig, Phatsima, and Mahobieskraal, more than 95% of respondents indicated that they had access to in-yard pit latrines. The reliance on pit latrines could result in a high potential for groundwater contamination in the area.

TABLE 7.25: BASELINE GROUNDWATER QUALITY (TWP, 2008)

Borehole	pH	EC	TDS	Ca	Na	Mg	K	P-Alk	Si	M-Alk	CO3	HCO3	Cl	SO4	NO3-N	F	Fe	Mn	NH3-N	As	B	Cr	Cu	PO4	U	IBE
FBH01D	8.25	75	346	43.2	79.7	37.7	1.6	0.3	25.8	390.3	3.85	468.23	20.0	20.9	0.3	0.5	0.03	0.01	1.00	0.001	0.028	0.001	0.001	0.40	0.004	-3.41
FBH02D	8.80	34	182	4.7	75.2	3.0	1.4	0.3	20.2	148.2	4.97	170.32	7.2	9.1	0.1	0.7	1.96	0.04	1.00	0.001	0.054	0.012	0.005	0.40	0.003	-5.86
FBH03D	9.33	31	204	5.0	55.0	1.4	2.2	0.3	14.8	38.6	3.77	38.13	46.4	25.8	0.1	1.6	0.60	0.01	1.00	0.002	0.066	0.005	0.001	0.40	0.000	-12.21
FBH04D	8.18	71	356	39.8	51.8	41.8	2.5	0.3	22.7	309.3	2.60	371.96	46.5	10.6	0.1	0.6	0.03	0.09	1.00	0.001	0.028	0.001	0.001	0.40	0.005	-3.69
FBH05D	8.12	96	522	46.6	46.9	64.3	4.3	0.3	11.9	336.5	2.47	405.43	99.3	62.0	3.9	0.5	0.03	0.09	13.60	0.001	0.027	0.001	0.001	0.40	0.000	-0.79
FBH05S	8.12	97	566	51.1	59.8	63.4	3.2	0.3	2.5	373.0	2.74	449.41	82.7	66.4	0.1	0.7	0.40	0.40	1.00	0.001	0.048	0.001	0.001	0.40	0.000	1.59
MBH01D	8.02	82	516	65.6	29.9	65.8	2.5	0.3	35.2	460.6	2.69	556.39	4.6	1.5	2.4	0.1	0.01	0.00	1.00	0.004	0.018	0.002	0.002	0.40	0.002	-2.38
MBH02S	8.21	53	312	34.8	16.2	44.0	0.9	0.3	3.4	248.8	2.24	298.88	10.9	36.7	0.1	0.2	0.05	0.30	1.00	0.001	0.044	0.001	0.001	0.40	0.000	5.42
MBH03D	8.11	82	504	66.0	34.2	61.0	2.0	0.3	33.9	433.9	3.11	522.95	15.7	7.8	7.9	0.1	0.02	0.10	1.00	0.002	0.019	0.001	0.002	0.40	0.002	-2.62
MBH04D	8.07	86	500	78.1	26.2	64.4	2.2	0.3	34.8	480.1	3.15	579.25	4.8	2.2	3.7	0.1	0.02	0.01	1.00	0.003	0.020	0.001	0.001	0.40	0.003	-2.52
WSBH01	8.50	85	642	83.1	55.1	59.1	3.6	7.8	25.0	369.3	6.39	437.35	105.9	61.1	0.1	0.7	0.03	0.20	1.00	0.005	0.013	0.001	0.001	0.90	0.001	-4.23
WSBH05	8.29	107	810	93.0	57.9	62.9	1.2	0.3	34.7	268.2	2.90	321.20	160.6	62.0	8.1	0.2	0.03	0.03	1.00	0.003	0.066	0.001	0.001	0.40	0.001	-3.85
WSBH07	7.88	62	426	50.9	55.5	29.7	3.4	0.3	33.4	165.0	0.70	199.83	68.8	21.9	11.8	1.6	0.03	0.03	1.00	0.002	0.012	0.002	0.002	1.40	0.007	-6.33
WSBH09	8.37	74	538	59.4	49.7	37.5	3.6	0.3	31.9	180.1	2.33	214.84	81.7	34.9	11.4	1.1	0.03	0.03	1.00	0.002	0.012	0.001	0.069	0.40	0.004	-5.00
WSBH11	7.97	64	356	55.3	48.7	27.1	3.8	0.3	33.1	168.8	0.88	204.09	58.8	20.7	10.2	1.2	0.03	0.03	1.00	0.002	0.013	0.001	0.027	0.40	0.005	-5.63
WSBH13	7.83	67	448	49.1	75.4	9.6	2.9	0.3	38.9	111.7	0.42	135.37	100.9	6.8	1.7	2.1	0.10	0.03	1.00	0.002	0.033	0.001	0.001	0.40	0.001	-15.55
WSBH14	8.43	86	574	51.8	77.8	42.8	4.4	0.3	32.2	267.1	3.95	317.66	84.4	44.9	4.5	1.7	0.03	0.03	1.00	0.002	0.009	0.001	0.001	0.40	0.009	-4.31
WSBH15	7.66	72	452	63.1	46.6	32.2	4.4	0.3	34.7	204.0	0.52	247.79	55.6	13.0	9.7	1.0	0.03	0.03	1.00	0.001	0.011	0.001	0.001	0.40	0.008	-3.15
WSBH16	8.13	80	518	62.2	47.7	43.7	1.1	0.3	12.3	344.6	2.59	415.07	62.9	55.0	0.5	0.1	0.03	0.03	1.00	0.001	0.012	0.001	0.001	0.40	0.005	-4.26
WSBH19	7.97	47	316	51.1	14.5	38.1	1.4	0.3	28.3	271.0	1.41	327.69	1.3	4.8	0.2	0.1	0.03	0.03	1.00	0.003	0.010	0.001	0.001	0.40	0.000	-2.60
WSBH20	7.46	95	670	80.4	22.5	88.5	3.3	0.3	40.0	598.4	0.97	728.06	18.6	18.5	0.1	0.1	0.10	0.20	1.00	0.003	0.033	0.001	0.001	0.40	0.004	-5.23
WSBH24	8.18	37	258	16.5	65.4	4.9	2.6	0.3	36.3	102.0	0.86	122.60	17.9	8.9	9.0	0.5	0.03	0.03	1.00	0.001	0.012	0.003	0.001	0.40	0.002	-15.41
UH03	8.14	63	384	38.2	82.1	16.3	5.1	0.3	25.1	233.2	1.79	280.78	49.8	22.3	2.7	1.9	0.03	0.03	1.00	0.003	0.056	0.001	0.001	3.70	0.002	-6.71
UH10	8.03	52	296	39.8	82.4	17.4	5.0	0.3	24.6	212.9	1.27	257.08	27.0	12.1	2.7	0.9	0.01	0.01	1.00	0.002	0.053	0.001	0.001	1.60	0.005	-3.85
UH13	8.06	88	522	36.4	118.0	19.3	13.4	0.3	8.0	189.9	1.22	229.13	126.9	74.5	1.7	0.8	0.03	0.12	1.00	0.001	0.038	0.001	0.001	0.40	0.001	-0.07
UH15	8.00	77	472	59.4	36.8	51.8	2.7	0.3	29.7	435.0	2.43	525.70	24.1	11.5	0.6	0.1	0.01	0.01	4.75	0.002	0.110	0.001	0.001	1.90	0.001	-6.12

Groundwater monitoring has been conducted since 2010. Since construction has begun there have been fluctuations above the pre-mining baseline; iron and Manganese which have been identified on numerous occasions to be above the SANS 241: 2011 standards. This was attributed to rusting of borehole casings, rather than mine activities. The locations of the monitoring points are shown in Figure 7-19

The most recent quarterly groundwater monitoring which was compared to the SANS 241: 2015 standards indicated the following:

- Electrical conductivity in all boreholes was low and remained below the SANS 241: 2015 Drinking Water Standard. The lowest average EC value (56.7 mS/m) was recorded on the eastern side of the mine (FBH02D) whilst the highest EC average was 105mS/m (FBH05) on the western side of the mine. Concentrations are consistent with previous monitoring events.
- Total dissolved solids within all boreholes are low, ranging between 345mg/l at FBH02D and 568mg/l at FBH05S. Concentrations are consistent with previous monitoring events.
- Iron and manganese were reported above the SANS 241: 2015 drinking water standard in borehole FBH05S. Although concentrations have fluctuated in this borehole it is generally consistent with previous monitoring events.
- Arsenic has been recorded in five of the boreholes during the December 2015 monitoring. Concentrations have been recorded in other recent monitoring, however not typical in groundwater for the area. Further sampling will identify trends.
- Concentrations of sulphate, nitrate, and fluoride, acknowledged in baseline quality data (TWP, 2008) as a concern, were all below SANS 241: 2015 drinking water standard for the December 2015 monitoring period.

CONCLUSION

Two groundwater aquifers occur in the area. These are an upper weathered aquifer and a lower fractured aquifer. Of major importance for groundwater flow in the area is that the semi- to impermeable interface between the upper shallow weathered aquifer and the deeper, fractured aquifer prevents rapid vertical drainage of the shallow aquifer on a regional scale, thus permitting lateral groundwater flow in the shallow aquifer driven by groundwater gradients related to local topography

Pre-mining quality monitoring shows elevated concentrations of nitrate (likely linked to pit latrines), fluoride (linked to geology), iron and manganese. Iron and manganese have remained elevated, but nitrate and fluoride have decreased to be below SANS 241: 2015 drinking water standards.

The groundwater level near the Shaft Complex has been declining over time. Groundwater is one of the sources of water for agriculture, domestic use and irrigation purposes. The project components will need to be appropriately designed and implemented to avoid a reduction in groundwater through potential contamination.

7.4.1.8 Air Quality

INTRODUCTION AND LINK TO ANTICIPATED IMPACT

Existing sources of emissions in the region and the characterisation of existing ambient pollution concentrations is fundamental to the assessment of cumulative air impacts. A change in ambient air quality can result in a range of impacts which in turn may cause a disturbance and/or health impacts to nearby receptors. Potential receptor sites areas of tourism including Sun City, the Bakubung Bush Lodge, the Pilanesberg National Park, animals and plants, residential areas including Phatsima, Ledig and Chaneng as well as the future Gabonewe Estate. There are also farming areas, including the properties spanning between the plant and TSF areas which is used as a grazing area.

The climatic conditions at the site will influence the potential for air dispersion (see Section 7.4.1.3). This section provides a baseline description of the ambient air quality, potential air receptors and emissions sources associated with the project.

DATA SOURCES

The information for this section was sourced from the Air Quality Impact Assessment (AQIA) conducted by Airshed Planning Professionals (Airshed, 2016; Appendix R) for the proposed project. Air quality data were identified through the review of available studies, available monitoring data from the mine and the specialist's knowledge of the project area.

RESULTS

<u>Ambient air quality within the region</u>

Current land uses within the vicinity of the project area are farming, residential and tourism. There is also shaft sinking currently occurring on site which involves blasting and deposition of waste rock on site. These land-uses contribute to baseline pollutant concentrations via the following sources:

- Miscellaneous fugitive dust sources including vehicle entrainment on roads and wind-blown dust from open areas: Fugitive dust emissions can occur as a result of vehicle entrained dust from local paved and unpaved roads, and wind erosion from open or sparsely vegetated areas. The extent of particulate emissions from the main roads is dependent on the number of vehicles using the roads and the silt loading on the roadways.
- Gaseous and particulate emissions from vehicle exhaust emissions: Air pollution from vehicle emissions can be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NOx, DPM and Pb. Secondary pollutants include: NO_2, photochemical oxidants (e.g. O3), HCs,

sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

- Gaseous and particulate emissions from household fuel burning: There are three main categories of energy use within the residential sector, these are traditional (consisting of wood, dung and bagasse), transitional (consisting of coal, paraffin and liquefied petroleum gas), and modern (consisting of electricity (increasingly this includes the use of renewable energy)).
- Gaseous and particulate emissions from biomass burning (e.g. wild fires): Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity wild fires may therefore represent a source of combustion-related emissions. Biomass burning is an incomplete combustion process, with CO, methane and NO_2 gases being emitted. In addition to the impact of biomass burning within the vicinity of the project, long-range transported emissions from this source can further be expected to impact on the air quality. It is impossible to control this source of atmospheric pollution loading. However, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

<u>Baseline air pollutant conditions</u>

The main air pollutants of concern associated with project activities are PM_{10}, NO_2 and SO_2. These pollutants pose a potential health risk to the surrounding communities. Dustfall (total suspended particulates (TSP)) is of concern due to its nuisance effects. Baseline conditions are presented below.

<u>Dustfall monitoring around the Mine</u>

Dustfall is an indicator of the amount of dust generated over a period of time (measured per day as per South African National Standards (SANS)). Dust deposition rates were evaluated based on the National Dust Control Regulations (NDCR) promulgated in November 2013, providing a residential limit of 600 mg/m²/day and a non-residential limit of 1 200 mg/m²/day, neither to be exceeded more than twice within a year or two sequential months.

Average annual dustfall rates for the period January 2011 to August 2015 were obtained for 16 points sampled around the project area. The monthly dustfall rates were generally below the relevant legislation thresholds with the exception of eight exceedances. Seven of the exceedances occurred in 2012 and one in 2014 at various locations. Dustfall rates were exceeded at the Lekwadi Section (which falls under the residential limit) three times in one year and also over two sequential months. None of the other sampled areas had more than one exceedance or sequential month exceedances. Refer to Figure 7-23 for the dustfall bucket locations

PM_{10} Monitoring around the Mine

Daily PM_{10} results from the particulate monitor were analysed for the period 27 July 2012 to 30 June 2015. The 24-hour national ambient air quality standards (NAAQS) limit value for PM_{10} of 75 µg/m³ was not exceeded over the sampling period. Refer to Figure 7-23 for the PM_{10} sampler location.

SO_2 and NO_2 Monitoring around the Mine

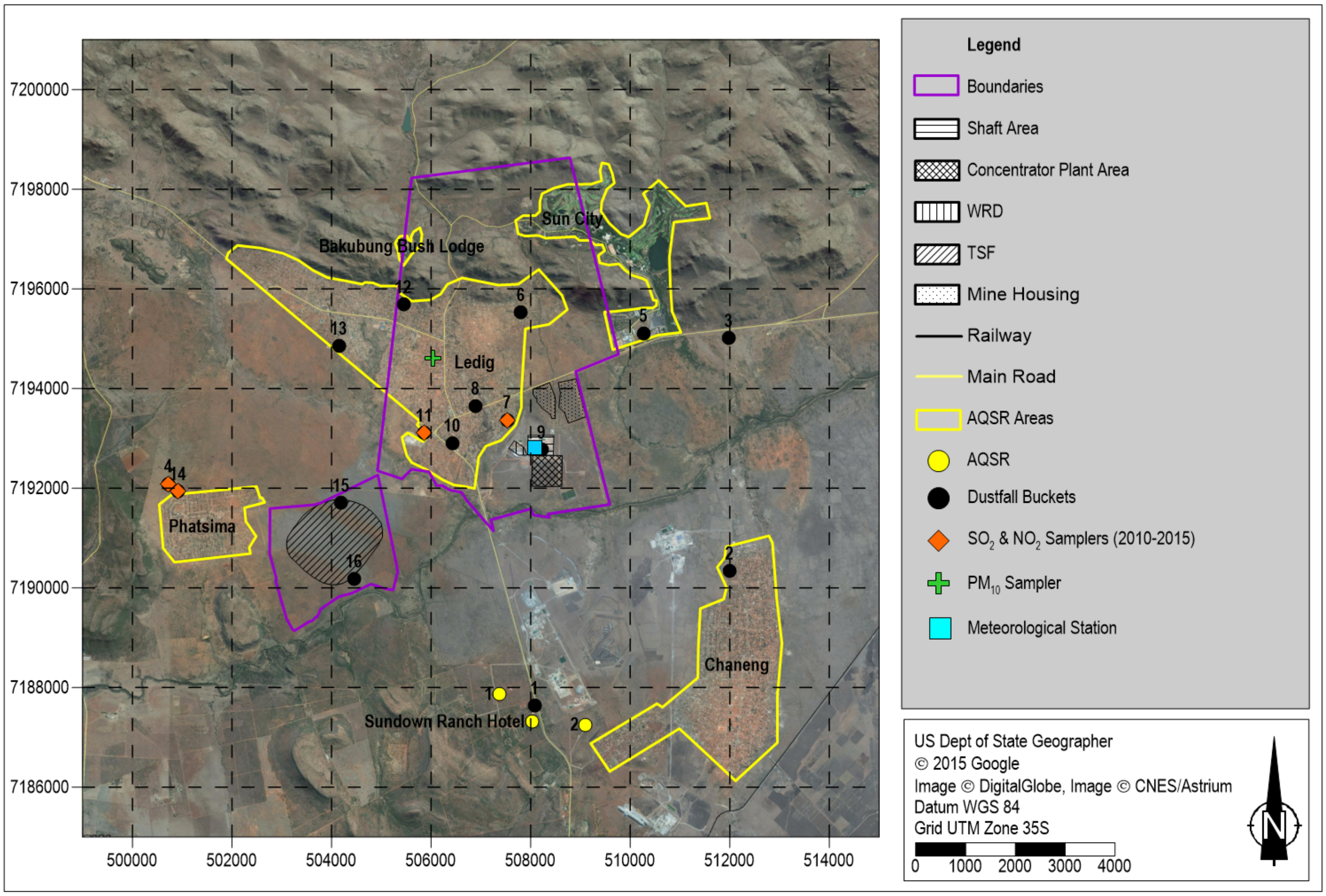
SO_2 and NO_2 sampling data was available for the period October 2010 to August 2015. There were no exceedances of the 1-year or 24-hour average NAAQS for SO_2 of 50 µg/m³ and 125 µg/m3 at any of the sites or NO_2 for 1-year average NAAQS of 40 µg/m³ at any of the sites. Extrapolated hourly concentrations were exceeded for two sites in January 2011 for SO2 and all sites during the sampling period for NO_2. However, this may be linked to the sampling methodology used, where samples are collected on a monthly basis rather than a bi-weekly basis which might skew the data. Refer to Figure 7-23 for the SO_2 and NO_2 sampler locations.

Potential air receptors

Potential air receptors around the project site include areas of tourism including Sun City, the Bakubung Bush Lodge, the Pilanesberg National Park, Sundown Ranch Hotel, animals and plants, residential areas including Phatsima, Ledig and Chaneng as well as the future Gabonewe Estate. There are also farming areas, including the properties spanning between the plant and TSF areas which is used as a grazing area.

CONCLUSION

The project falls within an area close to various potentially sensitive receptors including residential, tourism and farming areas and the proposed housing facilities for mine employees. The monitoring taken place to date indicates that there are some air pollution exceedances around the project site. The proposed project will present additional sources of pollutants that may influence existing pollutant concentrations. The proposed activities should therefore be carefully designed and managed to ensure that contributions from the proposed project remain within acceptable limits.



Bakubung Mine
Current Air Quality Monitoring Network
Dustfall Buckets, PM_{10}, SO_2 and NO_2 Samplers and Weather Station