9 BIOPHYSICAL IMPACT ASSESSMENT

9.1 IMPACT ON AIR QUALITY

This section describes the predicted air quality impacts associated with the Project determined through air dispersion modelling. The main air quality impacts associated with the Project from mining operations, ore crushing and screening, ore loading and offloading, as well as the transporting of ore include the following:

- Fugitive dust emissions from general works, wind erosion of exposed areas, aggregate handling, ore crushing and screening and storage piles.

- Dust generation from vehicle activities, such as haul trucks and traffic on unpaved roads (including Loop 10).

The impact assessment described below considers sensitive receptors in terms of human health. However dust deposition associated with the Project may impact sensitive vegetation and ecological functioning. While the modelled concentrations outlined below are relevant to the consideration of the impact on sensitive vegetation the impact is assessed in *Section 9.3.2* below.

Impact Assessment

The emissions that will be generated by Project activities, along with meteorological parameters provided input into an air dispersion model which provided ambient air pollution and dust deposition concentrations for the Project site. The modelled concentrations were then used in the impact assessment described below for human health and in *Section 9.3.2* on biodiversity.

Figure 9.1 and *Figure 9.2* below show the predicted concentration isopleths for the maximum annual concentration of PM_{10} and dust deposition, respectively. The annual guideline of 40 $\mu g/m^3$ (as applicable from 2015) was exceeded at the mining area and the access roads. The exceedances occur approximately between 200 m and 500 m around the N14, and approximately between 500 m and 1 km around the Loop 10 road.

The daily dust deposition, averaged over a 30-day period, around the Gamsberg mine and the access roads is shown in *Figure 9.2* below. It can be seen that the dust deposition was light (< 250 $mg/m^2/d$) around the N14, and moderate (250-500 $mg/m^2/d$) around the Loop 10 road. Heavy dust fall (> 500 $mg/m^2/d$) occurred mainly within the mining area and internal haul roads.

Figure 9.1 PM₁₀ Annual Maximum Concentration (Guideline: 40 µg/m³)

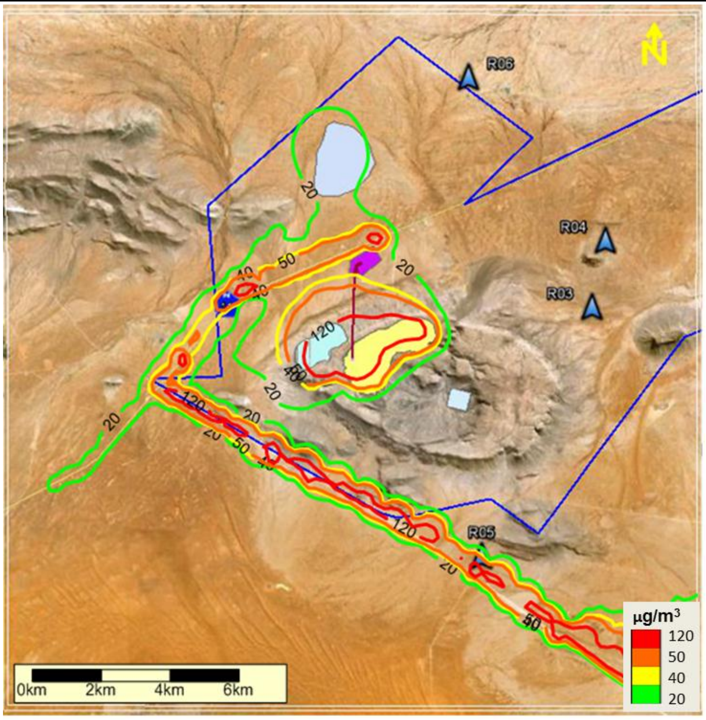


Figure 9.2 Averaged Daily Dust Deposition (Guideline: 600 mg/m²/d)

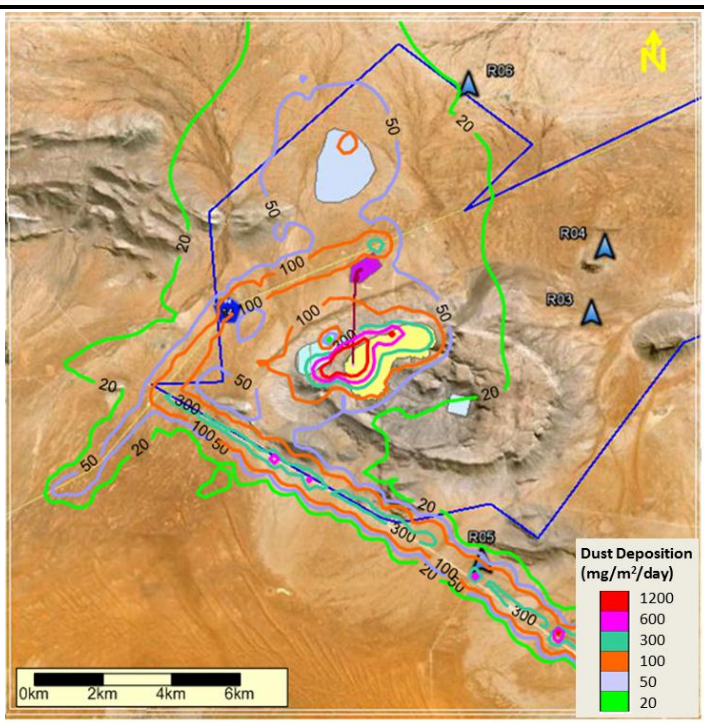


Table 9.1 below shows the modelled concentrations at the sensitive human receptors around the Gamsberg mine. It can be seen that the maximum 24-hr PM_{10} concentration at receptors R04 and R05 exceeded the SA guideline. However, only at R05 the exceedances per year were above the permissible number of 4.

The average daily dust deposition at all receptors was within the residential guideline of 600 (mg/m²/day).

Table 9.1 ***Modelled Air Quality Results at Sensitive Human Receptors***

Receptor	Description	PM_{10} Max 24-hr Concentration (µg/m³)	PM_{10} 24-hr Guideline Exceedances (No.)	PM_{10} Annual Concentration (µg/m³)	Dust Deposition (mg/m²/day)
R01	Farm House	18.1	0	1.0	4.8
R02	Farm House	19.8	0	1.6	5.8
R03	Farm House	28.3	0	2.4	9.8
R04	Farm House	100.0	1	3.1	10.5
R05	Farm House	88.5	5	66.9	159.2
R06	Farm House	52.7	0	4.1	18.7
R07	Aggeneys	19.2	0	2.7	6.3
R08	Farm House	< 20	0	< 7	< 20.6
R09	Farm House	< 20	0	< 7	< 20.6
R10	Farm House	< 20	0	< 7	< 20.6
R11	Farm House	< 20	0	< 7	< 20.6
R12	Farm House	< 20	0	< 7	< 20.6
R13	Farm House	< 20	0	< 7	< 20.6
R14	Farm House	28.8	0	24.6	94.5
R15	Farm House	< 20	0	< 7	< 20.6
R16	Farm House	24.4	0	12.4	37.3
R17	Farm House	22.4	0	10.7	28.2
R18	Farm House	< 20	0	< 7	< 20.6
Guideline		**75**	**5**	**40**	**600**

*Guideline exceedances shown in red.

9.1.2 *Impact on Air Quality (Human Health)*

The air quality impacts associated with the Project in relation to human receptors are discussed below.

Table 9.2 ***Impact Characteristics: Impact on Air Quality***

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Dust and particulate matter PM_{10} generation through site clearance, road upgrade and establishment of the camp, laydown and assembly areas.	Mining operations, including drilling, blasting, hauling, crushing and ore processing.	The removal of operational infrastructure, equipment and waste management of hazardous substances.
Impact Type	Direct	Direct	Direct
Stakeholders/ Receptors Affected	Local ambient air quality.	Local ambient air quality.	Local ambient air quality.

Construction

During construction operations, dust is generated during land clearing and topsoil removal, road grading, material loading and hauling, travelling on unpaved roads and wind erosion from exposes areas.

The sensitivity around the mining area was considered to be **low**, since there are only few local dwellings in the area, and these are located more than 4km away from the mining pit and processing plant. The closest community, which is Aggeneys, is located more than 10 km from the mining pit. The Gamsberg mine extends over a large area (an approximately 4km radius), and due to the temporal nature of the construction activities, the dust emission impact will most probably be contained within the site (**local**). The construction duration is expected to be **short-term**. The ambient air quality will be **negatively** affected, with **possible notable changes** within very close proximity to the construction face. The frequency of the impact is expected to be **once off**. With implementation of "good practice" mitigation measures, the impact significance will be **Negligible**. It should be noted that it was assumed that the "good practice" dust suppression measures indicated as essential in the recommendations section will be applied during construction. The impact ratings for the construction phase are summarised in Box 9.1, below.

Box 9.3 Construction Impact: Impact on Air Quality

Nature: Construction activities would result in a **negative direct** impact on existing ambient air quality in the mining area.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low.**

Impact Magnitude: **Small.**
Extent: The extent of the impact is **local**.
Duration: The expected impact will be **short-term**.
Scale: The impact will result in **notable** changes to the receptor.
Frequency: The frequency of the impact will be **once-off.**
Likelihood: Ambient air quality will possibly be affected, in terms of increased dust fallout and ambient PM_{10} concentrations.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **NEGLIGIBLE.**

Degree of Confidence: The degree of confidence is **high**.

Mitigation

Wet suppression or application of chemical dust suppressants will be used to mitigate dust and particulate matter generation during general construction and site preparation.

Operational Phase

The operational phase of the Gamsberg mine will last approximately 17 years. Dust and PM_{10} are expected to be the main air emissions due to the mining operations.

The air quality impact during the operational phase of the Gamsberg mine was quantified via dispersion modelling, and the cumulative effects of all emission sources were taken into consideration. The impact ratings for the operational phase of the mine are summarised in *Box 9.2* below.

The main emission sources were the haul trucks travelling on unpaved roads, the mining activities within the mining pit (including drilling and blasting), the crushing and stockpiling of ore, as well as wind erosion at exposed areas and stockpiles. From the above-mentioned sources, the haul trucks and wind erosion were the main contributors to the total emissions. Therefore, during the operational phase the main effort in reducing the project's impact on the ambient air quality should be focused primarily on minimising the emissions from the haul roads, blasting and reducing dust generation from erodible areas.

The sensitivity around the mining area was considered to be **low**, as the mine is located away from residential areas. In addition, the sensitivity around the Loop 10 road is also **low**, since there are only a small number of dwellings in close proximity to the road.

As shown by the dispersion modelling results, the dust fallout and elevated PM_{10} levels occur mostly within the mine and in close proximity to the Loop 10 road. Therefore, the extent of the impact is considered **local**. The duration of the impact will be **long-term**, as the mine is expected to be in operation for 17 years. The ambient air quality is **likely** to be **negatively** affected, with possible **notable changes**. The frequency of the impact is expected to be **periodic**. With implementation of the wet suppression measures incorporated into the daily operations, the impact significance will be **Minor**.

Box 9.2 Operational Impact: Impact on Air Quality

Nature: Construction activities would result in a **negative direct** impact on existing ambient air quality in the mining area and surrounding areas, including along the Loop 10 road.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low.**

Impact Magnitude: **Small.**
Extent: The extent of the impact is **local**.
Duration: The expected impact will be **long-term**.
Scale: The impact will result in **notable** changes to the receptor.
Frequency: The frequency of the impact will be **periodic.**
Likelihood: Ambient air quality will likely be affected, in terms of increased dust fallout and ambient PM_{10} concentrations.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MINOR.**

Degree of Confidence: The degree of confidence is **high**.

Mitigation Measures

The Project will implement the following mitigation measures:

- Phasing operational management of the working face to minimise the exposure of the working face to prevailing winds.
- Wet suppression or chemical dust suppressants will be used at the crusher, on haul roads, at materials handling and stockpile areas to reduce dust emission.
- A speed limit of 40km/hr on haul roads for trucks within the mining area.
- Blasting during periods of high wind velocity (>5m/s in a north westerly direction) will require approval by the Environmental Manager and these instances will be recorded in the annual environmental audit report.

Monitoring

Dust deposition and PM_{10} monitoring should be continued at the same positions as the baseline locations before the commencement of the project, in order to collect additional background data.

During the operational phase of the project, bi-annual monitoring should take place for dust deposition at six selected locations around the site and two locations along the Loop 10 route. The PM_{10} concentrations should be monitored at one selected boundary location, as well as at the closest residential dwellings.

Decommissioning

The air quality impacts associated with decommissioning are anticipated to be similar to construction impacts associated with movement of vehicles.

Localised impacts due to decommissioning activities are addressed through the implementation of appropriate mitigation detailed below:

- avoiding unnecessary disturbance of exposed surfaces and minimising areas of exposed ground;
- wet suppression to control dust;
- minimising drop heights for dusty materials and fitting shields to control windblown dust;
- cleaning dirty equipment, such as excavators, dump trucks and drilling equipment to avoid excessive build-up of dirt and mud;
- operation of a speed limit of 40km/hr for on-site vehicles moving in un-surfaced areas and restricting vehicle movements outside designated areas; and
- maintaining all vehicles and equipment in good working order to prevent excessive exhaust emissions.

Residual Impact

Pre-mitigation impacts were rated negligible for construction, minor for operational and negligible for decommissioning phases of the project. There is no anticipated loss of irreplaceable resources as a result of air quality impacts. The pre- and post-mitigation impacts are compared in *Table 9.3* below.

Table 9.4 Pre- and Post- Mitigation Significance: Impact on Air Quality (Human Health)

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Operation	**MINOR (-ve)**	**MINOR (-ve)**
Decommissioning	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**

9.2 *IMPACT ON GROUNDWATER*

Potential groundwater impacts from the Project will be associated with impacts on groundwater level changes associated with drawdown cones resulting from dewatering. Groundwater quality impacts are anticipated as a result of possible contamination resulting from mining sources or activities.

The impacts associated with drawdown or groundwater level changes are subdivided into two categories, namely (see Sections 9.2.1 and 9.2.2):

- Impact of groundwater level changes on the groundwater resource; and
- Impact of groundwater level changes on private users.

The impact drawdown may have on base flow dependant habitats is discussed in relation to biodiversity impacts in *Section 9.3.3*.

The impacts associated with groundwater quality are assessed by considering the following (see *Sections 9.2.3* and *9.2.4*):

- The groundwater quality impact on the resource; and
- The groundwater quality impact on private users.

9.2.1 *Impact of Drawdown on the Groundwater Resource*

Background

The topography is the dominant control on groundwater levels and the groundwater flow direction. The hydrocensus undertaken indicates that currently groundwater levels under the Gamsberg are higher than on the plains. As mining progresses dewatering will be required to ensure that the pit is kept dry. A groundwater model was used to predict groundwater level changes (drawdown cones) associated with mining activities. At the end of mining, the groundwater level will be at the base of the pit resulting in a maximum drawdown of approximately 500m.

Figure 9.3, Figure 9.4, and *Figure 9.5* show the change in groundwater levels in plan view (negative values show a drop in water level or drawdown and positive show an increase or groundwater mounding). These are presented at the end of mining, 50 years post closure and 100 years post closure. Existing (known) farm-boreholes are indicated with crosses, and labelled with the borehole ID given during the hydrocensus.

The drawdown cone induced by the planned mining activities develops from the pit towards the north-east, east, south and south-west. Drawdown is not expected to expand towards the west due to the increased recharge on the WRDs.

Groundwater mounds (increase in groundwater levels) develop under both the tailings storage facility (TSF) and the waste rock dumps (WRDs) due to increased recharge. However, the TSF will be drained during mine decommissioning and modelling results indicate that groundwater levels under the TSF will return to pre-mining levels approximately 80 years post closure. It is anticipated that the mound underneath the WRDs will remain as infiltration will continue indefinitely.

Figure 9.3 Hydraulic Head Change at 19 Years (End of Mining)

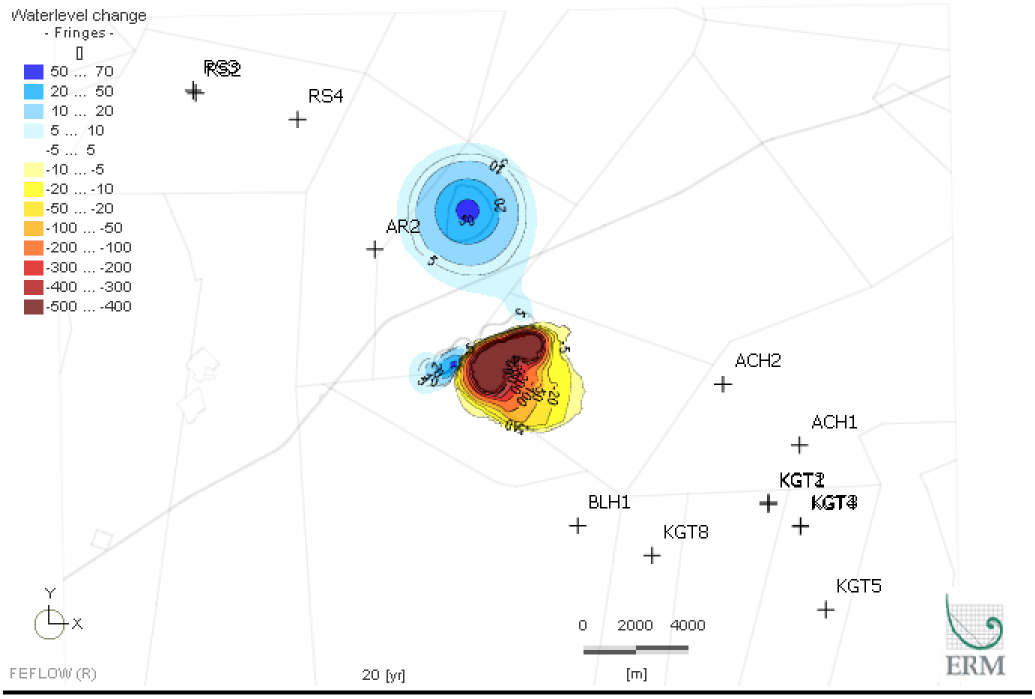


Figure 9.4 Hydraulic Head Change at 69 Years (50 Years after Mine Closure)

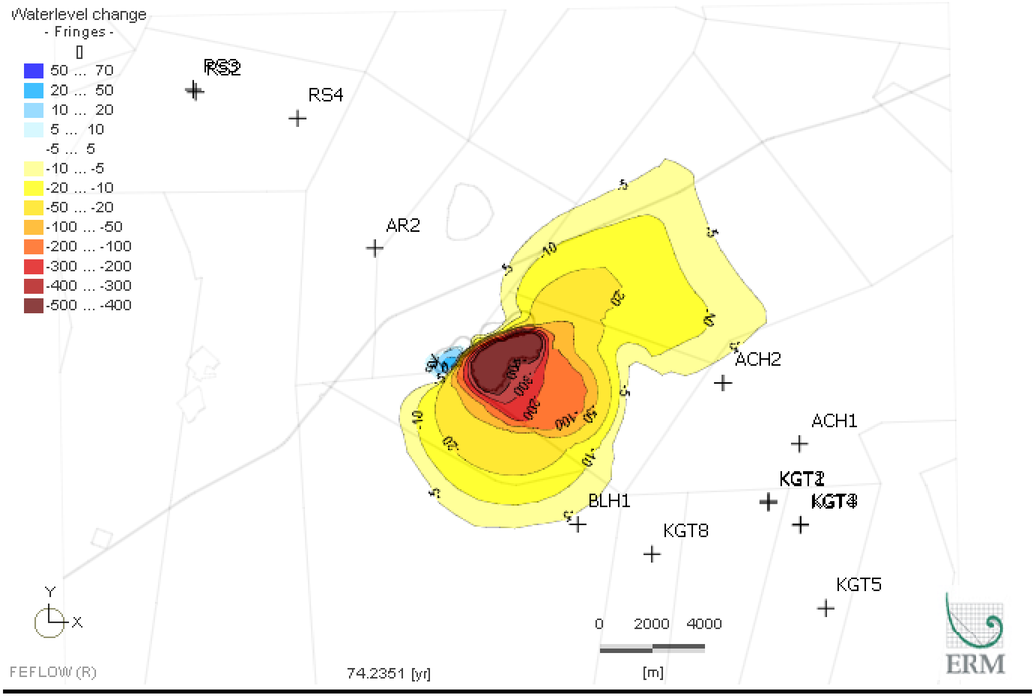
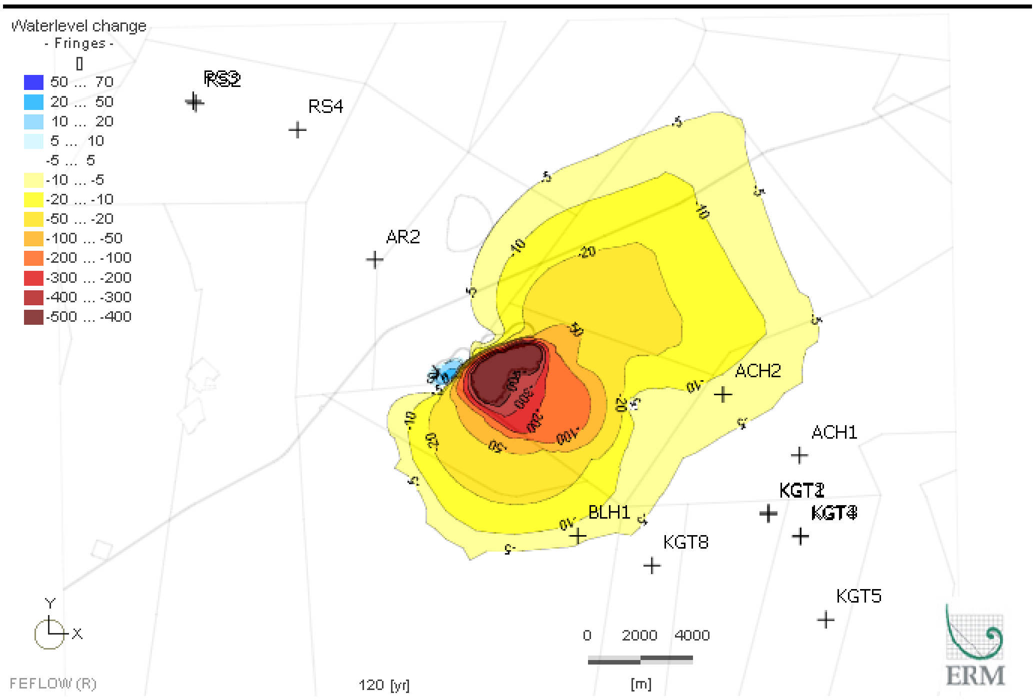


Figure 9.5 *Hydraulic Head Change at 119 Years (100 Years after Mine Closure)*



Groundwater modelling suggests that 100 years after mine closure drawdowns in excess of 5m can be expected to reach approximately 11km to the north-east and east of the pit and between 4-7km to the south-west, south and south-east.

The groundwater mound underneath the TSF is expected to disappear within 2-3 years after mine closure and groundwater levels are expected to reach pre-mining levels approximately 80 years post-closure. The mound underneath WRDs will remain as infiltration continues indefinitely.

Impact Assessment

The impact of groundwater level changes on the groundwater resource is considered in this section while the impact of these groundwater level changes on groundwater users is considered in Section 9.3, below.

Table 9.5 *Impact Characteristics: Drawdown on the Groundwater Resource*

Summary	Construction	Operation	Post-Closure
Project Aspect/Activity	Groundwater may be used for construction however this is not anticipated to result in significant changes in groundwater levels.	Open pit mining will dewater the aquifer and a drawdown cone will develop. Groundwater levels will rise (mounding) underneath tailings storage facility (TSF) and waste rock dumps (WRDs).	Abandoned pit will remain a groundwater sink and drawdown cone will continue to expand. Groundwater mounds underneath TSF will seep away, but will remain underneath the WRDs.
Impact Type	Direct.	Direct.	Direct.

Summary	Construction	Operation	Post-Closure
Stakeholders/ Receptors Affected	Groundwater Resource.	Groundwater Resource.	Groundwater Resource.

Construction Phase Impacts

It is anticipated that groundwater will be used during the construction phase which may result in localised groundwater level drawdown. This is, however, not expected to have noticeable impact on the groundwater resource. The significance rating is therefore **NEGLIGIBLE**.

Operational Phase Impacts

The planned open pit mining operation will dewater the aquifer on and around the Gamsberg and a drawdown cone will develop predominantly towards the north-east, east, south and south-west. Increased recharge from the WRDs will prevent the drawdown cone propagation towards the west and north-west.

Groundwater modelling suggests that at the end of mining drawdowns in excess of 5m can be expected to reach approximately 1km to the north-east and south-west of the pit and between 2-3km to the east and south-east. The maximum drawdown in close proximity of the pit is approximately 500m.

Groundwater levels will rise (mounding) underneath tailings storage facility (TSF) to approximately 25 metres above surface (mas) and underneath waste rock dumps (WRDs) to surface level.

Groundwater is used in the area and represents the sole source of water for a number of farmers despite groundwater quality in the study area being considered unsuitable for domestic use or livestock watering when compared to South African Water Quality Guidelines (Department of Water Affairs and Foresty , 1996). Farm boreholes closest to the planned Project are located in between 5.5 and 7km away from the planned open pit and remain unaffected during operation as the drawdown cone will be confined to the Project site. The Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium** since the groundwater resource is an important water supply in the area. The planned activity will result in the loss of an irreplaceable resource with regards to the groundwater resource.

Hydraulic head change is expected to be limited to the Project site and adjacent properties belonging to the client, and is on site and **local** in extent. Groundwater levels are not expected to recover after mine closure, since the pit will continue to act as a sink to groundwater based on the elevated evaporation rate, which results in a **permanent** impact. Lowering of the hydraulic head due to the proposed mining activities will result in drawdowns of up to 500m in the vicinity of the pit reducing to levels in line with natural fluctuations within 1 to 2km from the pit. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **certain**.

The impact magnitude is therefore rated as **Medium** and the impact significance (pre-mitigation) is **MODERATE**. The groundwater model is currently based on a number of conservative assumptions and is not calibrated to aquifer stresses of a similar order of magnitude to those applied to it. This implies that reliability of the model predictions is relatively low. However, the model confidence is deemed sufficient to assess conservative impacts and make appropriate mitigation recommendations at the EIA stage of the project. The degree of confidence in this assessment is **medium**.

Box 9.3 ***Summary of Operational Impact: Groundwater Level Changes on Groundwater Resource***

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will result in the loss of **irreplaceable** resources since in the groundwater levels onsite will not recover to a pre-mining state.

Impact Magnitude – Medium.

- Extent: The extent of the impact is **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale: The impact will **severely alter** the resource.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE.

Degree of Confidence: The degree of confidence is **medium**.

Operational Phase Mitigation

Groundwater level change (drawdown) cannot be mitigated. It is therefore recommended that groundwater levels in the vicinity of the pit, in radially increasing distance, as well as in each of the known farm boreholes, are monitored on a regular basis throughout the operational phase. The monitoring data should be stored in an appropriate data management tool/database.

Targeted monitoring, to provide data on key areas of uncertainty, allows the assumptions in predictive models to be reduced and thus the reliance of such models improves. Groundwater models should therefore be validated and updated using the monitoring data such that drawdown predictions can be updated. This will lead to models with a higher confidence level that can be used as management tools throughout the operational phase (ie update predicted impacts in order to be proactive etc) and for planning of the post-closure phase of the Project to ensure appropriate provisions are made.

Post-Closure Phase Impacts

Groundwater levels are not expected to recover after mine closure because the pit will continue to act as a groundwater sink due to the high evaporation rates, which will result in the expansion of the drawdown cone. The maximum drawdown in close proximity of the pit remains at approximately 500m.

Two farm boreholes located between 6 and 7km away from the planned open pit are expected to experience drawdowns of between 5 to 10m approximately 100 years after mine closure. These groundwater level changes match natural fluctuations currently experienced. The Sensitivity / Vulnerability / Importance of the groundwater resource remains **Medium** as the resource is an important water supply and is currently used. The planned activity will result in the loss of irreplaceable resource with regards to the groundwater resource.

Groundwater level change is expected to be limited to the Project site and adjacent properties, and remains **local** in extent. Groundwater levels are not expected to recover after mine closure, since the pit will continue to act as a sink to groundwater based on the elevated evaporation rate, which results in a **permanent** impact. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **certain**.

The impact magnitude is therefore rated as **Medium** and the impact significance (pre-mitigation) is **MODERATE**. The degree of confidence in this assessment is **medium**.

Box 9.4 Summary of Post-Closure Impact: Drawdown on the Groundwater Resource

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will result in the loss of **irreplaceable** resources as groundwater levels onsite will not return to pre-mining levels.

Impact Magnitude – Medium.

- Extent: The extent of the impact is **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale: The impact will **severely alter** the resource.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE.

Degree of Confidence: The degree of confidence is **medium**.

Post-Closure Phase Mitigation

Higher confidence groundwater models (developed/updated using monitoring data collected throughout the operational phase) should be used for post-closure planning and to determine the extent and frequency of post-closure groundwater level monitoring.

Residual Impact

The impact cannot be mitigated and therefore the impact significance for operational and post-closure phases remain unchanged. The pre- and post-mitigation impacts are compared in *Table 9.5* below.

Table 9.6 Pre- and Post- Mitigation Significance: Drawdown on the Groundwater Resource

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Operation	**MODERATE (-ve)**	**MODERATE (-ve)**
Post Closure	**MODERATE (-ve)**	**MODERATE (-ve)**

9.2.2 *Impact of Drawdown on Groundwater Users*

The impact of groundwater level changes on groundwater users is considered below.

Table 9.7 Impact Characteristics: Impact of Drawdown on Groundwater Users

Summary	Construction	Operation	Post Closure
Project Aspect/Activity	None	Open pit mining will dewater the aquifer and a drawdown cone will develop. Groundwater levels will rise (mounding) underneath tailings storage facility (TSF) and waste rock dumps (WRDs).	Abandoned pit will remain a groundwater sink and drawdown cone will continue to expand. Groundwater mounds underneath TSF will seep away, but stay underneath the WRDs.
Impact Type	N/A	Indirect.	Indirect.
Stakeholders/ Receptors Affected	N/A	Private Groundwater Users.	Private Groundwater Users.

Construction Phase Impacts

The Construction Phase of the Project is not expected to negatively impact on groundwater users in the Project Area and its significance is **NEGLIGIBLE**.

Operational Phase Impacts

Private groundwater users are not expected to be impacted during mining as the drawdown cone remains at a distance of more than 4km from the closest existing (known) farm boreholes being BLH1 and ACH2 and remains on site.

Groundwater is used in the area and represents the sole source of water for a number of farmers. Private groundwater users are not expected to be significantly impacted during mining as the drawdown cone remains at a distance of more than 4km from the closest receptors being BLH1 and ACH2 (see *Figure 9.3*).

Therefore, the Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium**. The planned activity will not result in the loss of an irreplaceable resource with regards to private groundwater users.

Drawdown cone is expected to be limited to the Project site and is therefore on-site and **local** in extent. Groundwater levels are not expected to recover after mine closure, since the pit will continue to act as a sink to groundwater based on the elevated evaporation rate, which results in a **permanent** impact. Lowering of the groundwater level due to the proposed mining activities will not extend off site and therefore groundwater users are not anticipated to be impacted. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **likely**. The impact magnitude is therefore rated as **Negligible** and the impact significance (pre-mitigation) is **NEGLIGIBLE**. The degree of confidence in this assessment is **medium**.

Box 9.5 Summary of Operational Impact: Drawdown on Groundwater Users

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Negligible.
- Extent: The extent of the impact is on-site and **local.**
- Duration: The expected ground level change will be **permanent (ie irreversible).**
- Scale: The drawdown cone is not anticipated to impact groundwater users off-site.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: Groundwater drawdown is **likely.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE.

Degree of Confidence: The degree of confidence is **medium**.

Operational Phase Mitigation

Groundwater level change (drawdown) cannot be mitigated. However, it is further recommended that groundwater levels in each of the known farm boreholes are monitored on a regular basis throughout the construction and operation phases.

Should monitoring confirm that any of the private boreholes are affected by lowering the groundwater table, rendering boreholes unusable (ie loss of water supply source), the client will compensate affected famers for their loss, replacing the lost water supply source. This can be achieved for example by drilling new boreholes for the affected farmers outside of the drawdown cone, by increasing the depth of the existing boreholes or by providing an alternative good quality water source.

Post-Closure Phase Impacts

Modelling results suggest that two private boreholes located to the south-east of the Gamsberg (BLH1 and ACH2) will experience drawdowns of between 5 and 10m approximately 100 years post closure. Other existing (known) private boreholes will not experience any significant drawdowns (ie less than 5m). However, since the drawdown cone extends to additional farms located adjacent to the Project, this may impact future groundwater users.

The Sensitivity/Vulnerability/Importance of the groundwater resource remains **Medium**. The planned activity is not expected to result in the loss of irreplaceable resource with regards to private groundwater users.

Hydraulic head change is expected to extend off site but remains **local** in extent. Groundwater levels are not expected to recover after mine closure, since the pit will continue to act as a sink to groundwater based on the elevated evaporation rate, which results in a **permanent** impact. Lowering of the hydraulic head due to the proposed mining activities is likely to extend to groundwater users in the vicinity of the site. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **likely**. The impact magnitude is therefore rated as **Medium** and the impact significance (pre-mitigation) is **MODERATE**. The degree of confidence in this assessment is **medium**.

Box 9.6 *Summary of Post-Closure Impact: Drawdown on Groundwater Users*

Nature: Operational activities would result in a **negative direct** impact on groundwater users in the vicinity of the Project, post-closure.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Medium.

- Extent: The extent of the impact is **local.**
- Duration: The expected ground level change will be **permanent (ie irreversible)**Scale: The drawdown cone is anticipated to impact two groundwater users off-site.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: Groundwater drawdown is **likely.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE.

Degree of Confidence: The degree of confidence is **medium**.

Post-Closure Phase Mitigation

Higher confidence groundwater models (developed/updated using monitoring data collected throughout the operational phase) should be used for post-closure planning and to determine the extent and frequency of post-closure groundwater level monitoring.

Should monitoring confirm that any private boreholes are affected by lowering the groundwater table, rendering boreholes unusable (ie loss of water supply source), the client will compensate affected famers for their loss, replacing the lost water supply source. This can be achieved for example by drilling new boreholes for the affected farmers outside of the drawdown cone, by increasing the depth of the existing boreholes or by providing an alternative good quality drinking water source.

Residual Impact

Compensation of impacted farmers, where impact is confirmed through monitoring data, would result in the operation and post-closure impacts of **NEGLIGIBLE** and may even change the **negative** impact to a **positive** impact (ie if the quality of the alternative water source provided by the project exceeds the existing one which does not meet drinking water or stock-watering standards).

The pre- and post-mitigation impacts are compared in *Table 9.5* below.

Table 9.8 *Pre- and Post- Mitigation Significance: Private Groundwater Users*

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Operation	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Post Closure	MODERATE (-ve)	NEGLIGIBLE (-ve)

9.2.3 *Impact on Groundwater Quality*

Background

Figure 9.6, *Figure 9.7* and *Figure 9.8* show the sulphate plumes emanating from WRDs and TSF for different time stages (end of mining, 50 years post closure and 100 years post closure). The figures show groundwater concentrations above the SANS 241-1:2011 (2011) drinking water limit of 400 mg/L.

The plumes grow over time due to the continued leaching and combined dispersion and diffusion processes. SO_4 concentration of leachate released from the TSF is increasing over time and is higher than the SO_4 concentration of leachate from the WRDs. Therefore, the maximum SO_4 concentration modelled is observed underneath the TSF at 10 500 mg/L, at the end of mining. Thereafter, the SO_4 concentrations in groundwater underneath the TSF will decrease slowly (refer *Figure 9.8*) and the plume will start to move eastwards.

Figure 9.6 Sulphate Plume in Year 19 (End of Mining)

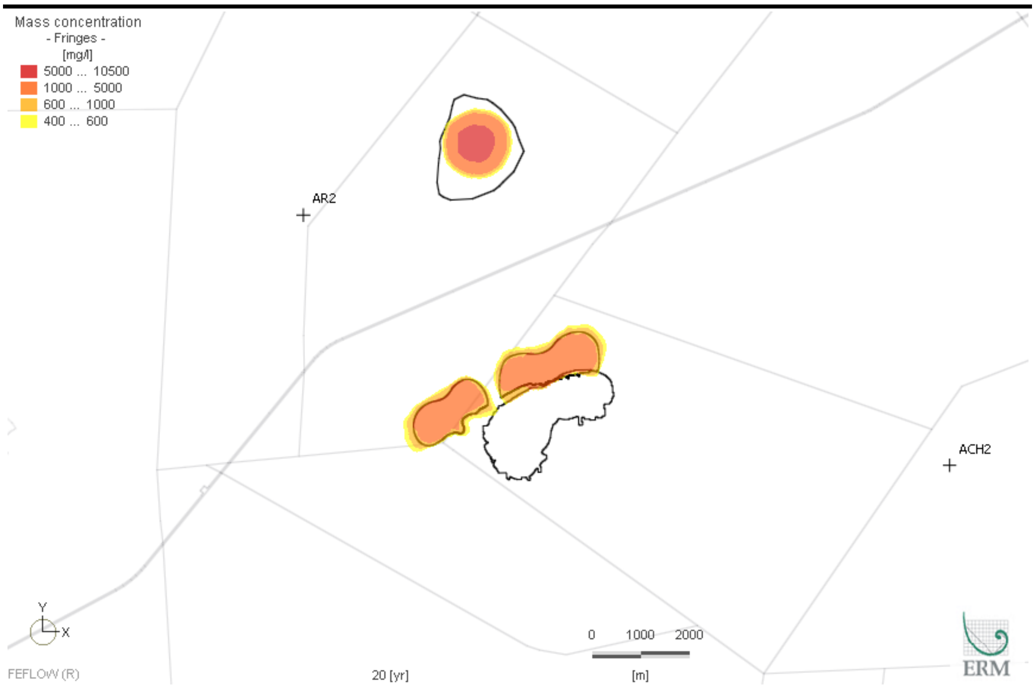


Figure 9.7 Sulphate Plume in Year 69 (50 Years after Mine Closure)

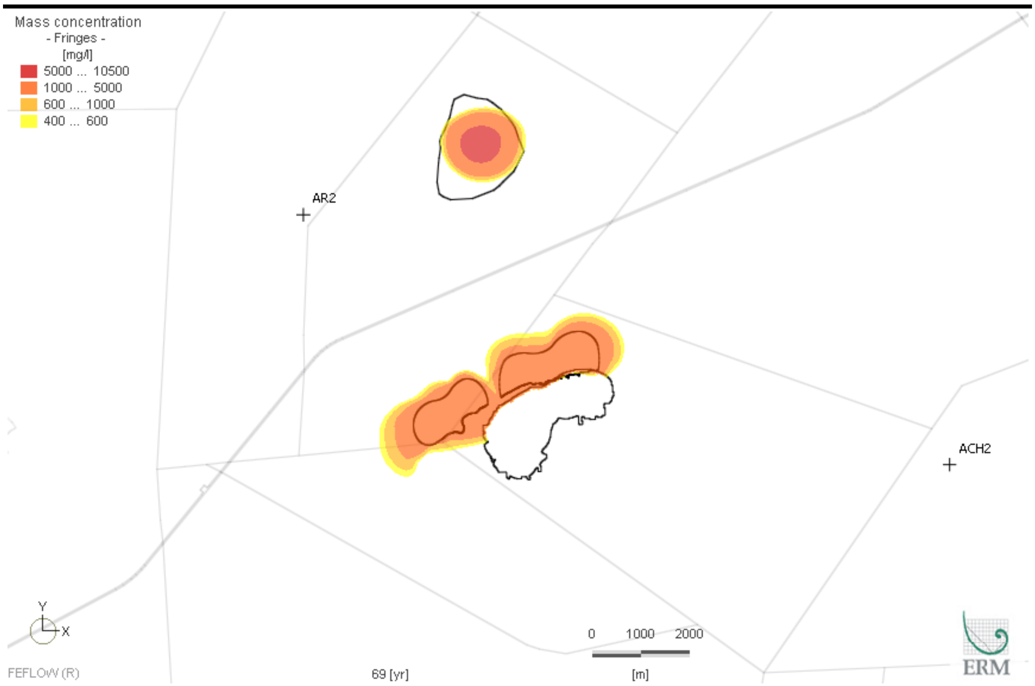
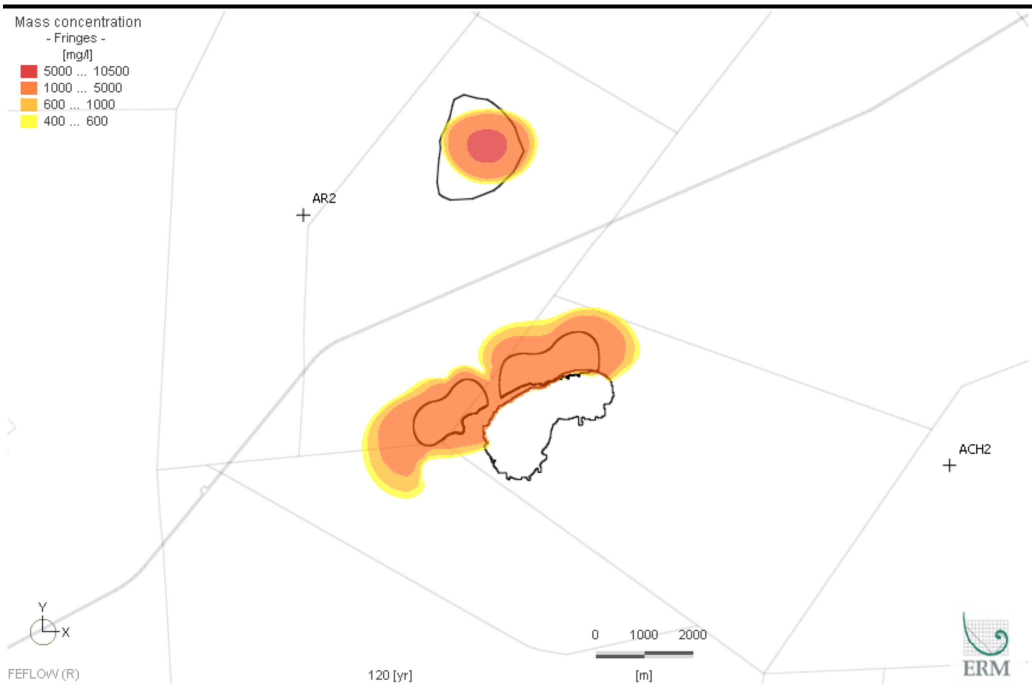


Figure 9.8 Sulphate Plume in Year 119 (100 Years after Mine Closure)



The impact on groundwater quality in this section is considered with respect to the groundwater resource while the impact this will have on groundwater users is considered in *Section 9.2.4*, below.

Table 9.9 Impact Characteristics: Groundwater Quality

Summary	Construction	Operation	Post Closure
Project Aspect/Activity	Accidental spillage from construction equipment and chemicals storage areas.	Contaminated leachate from tailings storage facility (TSF) and waste rock dumps (WRDs). Spillage from mining equipment. Contamination through residuals of explosives used in the mining process.	Contaminated leachate from tailings storage facility (TSF) and waste rock dumps (WRDs).
Impact Type	Direct.	Direct.	Direct.
Stakeholders/ Receptors Affected	Groundwater Resource.	Groundwater Resource.	Groundwater Resource.

Construction Phase Impacts

Accidental spillage of hydrocarbons or other chemical substances used and stored during the Construction Phase can potentially contaminate groundwater locally.

The sensitivity and vulnerability of the groundwater resource to contamination is rated **Medium**.

It is anticipated that large volumes of chemicals, that have a potential to contaminate groundwater, will be stored/used on site during the construction phase however the impact magnitude is **Small** and it is not anticipated that the activity will result in the loss of an irreplaceable source. The impact significance (pre-mitigation) is **MINOR** and the degree of confidence is **Medium**.

Box 9.7 Summary of Construction Impact: Groundwater Quality

Nature: Construction activities could have a **negative direct** impact on groundwater quality.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Small.

- Extent: The extent of the impact is **on-site.**
- Duration: The expected impact will be **permanent.**
- Scale: The resource/ receptor will remain **unaltered.**
- Frequency: The frequency of the impact will be **once off.**
- Likelihood: Likelihood for accidental spillages is **possible**.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR.

Degree of Confidence: The degree of confidence is **medium.**

Construction Phase Mitigation

A construction environmental management plan (EMP) needs to be in place including, but not limited to:

- Adhere to best practice principles;
- Construction equipment should be up to standards and serviced regularly to prevent oil spills;
- A spill response plan should be in place and construction workers should be trained accordingly; and
- On-site storage areas for hydrocarbons and other chemicals should be constructed in a way that potential tank failures can be contained including bunds and surface hardstanding.

Operational Phase Impacts

Contaminants of Concern (CoCs) related to the mining operation were identified during the geochemical assessment and include sulphate (SO_4), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), cadmium (Cd), lead (Pb), arsenic (As) and nitrate (NO_3). Further, due to blasting activities it is expected that large amounts of NO_3 will be released and possibly diesel depending on the explosives used.

SO_4 leachate concentrations for tailings storage facility (TSF) and waste rock dumps (WRDs) were quantified using geochemical modelling for input into the groundwater model. SO_4 groundwater contamination emanating from TSF and WRDs was quantified using numerical solute transport modelling. SO_4 is a conservative tracer, providing an indication of conservative contaminant extent.

At the end of mining modelled SO_4 plumes at concentrations exceeding the SANS 241-1:2011 drinking water standard of 400mg/L are mainly confined to within the immediate footprint (250m) of the contaminant sources. The plumes are expected to impact areas of 1.6km^2 (TSF) to 3.8km^2 (WRDs) and not extend off-site.

WRDs are located immediately adjacent to the mine pit and contaminated seepage from the WRDs is expected to partly flow into the pit. It is unlikely that water will be visible in the pit except following heavy rain events. Due to the high evaporation rate, salts and other contaminants are expected to accumulate in the pit and can be dissolved and mobilised during rain events. Pumped water from the pit following rain events could therefore be heavily contaminated. Further, toe seepage is expected to occur at the base of the WRDs following rain events and continuously at the base of the TSF. This seepage is expected to be contaminated.

The Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium** since the groundwater is an important resource even though groundwater quality does not meet drinking water or stock watering standards. The planned activity will not result in the loss of irreplaceable resource with regards to the groundwater resource.

Sulphate leaching from the TSF is predicted to steadily increase in concentration to a maximum of about 12 000 mg/L on closure. This is significantly higher than sulphate concentrations measured in groundwater sampled from hydrocensus boreholes during the current study which range from 22 mg/L to 1706 mg/L. However, water quality impacts are expected to be limited in extent to the footprints of the TSF and WRDs and are therefore on-site and **local** in extent. Groundwater quality is not expected to improve after mine closure, hence it will be a **permanent** impact. Leaching of contaminated water from TSF and WRDs will severely alter the groundwater quality within the footprint of these facilities. The frequency is classified as **continuous** due to the nature of the project and the impact on groundwater quality is considered to be **likely**. The impact magnitude is rated as **Medium** and the impact significance (pre-mitigation) is **MODERATE**. The degree of confidence in this assessment is **medium**.

Box 9.8 Summary of Operational Impact: Groundwater Quality

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Medium.

- Extent: The extent of the impact is confined to the footprint of the TSF and the WRDs and is therefore on-site and **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale:The impact will **severely alter** the groundwater quality within the footprint of the TSF and WRDs.
- Frequency: The frequency of the impact will be **once off.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE.

Degree of Confidence: The degree of confidence is **medium**.

Operational Phase Mitigation

In keeping with the mitigation hierarchy, the priority in mitigation is to apply mitigation measures to the source of the impact, main sources being the TSF and WRDs.

Modelling results indicate that the TSF and WRDs will produce acid rock drainage (ARD) which is expected to seep into groundwater. This will result in a moderate significance rating based on the assumptions made during modelling. Detailed geotechnical and geophysical investigations will be undertaken prior to construction to refine and confirm assumptions made in respect to the current studies around the integrity of the subsurface beneath the TSF. Mitigation measures required to reduce the impact on groundwater quality include the following:

- Prior to construction of WRDs and TSF, the ground of the facility's footprint should be prepared to reduce the hydraulic conductivity of the material, ie through means of compaction, so that seepage water is forced out of the facility at ground level rather than infiltrating into groundwater.

- Toe drains (interception trenches) along the base of both TSF and WRDs to intercept drainage and convey to a return water dam. Toe seepage from these facilities is expected to be contaminated and suitable management measures should be in place to prevent the release of this contaminated water into the environment. It is recommended to recycle as much water as possible and re-use it.

Management options specifically for the TSF include the following:

- Short deposition cycles should be followed by regularly covering fresh tailings soon after deposition to prevent them drying out and oxidising on placement. Cladding the TSF side slopes with inert waste rock, concurrently with deposition, to minimise both oxygen ingress and side-slope erosion.

- Further addition of additives such as lime or slaked lime could help to increase the alkalinity of the Gamsberg tailings prior to deposition. The WMB (2000) results suggest, however, that the liming requirement to offset the acid potential of the tailings would be high. Note also that neutralising materials introduced during tailings amendment may dissolve and be flushed from the TSF system prior to reacting with acidity generated by the oxidation of sulphides in the tailings.

To decrease quality impact on the groundwater resource in the vicinity of the TSF, a mineral liner system as specified by the design engineers is required to be installed beneath the TSF (see details included in *Annex B*). The detailed specifications of the TSF liner system requirements will be agreed upon by the Department of Water Affairs and be in line with the conditions of the IWULA.

The present numerical groundwater flow and transport model is based on a number of conservative assumptions and should be updated/validated as additional information becomes available (ie SEEP/W model results, geophysics results and hydraulic conductivity of tailings material) prior to construction to ensure assumptions made during the development of the model remain valid.

Pumped water from the pit following heavy rain events is expected to be contaminated and will need to be contained, or treated to applicable standards if it is to be released into the environment, in accordance with the water use licence requirements.

It is further recommended that these mitigation measures be complemented with groundwater quality monitoring in the vicinity of contamination sources and in radially increasing distance from them. Monitoring should be carried out on a regular basis throughout the construction and operational phases. The monitoring data should be stored in an appropriate data management tool/database.

Targeted monitoring, to provide data on key areas of unknown, allows the assumptions in predictive models to be reduced and thus the reliance of such models improves. Groundwater models should therefore be validated and updated using the monitoring data such that transport model predictions can be updated (ie plume extent, modelled concentrations). This will lead to models with a higher confidence level that can be used as management tools throughout the operational phase (ie update predicted impacts in order to be proactive etc) and for planning of the post-closure phase of the Project to ensure appropriate provisions are made.

Post Closure Phase Impacts

The seepage from WRDs is controlled by increased recharge from rainfall due to the disruption of natural material, increase in hydraulic conductivity and the higher porosity of the dumps reducing the amount of surface runoff and increasing the amount of infiltration. Therefore the seepage from WRDs is not expected to stop after mine closure and is therefore expected to expand further.

The TSF will be drained at the end of mine and is not expected to continue releasing contaminants, assuming that due to the fine texture of the tailings material any rainfall would not result in infiltration but rather surface run-off. The plume emanating from the TSF is expected to remain in proximity of the footprint of the facility.

Impact on the groundwater resource is therefore expected to be more significant as a result of seepage from the WRDs, although seepage from the TSF has higher SO_4 concentrations. Modelled areal extent of SO_4 plumes 100 years after mine closure are 2.4km^2 for the TSF and 8.8km^2 for the WRDs which represents increases of 50% and 140% respectively. The maximum travel distance of 1.2km is observed from the WRDs in south-westerly direction.

The Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium**. The planned activity will not result in the loss of irreplaceable resource with regards to the groundwater resource.

Water quality impacts are expected to be limited to the footprints of the TSF and WRDs, and are on-site and **local** in extent. Groundwater quality is not expected to improve after mine closure, hence it will be a **permanent** impact. Leaching of contaminated water from TSF and WRDs will severely alter the groundwater quality within the footprint of these facilities. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **certain**. The impact magnitude is rated as **Medium** since the SO_4 concentrations are high however the extent of the plume is confined to the mine lease area. The impact significance (pre-mitigation) is **MODERATE**. The degree of confidence in this assessment is **medium**.

Box 9.9 Summary of Post-Closure Impact: Groundwater Quality

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Medium.

- Extent: The extent of the impact is on-site and **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale: The impact will **severely alter** the resource.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE.

Degree of Confidence: The degree of confidence is **medium**.

Decommissioning and Post Closure Phase Mitigation

Operational mitigation measures have to be maintained post closure. Further, final profiling of the TSF and WRDs should be aimed at reducing erosion and minimising further water infiltration.

Higher confidence groundwater models (developed/updated using monitoring data collected throughout the construction and operational phases) should be used for post-closure planning and to determine the extent and frequency of post-closure groundwater level monitoring.

Residual Impact

The implementation of the mitigation measures outlined above would reduce the construction impacts from **Minor** significance to **Negligible** and the operation impacts from **Moderate** to **Moderate-Minor**. The implementation of the decommissioning phase mitigation measures would not reduce the significance rating, and thus remain **Moderate**. The pre- and post-mitigation impacts are compared in *Table 9.5* below.

Table 9.10 Pre- and Post- Mitigation Significance: Groundwater Quality

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**MINOR (-ve)**	**NEGLIGIBLE (-ve)**
Operation	**MODERATE(-ve)**	**MODERATE (-ve) to MINOR(-ve)**
Decommissioning and Post Closure	**MODERATE (-ve)**	**MODERATE (-ve) to MINOR (-ve)**

9.2.4 *Impact of Water Quality on Groundwater Users*

This section considers the potential impact of water quality on groundwater users.

Table 9.11 Impact Characteristics: Groundwater Users

Summary	Construction	Operation	Post Closure
Project Aspect/Activity	N/A	Contaminated leachate from tailings storage facility (TSF) and waste rock dumps (WRDs). Spillage from mining equipment. Contamination through residuals of explosives used in the mining process.	Contaminated leachate from tailings storage facility (TSF) and waste rock dumps (WRDs).
Impact Type	N/A	Indirect.	Indirect.
Stakeholders/ Receptors Affected	N/A	Groundwater Users.	Groundwater Users.

Construction Phase Impacts

The Construction Phase of the Project is not expected to negatively impact on groundwater users in the Project Area and its significance is therefore **NEGLIGIBLE**.

Operational Phase Impacts

SO_4 groundwater contamination emanating from TSF and WRDs was quantified using numerical solute transport modelling. SO_4 is a conservative tracer, providing an indication of conservative contaminant extent.

At the end of mining modelled SO_4 plumes at concentrations exceeding the SANS 241-1:2011 drinking water standard of 400mg/L are mainly confined within the immediate footprint (250m) of the contaminant sources and are not expected to affect any private groundwater users (farm boreholes).

The Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium**. The planned activity will not result in the loss of irreplaceable resource with regards to the groundwater resource.

Water quality impacts are expected to be limited to the footprints of the TSF and WRDs, and are **on-site** in extent. Groundwater quality is not expected to improve after mine closure, hence it will be a **permanent** impact. Leaching of contaminated water from TSF and WRDs will remain **unaltered** the groundwater quality outside of the footprint of these facilities. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **certain**.

The impact magnitude is therefore rated as **Negligible** and the impact significance (pre-mitigation) is **NEGLIGIBLE**. The degree of confidence in this assessment is **medium**.

Box 9.10 ***Summary of Operational Impact: Groundwater Users***

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Negligible.

- Extent: The extent of the impact is confined to the site and is **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale: The groundwater resource is expected to remain **unaltered** outside of the footprint of TSF and WRDs.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE.

Degree of Confidence: The degree of confidence is **medium**.

Operational Phase Mitigation

Groundwater quality should be monitored at the existing (known) private boreholes in regular intervals to confirm modelling results. Should monitoring data confirm impact on private users, the client will compensate affected famers for their loss, replacing the lost water supply source.

Post Closure Phase Impacts

The seepage from WRDs is not expected to stop after mine closure and will therefore continue to expand post-closure. The plume emanating from the TSF is expected to remain in proximity of the footprint of the facility.

Modelled areal extent of SO_4 plumes 100 years after mine closure are 2.4km^2 for the TSF and 8.8km^2 for the WRDs which represents increases of 50% and 140% respectively. The maximum travel distance of 1.2km is observed from the WRDs in south-westerly direction. Private groundwater users are not expected to be impacted by groundwater contamination as plumes remain within farms owned by the client.

The Sensitivity/Vulnerability/Importance of the groundwater resource was rated as **Medium**. The planned activity will not result in the loss of irreplaceable resource with regards to the groundwater resource.

Water quality impacts are expected to be limited to the footprints of the TSF and WRDs, and remain on site and **local** in extent. Groundwater quality is not expected to improve after mine closure, hence it will be a **permanent** impact. Leaching of contaminated water from TSF and WRDs will remain **unaltered** the groundwater quality outside of the footprint of these facilities. The frequency is classified as **continuous** due to the nature of the project and the likelihood is **certain**.

The impact magnitude is therefore rated as **Negligible** and the impact significance (pre-mitigation) is **NEGLIGIBLE**. The degree of confidence in this assessment is **medium**.

Box 9.11 Summary of Operational Impact: Groundwater Users

Nature: Operational activities would result in a **negative direct** impact the groundwater resource in the Project Area.

Sensitivity/Vulnerability/Importance of Resource/Receptor – Medium.
Irreplaceability: The activity will **not** result in the loss of **irreplaceable** resources.

Impact Magnitude – Negligible.

- Extent: The extent of the impact is confined to the site and is **local.**
- Duration: The expected impact will be **permanent (ie irreversible).**
- Scale: The groundwater resource is expected to remain **unaltered** outside of the footprint of TSF and WRDs.
- Frequency: The frequency of the impact will be **continuous.**
- Likelihood: The likelihood of the impact is **certain.**

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE.

Degree of Confidence: The degree of confidence is **medium**.

Operational Phase Mitigation

Groundwater quality should be monitored at the existing (known) private boreholes in regular intervals starting prior to or during construction to confirm modelling results (see the groundwater management plan in *Section 10*). Should monitoring data confirm impact on private users, the client will compensate affected famers for their loss, replacing the lost water supply source.

The present numerical groundwater flow and transport model will be updated at regular intervals starting prior to construction as additional information becomes available to ensure assumptions made during the development of the model remain valid and that model predictions remain current.

Residual Impact

Pre-mitigation impacts were rated **NEGLIGIBLE** for construction, operational and post-closure phases of the project, maybe change the **negative** impact to a **positive** impact (ie if the quality of the alternative water source provided by the project exceeds the existing one). The pre- and post-mitigation impacts are compared in *Table 9.11* below.

Table 9.12 Pre- and Post- Mitigation Significance: Groundwater Users

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post-mitigation)**
Construction	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Operation	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Post Closure	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**

9.3 IMPACTS ON BIODIVERSITY

Impacts to biodiversity are described in this Chapter. Impacts to priority Ecosystem Services are presented in *Section 6.14*.

Background

The Gamsberg lies at the heart of what is termed the "Bushmanland Inselberg Region", which includes all the large, quartzite-capped inselbergs located in the northern Bushmanland plains in South Africa. This region is located on the boundary between winter and summer rainfall systems of southern Africa, and the overlap of two biomes is a unique feature and sets these inselbergs apart from other inselbergs elsewhere in the Nama Karoo.

The Bushmanland inselbergs effectively comprise an archipelago of rocky islands within a vast expanse of sand. These rocky islands share common floristic affinities that are fundamentally distinct from the surrounding sandy plains. The flora of these inselbergs forms a distinct centre of plant endemism located within the larger Eastern Gariep Centre of Endemism. There are many species endemic to the Bushmanland Inselbergs and the region is defined as a distinct centre of endemism termed the "Bushmanland Inselberg Centre of Endemism". This centre of endemism is sometimes referred to as the "Gamsberg Centre of Endemism" as this inselberg lies at the floristic centre of this region and is the key biodiversity feature underpinning ecological processes/function in this system. The endemism is associated with the inselbergs and not the sandy Bushmanland plains that comprise 90% of the region.

Impact Assessment

Baseline Assessments presented by Desmet (2013) have mapped and classified the vegetation from five vegetation types into 19 habitats. These have been rated on a nationally accepted sensitivity scale as either irreplaceable (unique), constrained or flexible (widespread) habitats. The habitats have not been classified as modified, natural or critical habitats as required by the Vedanta Standard (based on the IFC standards) for Biodiversity. For the purpose of this impact assessment, the following classification of habitats as per the Vedanta Standards is used:

- The Gamsberg is a Greenfields site, and no modified habitats of sufficient extent have been mapped.

- The constrained and flexible habitats shall be considered natural habitats. The standards require that mitigation measures are implemented to achieve no net loss of biodiversity.

- The irreplaceable habitats are considered critical habitats based on the critical habitat requirements of the Vedanta Standard (Criteria 4: Highly threatened and/or unique ecosystems). These standards require that mitigation measures are implemented to achieve "on the ground" net gain in biodiversity values, which can be referred to as a "no net loss plus" approach.

The Vedanta Standards recommend assessment of the following generic impacts typically associated with development projects:

- Habitat loss;
- Habitat fragmentation;
- Human influx (sometimes referred to as Third party access); and
- Spread of alien and invasive species.

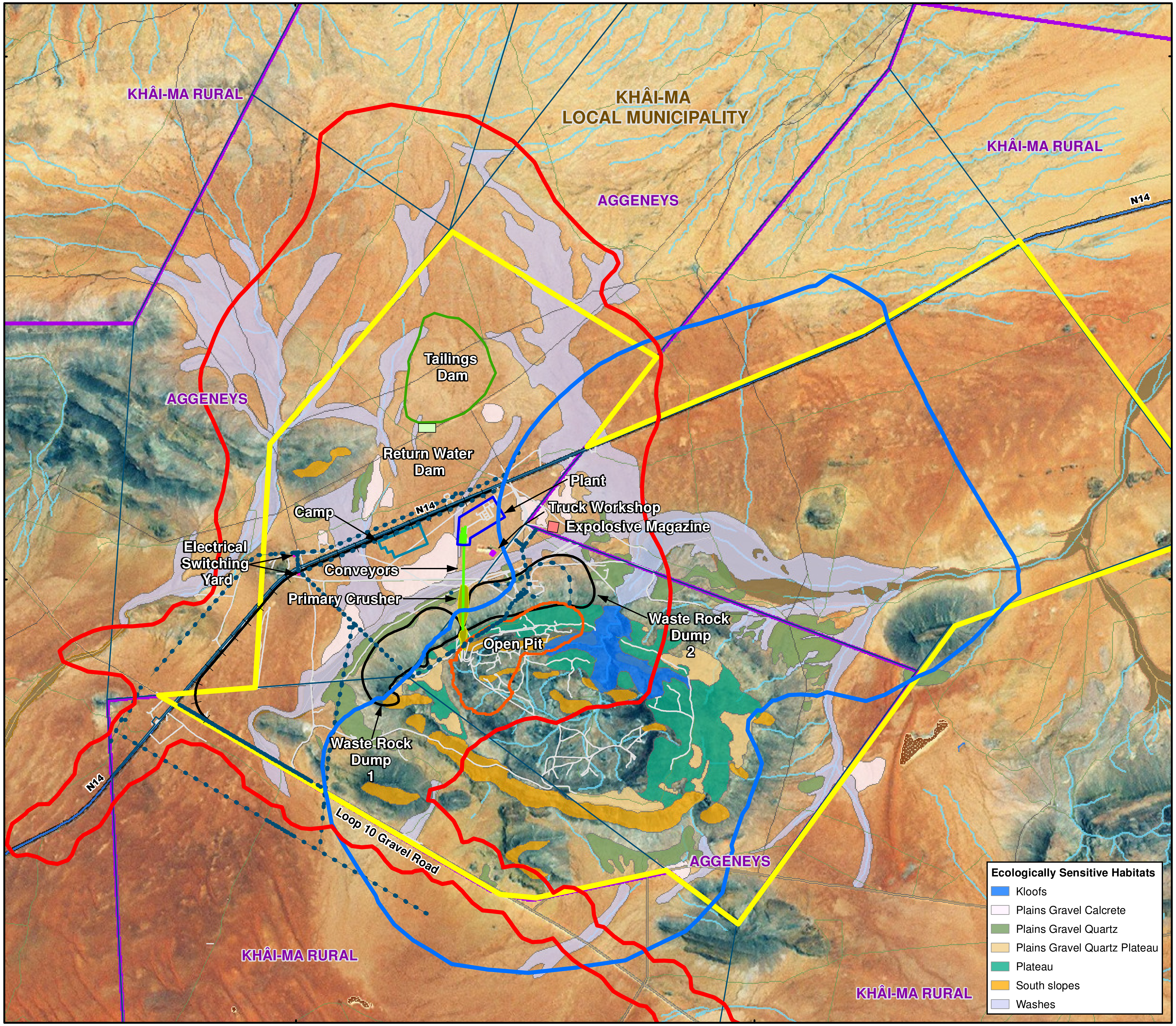
The above impacts are assessed from an ecological perspective, together with the following impacts to comprehensively assess the situation faced by the current project:

- Habitat degradation as a result of dust deposition and groundwater drawdown impacts and include associated impacts from altered surface runoff, acid rock drainage and groundwater quality; and

- Loss of species diversity and species of conservation concern.

Habitat loss and degradation are the primary impacts on the biodiversity as a result of the proposed mining activities; the mine footprint, dust deposition and drawdown of the groundwater level being the principal drivers of habitat loss and degradation. Habitats have been mapped and their sensitivity assessed by Desmet (2013) as illustrated in *Figure 9.9*.

Figure 9.9 presents the proposed infrastructure footprint, extent of the modelled dust deposition zone (20mg/m^2/day) and groundwater drawdown relative to the sensitive vegetation units identified by Desmet (2013). These sensitive habitats are presented in *Table 9.12* with the calculated areas of overlap from the mine footprint, dust deposition and loss of groundwater impact zones. Details of these impacts are discussed in the sections that follow; the areas of significant impact on the sensitive habitats have been indicated by orange shading in *Table 9.12*.



Legend

- Non-Perennial River
- Dry Water Course Centre Line
- Dry Water Course Floodplain
- Dam
- Dry Pan
- National Route (N14)
- Main Road
- Secondary Road
- Other Road
- Track/Footpath
- Railway
- Electrical cables
- Haul Roads
- Town Boundary
- Cadastral Boundaries

- Open Pit
- Contractors Camp
- Conveyor
- Electrical Switching Yard
- Explosive Magazine
- Plant
- Primary Crusher
- Return Water Dam
- Tailings Dam
- Truck Workshop
- Waste Rock Dump 1
- Waste Rock Dump 2

- Mineral Rights Area
- Groundwater 100 year drawdown zone
- Dust deposition zone (20mg/sqm/day)

SCALE: 0 1 2 3 4 Kilometres

N

TITLE:
Figure 9.9:
Sensitive Habitats, Infrastructure, Dust Deposition and Groundwater Drawdown Zones

CLIENT:
vedanta
BLACK MOUNTAIN MINING (PTY) LTD

DATE: Apr 2013	CHECKED: MP	PROJECT: 0164903
DRAWN: AB	APPROVED: SHC	SCALE: 1 : 72 000

DRAWING:	REV:
Sensitive Habitats Infra Dust GW.mxd	0

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
Fax +27 21 686 073
ERM

Projection: Transverse Mecator, CM19. Datum : WGS84
Source: Chief Directorate National Geo-Spatial Information. Black Mountain Mining (Pty) LTD
Inset Map: Esri Data & Maps

SIZE: A3

T:\Gis Projects\0164903_Gamsberg\Mapping\MXD\Report\April2013\Sensitive Habitats Infra Dust GW.mxd

Table 9.13 Overview of Habitats and Extent (ha) of Impact through the Mining Footprint, Dust Deposition and Groundwater Loss

Vegetation Types, Habitat Units, Sensitivity & Ecosystem Status (including residual impact	Mine footprint	Dust Deposition 50 mg/m²/day	Dust Deposition 20 mg/m²/day	Groundwater Drawdown	Extent of Impact
Aggeneys Gravel Vygieveld					
Mountain plateau; Irreplaceable (EN)	123.2	58.5	117.1	280.8	181.7
Plateau quartz gravel; Irreplaceable (EN)	10.2	39.5	1.8	98.5	**51.5**
Plateau quartz gravel (fine grain); Irreplaceable (CR)			49.1		**49.1**
Plains quartz gravel; Irreplaceable (VU)	115.9	179.9	110.9	325.5	406.7
Plains quartz gravel intermediate; Flexible (LC)		56.5	231.0	240.4	56.5
Plains feldspar gravel; Irreplaceable (EN)		17.4	73.8		91.2
Plains rocky; Flexible (LC)	71.8	160.6	559.0	237.6	232.5
Bushmanland Inselberg Shrubland					
Mountains; Flexible (LC)	535.4	335.5	751.3	1 314.5	871.0
Bushmanland Arid Grassland					
Flat sandy plains; Flexible (LC)	447.5	1 947.0	2 083.6	3 038.3	2 394.5
Hummocky sandy plains; Flexible (LC)	17.2	316.8	447.4	0.0	334.0
Calcrete gravel plains; Irreplaceable (CR)	20.3	154.1	229.4	44.6	**403.7**
Bushmanland Sandy Grassland					
Mobile sandy dunes; Flexible (LC)		5.3	29.6	18.1	5.3
Eastern Gariep Plains Desert					
Plains Rocky; Flexible LC			252.1	120.7	
Bushmanland Inselberg Succulent Shrubland					
Southern Slopes; Irreplaceable (VU)	58.1	40.3	133.4	246.0	98.4
Azonal Habitats					
Kloof; Irreplaceable (CR)	27.8			148.9	**176.7**
Freshwater springs & Head-water Seep; Irreplaceable (CR)	-			-	**-**
River (Wash with sub-surface flow); Constrained (LC)	11.9			1 010.2	1 022.1
Wash; Constrained (LC)	39.9	442.4	928.9	276.5	482.3
TOTAL IMPACTED AREA (ha)					**6 857.1**

(a) Mine footprint includes pit, waste rock dumps, tailings, explosives magazine, plant, dams, administrative buildings, buffers on previous, roads and road buffers.
(b) Dust deposition is modeled extent of 50 mg/m²/day and 20 mg/m²/day. Habitats where dust exceeds 25% (50 mg/m²/day) of normal baseline are considered significantly impacted, similarly habitats where a high proportion of available habitat is affected by the 20 mg/m²/day dust zone.
(c) Groundwater drawdown based on the extent of the 10m drawdown after 100 years.
(d) Extent of Impact = sum of areas of affected habitats. (**Note:** Above areas exclude overlap and can be added)
LC – Least Concern; VU – Vulnerable; (VU) - VU implied by level of threat; EN – Endangered habitat.

Key to shading:	Habitat affected by respective impact	High proportion of available habitat affected	**Very high proportion of available habitat impacted**

9.3.1 *Habitat Loss Caused by the Mine Footprint and Associated Activities*

The footprint of the mine includes the opencast pit, waste rock dumps, crushers, concentrator plant, explosives magazine, tailings facilities (TSF), roads, pipelines, conveyors, electrical infrastructure, dams and administrative buildings. Development of this infrastructure is considered to result in the loss of habitat covering approximately 1480 ha. This figure includes impact buffers developed by Desmet (2013) on the infrastructure and road networks. Nineteen percent of this area has been mapped as important or conservation significant habitat (*Table 9.12*) and represents 6% of the mapped extent of these habitats within the vicinity of the proposed operation (Desmet, 2010).

The Housing Development and Waste Water Treatment Works in Aggeneys and the powerline from the Gamsberg mine pass through the Bushmanland arid and sandy grasslands that are widespread and are not considered sensitive. Habitat loss as a result of these developments is therefore not considered significant.

Table 9.14 ***Impact Characteristics: Habitat loss caused by the mine footprint and associated activities***

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	Development of plant and infrastructure. Stripping of overburden prior to excavation of the pit.	Excavation of pit and growth of Waste Rock Dump and TSF.	Presence of pit, TSF and Waste Rock Dump.
Impact Type	Direct Negative (all phases of mine).		
Sensitive Receptors Affected	Irreplaceable and highly significant habitats (*Table 9.12*).		

Box 9.12 Summary of Impact: Habitat Loss Caused by the Mine Footprint and Associated Activities during all Mine Phases

Nature: The construction, operation and decommissioning of the above mentioned facilities and infrastructure will have a **direct negative** impact on the loss of ecological habitat.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium to High.**
Irreplaceability: The infrastructure footprint extends over some highly significant and irreplaceable habitats, and the loss of this habitat will be permanent.

Impact Magnitude: **High.**
Extent: The extent of the impact is **Local**, as the mine footprint is contained within the site boundary with the exception of some developments outside.
Duration: The expected impact will be **Permanent** (ie irreversible). The irreplaceable habitats cannot be restored through rehabilitation efforts.
Scale: The impact will result in **Notable** changes to the receptor with the greatest extent of loss of any particular habitat being 15.8% (*Table 9.12*).
Frequency: The frequency of the impact will be permanent and continuous once the habitat is displaced.
Likelihood: Habitat loss will occur through planned activities, and is thus **Definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MAJOR** (for all phases of the mine).

Degree of Confidence: **High** - Sensitive habitats have been accurately mapped and there is definite overlay by the mining infrastructure.

Mitigation Measures

Measures to avoid and reduce at source:

- Chapter 4 provides a detailed assessment of alternative mining options, which have included ecological considerations. Many of the ecologically least destructive options have been adopted. These include:
  - Placement of the tailings facility away from the inselberg and avoiding any irreplaceable habitats;
  - Location of the waste rock dump adjacent to the pit with minimal overlap of irreplaceable habitats, as opposed to the top of the inselberg;
  - Concentrator plant located away from the inselberg basin;
  - Placement of the contractor's camp in non-sensitive habitat.
- The extremities of the waste rock dump may still be adjusted, where technically feasible through discussions with the botanist and engineering team. The results of this will not change the significance ratings on the impact assessment and may require some fine adjustments to the residual impact and resultant offsets. This will be finalised in the offset report.
- Consider designing and constructing a rock dump comprising only quartzite rock to fill the remaining portion of the western kloof thereby

shielding the main kloof from any direct impacts of mining activities in the pit. Careful placement of this barrier must be defined with input from a qualified botanist prior to the placement of the rock.

- Consider designing and constructing a rock-dump (or berm), where technically feasible, in the crater to the south and south-eastern side of the pit to shield the remainder of the basin/crater from mining activities. The berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. Careful placement of this barrier must be defined with input from a qualified botanist and the engineering team prior to the placement of rock.

- Associated with the two above mitigations, the botanist will work with the engineering team to consider the design and construction of appropriate structures to deal with erosion, storm water and dirty water within the crater.

- A detailed Biodiversity Management Plan (BMP) (1) will be developed to ensure that the proposed onsite (excluding offsets) avoidance, minimisation and rehabilitation measures associated with mine construction, operation and closure are consolidated for effective implementation and subsequent auditing. (2) Aspects of this plan are discussed throughout this impact assessment, however the plan will, in broad terms, include:

    - Optimal approach to management of the mine property and mine controlled areas including setting aside a large conservation area within these areas;

    - Approach towards implementing controlled access to the mine property and mine controlled areas;

    - Management measures to ensure protection and appropriate management of the biodiversity features on the mine property and mine controlled areas involving:
        - Avoidance of any forms of fire within the area;
        - Wildlife management plan focused on management of the medium to large faunal species and their habitat requirements to avoid habitat destruction through overgrazing;
        - Flora and fauna translocation plan from areas prior to disturbance when appropriate;

    - An ecological rehabilitation programme for impacted areas;

(1) Black Mountain Mining may already have an existing BMP which could be expanded or consolidated with the above requirements.
(2) An offset plan and associated management requirements would be prepared separately if required.

- Independent monitoring and ongoing inventory development of the mine property's biological and physical environments to inform adaptive management measures and/or corrective action as required;

- Alien and invasive species control program;

- General awareness training will be done as part of the mine induction to inform all staff and contractors of the sensitivities of the biodiversity aspects of the mine and surrounds and appropriate environmental work-place etiquette;

- The BMP will consider means of avoiding and mitigating "foot print" creep; and

- Measures to manage emergency, accident or upset conditions where biodiversity may be adversely affected.

- All operational waste will be contained and disposed of in accordance with the Waste Management Plan. All waste, rubble and debris will be kept clear of the kloof, wash out and inselberg basin and confined to designated areas within already degraded areas, as illustrated in *Figure 9.9*.

Measures to abate at site:

- Topsoil must be stockpiled where practical and used for rehabilitation purposes.

- Search and Rescue operations will be conducted to capture and translocate faunal species that are not able to escape prior to any land clearing exercises. Translocations will be in accordance with the BMP and as discussed in Section 9.3.5.

- Design and construct the southern approach road within the available flat surface, cutting of the slope should be limited to areas where the available surface does not allow for the required surface width. Berms should be constructed with materials cut from the slope and rocks rolling down the slope are to be kept to a minimum.

- Areas of high conservation need to be clearly demarcated with appropriate barriers and signage to ensure not further encroachment. Any infringements will be reported and appropriate penalties are to be enforced on the staff member or contractor (a suggested fine of R10 000 for infringements is proposed and should go towards a fund for small projects to improve conservation of the Gamsberg).

- Efforts will be taken to minimise the footprint of short-duration activities during construction, operation and decommissioning phases of the mine and the projects outside of the BMM concession. Efforts to minimise the footprint will involve advance planning, demarcating on the ground and informing staff and contractors of the need to constrain activities to the predetermined footprint, which include parking, vehicle turning areas, materials and equipment laydown zones, toilet facilities etc.

- Linear infrastructure should be grouped where possible and appropriate to minimise the footprint of these disturbances, eg roads, powerlines and pipelines should follow the same route adjacent to one another.

Measures to repair or remedy:

- Rehabilitation measures are to be central to the decommissioning phase of the mining operation. The arid environment does restrict the potential for rehabilitation, but a Rehabilitation Plan will be designed by a competent restoration ecologist as part of the BMP. The Rehabilitation Plan will include erosion control structures and re-vegetation measures of damaged areas using indigenous shrubs and grasses only. These areas will provide habitat for fauna to re-colonise the area. Special attention will be paid to ensuring that critical topography is reconstructed as far as practical.

- A progressive rehabilitation of impacted sites will be implemented as appropriate during all phases of the mine, ie construction, operation and decommissioning.

Residual Impact

Prior to the application of mitigation, the significance of habitat loss resulting from the mine footprint was assessed as MAJOR (*Table 9.14*) primarily due the loss of irreplaceable habitat, ie the Kloof and Headwater Seep. Key mitigation measures listed above include:

- Setbacks of the eastern edge of the pit to avoid encroachment onto the catchment (slopes) of the main kloof and similarly to avoid populations of *Conophytum* species on the inselberg foot-slopes.

- A well implemented BMP, including conservation of a set aside area within the mine site, will reduce the impact from loss of habitat and general biodiversity during all phases of the mine, and remaining habitats are expected to improve with protection and proactive management of the mine property.

Habitat loss will still occur as a residual impact but could be reduced to MODERATE/MAJOR significance with effective mitigation (*Table 9.14*). Based on the estimated areas of loss (*Table 9.12*), approximately 232 ha of irreplaceable habitat and 234 ha of constrained habitat will be lost to the mine infrastructure footprint. Even with mitigation, mining will result in a permanent and irreversible loss of habitat. For non-irreplaceable habitats effective mitigation will reduce the impact to MODERATE significance. For irreplaceable habitats, even with effective mitigation, the impact will remain MAJOR (*Table 9.14*).

It may not be possible to create a biodiversity offset to compensate for the loss of irreplaceable habitats. Although the Headwater Seep supports no unique species, the habitat itself is unique to the Bushmanland Inselberg Region. Up to 82% will be permanently lost, whereas for the Kloof habitat, there is only one other similar kloof elsewhere in Bushmanland. Several other habitats will be impacted beyond the conservation targets that have been set for them as described in the offsets specialist report (see *Annex F* by M. Botha, 2013).

Table 9.15 Pre- and Post- Mitigation Significance: Habitat loss caused by the mine footprint and associated activities

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**MAJOR (-ve)**	**MODERATE (-ve) to MAJOR (-ve)**
Operation	**MAJOR (-ve)**	**MODERATE (-ve) to MAJOR (-ve)**
Decommissioning and Post Closure	**MAJOR (-ve)**	**MODERATE (-ve) to MAJOR (-ve)**

9.3.2 Impacts Resulting from Habitat Degradation from Dust Deposition

Dust will be generated within the project area primarily from the blasting, pit excavation works, crushing, stockpile, conveyor transfer points, TSF and traffic on unpaved roads. Dust from the pit blasting and excavation, stockpile, conveyor and TSF will be of a dark brown/black colour and is expected to have acid forming properties. Dust generation resulting from construction and operation of the Project has been estimated, and the zone of dust deposition has been modelled based on prevailing winds and climate variables (refer to *Section 6* above).

There is a high ambient dust deposition within the natural environment, which is a fine red dust of calcareous origin. Baseline ambient dust levels show a massive range depending on prevailing climatic conditions, with a median dust deposition rate of 200 mg/m^2/day. The surrounding ecosystems would have a relatively high tolerance for dust and that deposited dust will remain highly mobile. However, the ecological impacts from dust deposition are considered significant if the dust input from mining exceeds a 25% change in the baseline dust deposition. All habitats exposed to 50mg/m^2/day are therefore considered impacted by dust (*Table 9.12* and *Figure 9.9*). More importantly, habitats in which a high proportion of their available extent (within the Bushmanland Inselberg Region) occurs within the 20mg/m^2/day dust deposition zone are also considered significantly impacted. These habitats have been rated as affected on two levels (*Table 9.12*) based on the extent of available habitat affected.

Of concern relating to the dust impact is not the volume of dust but the colour and chemical properties of the dust produced from the mining operations. The ecosystems at the site are dominated by dwarf leaf-succulent plants, some only a few millimetres in size. The micro-climatic properties of quartz patches are a result of the white quartz reflecting sunlight and thereby insulating the soil. This may change with a layer of darkly covered dust leading to increased surface temperatures. Moisture derived from mist is the dominant moisture source for the winter-rainfall component of the local flora and affects the soil surface only. Altered chemical properties on the soil surface from acid-generating dust could have adverse consequences on small shallow-rooted species. There is concern that even small changes in the chemical and physical properties of background dust could impact upon sensitive plant species (eg *Conophytum ratum*, *Conophytum angelicae* "dwarf form") over an important part of their restricted range.

Most of the impacts from dust will be reversible within a period of time after mine closure, however these small succulent species have a short lifespan (2 to 5 years) and depend on reproduction through seed production. Approximately 80% of the populations of the above *Conophytum* species are focussed around the fine grain quartz gravel patches. These species are thus at high risk of extinction in the wild within the period of the mine operation as a result of the dust despite the fact that habitats may restore themselves. A cautious approach is therefore followed with regard to analysis of the dust impact in this assessment, which is in line with requirements of the South African legislation and the IFC performance standards

Uncertainties

There are many unknowns regarding the impacts of dust on these habitats. The following uncertainties are highlighted:

- The mobility of the dust once settled is uncertain, and whether there will be a net accumulation of mine-generated dust over a period of time remains to be determined.

- The available dust model does not distinguish between different sources of dust. The dust generated from roads and other sources should not lead to the negative consequences of concern as described above. The geology of the area to be excavated for the pit is varied and not all of the rock will necessarily produce darkly coloured dust with acid-generating properties. Blasting, excavation and processing of the Gamsberg Iron Formation (GIF) is expected to generate a black dust with potential acid-generating properties. The severity, duration and extent over which this dust will be generated are currently unknown.

- The extent to which dark acid-generating dust will lead to long-term impacts on the sensitive receptors (small succulent species) is unknown.

A conservative approach is followed in this assessment due to the many uncertainties and the highly sensitive habitats involved.

Table 9.16 *Impact Characteristics: Habitat degradation from Dust Deposition*

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	Construction activities, driving on unpaved roads.	TSF, pit excavation, blasting, stockpiles and conveyors, driving on unpaved roads.	TSF, driving on unpaved roads.
Impact Type	Direct Negative (all mine phases).		
Sensitive Receptors Affected	Plains Gravel Quartz habitat; Plains Gravel Calcrete habitat; Kloof and South Slopes habitats (*Table 9.12*).		

Box 9.13 *Summary of Impact: Habitat Degradation from Dust Deposition for all Phases of the Mine*

Nature: The deposition of acid-generating dust causing increased soil temperatures is a **Direct** and **Indirect Negative** impact on sensitive habitats.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **High.**
Irreplaceability: Numerous **Irreplaceable** habitats will potentially be degraded or lost.

Impact Magnitude: **Medium to High.**
Extent: The extent of the impact is **Local**, as many irreplaceable habitats that are important on a regional scale may be irreparably damaged.
Duration: The impact is expected to last the duration of the life of mine, ie **Long term**.
Scale: The impact will result in **Widespread** changes to the affected habitats.
Frequency: The frequency of the impact will be **Frequent to Continuous** due to the dry climate and regular winds.
Likelihood: The likelihood of the impact occurring is **Definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MAJOR.**

Degree of Confidence: **Low.**

Mitigation Measures

Measures to abate at site:

- Mitigation measures for suppression of dust from blasting and haulage activities in the pit, on the waste rock dumps and along unpaved roads will reduce dust-related impacts on the environment, as discussed in *Section 9.*
- Dust monitoring programmes will be implemented and actions taken when threshold levels are exceeded, as discussed in *Section 9.*

Measures to abate at receptor:

- Monitoring of sensitive ecological receptors will be implemented and include the following considerations:
  - Permanent monitoring plots will be established within sensitive habitats at high risk of loss of important plant species from dust deposition;
  - A competent botanist will be contracted to oversee the monitoring programme; and
  - Threshold levels of loss of individual plants will be determined and actions to be followed in the event of exceeding these levels.
  - If thresholds are exceeded, corresponding increases in terms of the Offset metrics will need to be implemented by the mine, and reported to the competent authority.

Residual Impact

Prior to the application of mitigation, the significance of habitat degradation resulting from dust deposition ranged from **MODERATE** to **MAJOR** (*Table 9.16*) due to the large coverage over restricted irreplaceable habitats, primarily the Quartz gravel plains but also the Calcrete gravel plains, the South slopes and the Kloof. Confidence on the assessment of impact significance on the terrestrial ecology is however low due to possible variability in the properties of the dust and uncertain ecological consequences, and few options for mitigation are possible except avoidance measures to reduce dust generation at the source. A monitoring plan to assess the ongoing impact of dust deposition on sensitive receptors will be developed and implemented.

Approximately 805 ha of irreplaceable habitat, 809 ha of constrained habitat and 2 605 ha of flexible habitat could *potentially* be ecologically degraded or lost as a result of dust deposition (*Table 9.12*). Consideration will need to be given to acquiring an offset that protects similar habitats to achieve an "on the ground" net gain in biodiversity values for this impact as required by the Vedanta Standards.

Table 9.17 Pre- and Post- Mitigation Significance: Habitat Degradation from Dust Deposition

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**MODERATE (-ve)**	**MODERATE (-ve)**
Operation	**MAJOR (-ve)** ***(Low confidence)***	**MAJOR (-ve)** ***(Low confidence)***
Decommissioning and Post Closure	**MODERATE (-ve)** ***(Low confidence)***	**MODERATE (-ve)** ***(Low confidence)***

9.3.3 *Habitat Degradation Impacts Resulting from Groundwater Drawdown*

The large open cast pit will draw groundwater flows from the surrounding areas. Groundwater levels have been modelled based on the underlying geology, rainfall and evaporation rates. Results have revealed that groundwater levels are expected to stabilise 100 years after mine closure, and will result in a large area as illustrated in *Figure 9.9* with a depressed groundwater table in excess of 10 meters below current baseline levels. High evaporation rates as a result of the dry climate are expected to exceed the groundwater flows into the pit, and the pit will remain dry with a permanently depressed groundwater zone (*Annex G2*). Groundwater within the inselberg and immediate vicinity will be reduced to the level of the pit base 100 years post-closure, which is approximately 300 meters below the groundwater of the surrounding plains, but will rise sharply to less than 20 meters below current baseline levels within a short distance from the inselberg. Groundwater levels within the Kloof habitat are expected to remain 100 to 150 meters below current baseline levels 100 years post closure.

A number of seeps, springs and associated vegetation around the inselberg and the riparian plant community, mainly trees, growing in the kloof and mouth of the kloof on the north side of the inselberg are currently dependent on subterranean water sources. Lowering of the water table in riparian areas will result in a die off or reduce the ability of trees to regenerate. The tree species affected are mostly widespread throughout southern Africa although locally they are rare or uncommon being confined to these habitats. These species are a keystone ecological resource so their loss will imply a permanent and irreversible loss of ecological function.

Azima tetracantha (Needle-bush) is a shrub growing in the spring on the eastern slopes of the mountain. It is a widespread species from the Eastern Cape and KwaZulu-Natal but within this landscape is a palaeo-relic from past climates. It is possible that it has been growing in this spot of at least the past 10 000 years and may have developed unique genetic adaptations to survive here. The loss of this spring is likely to result on the demise of this species at this site, and the possible loss of unique genetic material.

The wash area at the mouth of the Kloof where it exits the Gamsberg inselberg has been identified as an important faunal habitat which supports high densities of scorpions and invertebrates in general (GroundTruth, 2013). The groundwater level is typically just below the surface at this point, which may explain their abundance, but also the occasional surface flows bring nutrients and plant material that sustains their prey. These invertebrates provide an important food source for species higher in the food chain. The natural groundwater level will be permanently altered as a result of the groundwater drawdown.

Table 9.18 ***Impact Characteristics: Habitat Degradation from Groundwater Drawdown***

Summary	Construction	Operation	Decommissioning/ Post Closure

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	None	Pit excavation.	Presence of pit.
Impact Type	None	Direct Negative.	
Sensitive Receptors Affected	None	Mountains plateau, Kloof and South slopes habitats (*Table 9.12*).	

Box 9.14 Summary of Impact: Habitat Degradation from Groundwater Drawdown

Nature: Excavation of the open cast pit will lead to a groundwater drawdown that will have a **Direct Negative** impact on the functionality of surrounding habitats.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **High.**

Irreplaceability: The entire Kloof habitat and a number of freshwater springs (classified as Irreplaceable) where much of the ecological functionality depends on surface water availability, will be affected. The Wash habitats (classified as constrained) may be affected to a lesser amount.

Impact Magnitude: **High.**

Extent: The groundwater drawdown zone extends beyond the boundaries of the site, however the ecological impacts are **Local**.

Duration: The presence of the large opencast pit will prevent recovery of groundwater levels after mine closure, and the impact will thus be **Permanent** (ie irreversible).

Scale: The impact will result in complete changes to the irreplaceable Kloof and Freshwater Spring habitats.

Frequency: The frequency of the impact will be **Continuous and Permanent.**

Likelihood: Excavation of the pit is a planned event and the resulting impact is thus **Definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MAJOR.**
(operation and decommissioning phases only)

Degree of Confidence: **High.**

Mitigation Measures

Measures to repair or remedy:

- Water will be provided artificially to maintain selected faunal diversity at least for the duration of the life of mine, and possibly continued by the responsible management authorities post mine closure. The following approaches will be implemented:

  - Provision of artificial drinking water in appropriate areas within the inselberg basin throughout the year for wildlife, such as baboons and antelope, that is currently dependant on the surface water of the Kloof habitat (prior to excavation of the pit).

  - Seasonal provision of water in natural pools in appropriate locations within current wetland habitats for frog species (eg *Phrynomantis annectens, Strongylopus springbokensis, Vandijkophrynus robinsoni* etc.) and aquatic fauna to complete their breeding cycles. The undescribed alga *Hydrodictyon sp.nov.* is likely to depend on these pools.

  - These forms of water provisioning will need to be continued after mine closure, and incorporated into the future land management programmes for the Gamsberg post-mining with financial provision secured by BMM.

- The Needle-bush shrub (*Azima tetracantha*) will be cultivated *ex-situ* in a nursery from seeds or genetic material collected within the Gamsberg, and used in landscaping projects around the mine offices and other facilities. This species is well suited to propagation, and this measure will preserve local genetic material.

- A monitoring plan will be developed and implemented to monitor the ecological integrity of all habitats that are ecologically affected by the groundwater drawdown and the effectiveness of artificial water provision. This programme may provide additional options to mitigate the impact or contribute towards the determination of offset metrics. The monitoring programme will start immediately to provide a reliable benchmark against which to measure impacts of the mining operations.

Residual Impact

Prior to the application of mitigation, the significance of habitat degradation resulting from groundwater drawdown was MAJOR due the total inclusion of restricted irreplaceable habitats, primarily the Kloof, Headwater seen and springs. These habitats depend on groundwater for seepage and maintenance of riparian vegetation which provide important ecological functions.

Mitigation measures for impacts on habitats and species include artificial provisioning of water and *ex-situ* cultivation which at best will support a fraction of the species diversity dependent on those habitats. These mitigation measures are not considered effective in alleviating the impact, and the significance of the impact will remain of MAJOR significance (*Table 9.18*). Consideration will need to be given to acquiring an offset for those habitats that are not irreplaceable that protects similar habitats to achieve an "on the ground" net gain in biodiversity values for this impact as required by the Vedanta Standards. Impacts on irreplaceable habitats cannot be offset.

Table 9.19 Pre- and Post- Mitigation Significance: Habitat Degradation from Groundwater Drawdown

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post–mitigation)**
Construction	**N/A**	**N/A**
Operation	**MAJOR (-ve)**	**MAJOR (-ve)**
Decommissioning and Post Closure	**MAJOR (-ve)**	**MAJOR (-ve)**

9.3.4 *Impacts Arising from Habitat Fragmentation*

Inselbergs within the Bushmanland Inselberg Region represent an archipelago of rocky islands within a vast expanse of sand. These inselbergs serve as stepping stones for many species that hop from one inselberg to another, eg birds and wind-blown seed dispersal of plants. They also provide important ecological refugia for species that are important from an evolutionary/ climate adaptation perspective. The inselbergs form a sequence that represent an ecological corridor that has been defined by the Namakwa District Map of Critical Biodiversity Areas. This corridor was recognised to safeguard movement of biota between the Bushmanland inselbergs. The Gamsberg is located midway along this corridor and its position is key to the east-west movement of species. The Gamsberg inselberg is considered to be the key biodiversity feature underpinning ecological processes/ function in this system.

Mining will reduce the Gamsberg's ecological function as a movement /migratory stepping-stone/corridor for species between inselbergs. The mine infrastructure footprint, the dust deposition and the ecologically-affected areas from the groundwater drawdown will adversely affect the ecological corridor's functionality.

A lesser ecological corridor is identified on the Namakwa District Map of Critical Biodiversity Areas to the south of the Gamsberg. This corridor provides an alternative route for migration of various species and genetic material. However this corridor follows the Koa river valley or arid sandy grassland and does not support the irreplaceable habitats present in the Gamsberg corridor and essentially serves non-inselberg dependent species. The design of any accompanying offset would need to cater for retaining as much of an inselberg corridor as possible.

Table 9.20 Impact Characteristics: Habitat Fragmentation

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Combination of activities, but particularly the mine infrastructure, pit and TSF footprints and dust deposition footprint.		
Impact Type	Direct Negative.		
Sensitive Receptors Affected	Ecological 'stepping-stone' corridor through the Bushmanland Inselberg region.		

Box 9.15 Summary of Impact: Habitat Fragmentation during all Mine Phases

Nature: The combined impacts of the mine footprint, dust deposition and groundwater loss will have a **Direct Negative** impact on lowering the functionality of an ecological 'stepping-stone' corridor through the BIR.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium.**

Irreplaceability: The ecological corridor links many habitats, some of which have been classified as **Irreplaceable** or constrained. Significant ecological process depend on the Gamsberg in the inselberg system, and it is identified as the most efficient/ effective configuration for conservation in this landscape.

Impact Magnitude: **Medium.**

Extent: The extent of the impact is **Regional**, as the ecological corridor extends far beyond the project site.

Duration: The expected duration of the impact will be **Long-term to Permanent**.

Scale: The impact will result in **Notable** changes to the receptor (ie the corridor and species that move along it.).

Frequency: The frequency of the impact will be **Continuous.**

Likelihood: The likelihood of the impact occurring is **Definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MAJOR.**

Degree of Confidence: **Medium -** There is limited means to quantify or demonstrate the functionality of an ecological corridor or the result of the impact.

Mitigation Measures

Measures to avoid at source:

- Set aside a large part of the mine property and mine controlled areas for conservation purposes. Appropriate management and conservation of this set aside conservation area is required through effective implementation of a comprehensive BMP (as discussed in Section 0) to ensure that natural habitats are maintained in the best possible state over the life of mine and thereafter.

- The remaining area of the Gamsberg under the control of the mine must be maintained in a good ecological state through controlled access, prohibition on livestock grazing and proactive management as required through implementation of a BMP (as discussed in Sections 0 and 9.3.7).

- Small areas of natural vegetation will be maintained as islands for the refuge of species wherever possible within the mine footprint, eg strips of vegetation beneath powerlines and between roads. These small patches of natural vegetation will not compensate for the loss of a corridor, but will allow the movement of bird and other faunal species that would otherwise be reluctant to traverse large areas of continuous disturbance.

Measures to abate at site:

- Fencing of the mine properties and mine controlled areas will be maintained in a good state in the form of 4 or 5 strand livestock fences. These fences must allow unrestricted movement of small and medium-sized wildlife in and out of the mine properties and mine controlled areas.

- Artificial barriers to species movements will be minimised, and measures taken to allow movement across unavoidable barriers. Examples include:
  - regular culverts will be installed beneath roads and pipelines, and
  - small gaps incorporated into security mesh fences.

- Night lighting for the plant and security purposes will be kept to a minimum and both inward and downward facing to minimise the disturbance to the movement of nocturnal species. It is recommended that low pressure sodium vapour lights/or LED lights should be used with wavelengths of limited attractiveness to insects.

Measures to repair or remedy:

- Artificial water provision will be provided to maintain selected faunal diversity as described in Section 9.3.3.

- Locally indigenous plant species will be used in landscaping projects around offices and mine facilities.

Residual Impact

The pre-mitigation significance of habitat fragmentation has been assessed as MODERATE to MAJOR due to the interruption of an ecological corridor comprising a sequence of inselbergs. Mitigation measures have been presented to ensure that natural habitats are retained and well managed over much of the Gamsberg inselberg and that efforts are taken to ensure barriers created by the project are permeable to a range of species.

This impact can be reduced to MODERATE significance (*Table 9.20*) through a number of effective mitigation measures presented above. It is not possible to demonstrate the direct dependence on critical habitats, yet the majority of the habitats that would be affected on a regional scale are natural, and the Vedanta Standard for natural habitats would thus apply, ie to show no net loss of biodiversity. However far wider consideration of ecological processes are relevant. The Vedanta standards (based on the IFC PS6) emphasises supporting the ecological processes underpinning patterns of biodiversity.

It will be possible to incorporate a landscape corridor criterion (maintaining functional corridor width within a 5km buffer around the mine impact area) into the design of a biodiversity offset aimed at retaining the landscape connectivity. By maintaining continuous "buffers" of natural habitat north and south of the mining area it would be possible to retain a level of east-west landscape connectivity, albeit reduced in scale.

Table 9.21 Pre- and Post- Mitigation Significance: Habitat Fragmentation

Phase	Significance (Pre-mitigation)	Residual Significance (Post–mitigation)
Construction	MODERATE (-ve)	MINOR (-ve)
Operation	MAJOR (-ve)	MODERATE (-ve)
Decommissioning and Post Closure	MODERATE (-ve)	MINOR (-ve)

9.3.5 *Impacts on Species Diversity as a result of Mining-related Activities*

While the biodiversity impacts have been considered in the previous sections, it is also important to consider the impacts on individual species. The impact on flora and fauna as a result of the project is discussed separately below.

Floral Species Importance

The Bushmanland Inselberg Region straddles the boundary of the winter and summer rainfall systems of South Africa, and thus overlaps two biomes. As a result, the floral composition of this area is unique and the Bushmanland Inselberg Region defines a distinct centre of endemism termed the "Bushmanland Inselberg Centre of Endemism". The endemism is associated with the inselbergs and not the sandy Bushmanland plains that comprise 90% of the region. *Table 9.21* presents a list of conservation important plant species identified in the study area, which includes five species listed on the IUCN Red List of threatened species and nine species endemic to the Bushmanland Inselberg Centre of Endemism. Four species are restricted to three or less inselbergs and three species are considered relics of a past climate.

Table 9.22 Plants Species of Conservation Concern Identified in the Study Area (Desmet, 2010)

Species	Conservation Status	Habitat
Anacampseros bayeriana	VU, Rare	Calcrete gravel patches.
Crassula mesembrianthemopsis	VU, Rare	Calcrete gravel patches.
Titanopsis hugo-schlechteri var. hugo-schlechteri	VU, Rare	Calcrete gravel patches.
Conophytum ratum (plains form)	VU, END	Plains quartz gravel patch.
Mesembryanthemum inachabense	END	Plains quartz gravel patch.
Trachyandra sp.nov.	END (DD)	Plateau.
Tylecodon sulphureus	END	Plateau.
Adromischus nanus	END	Plateau quartz gravel patch.
Conophytum angelicae subsp. angelicae (dwarf form)	Rare	Plateau quartz gravel patch.
Conophytum ratum (dwarf/plateau form)	END & VU	Plateau quartz gravel patch.
Aloe microstigma	Relic	South slopes.
Conophytum limpidum (dwarf form)	NT, END	South slopes.
Othonna sp. nov.	END (DD)	South slopes.
Sceletium tortuosum	Relic	South slopes.
Azima tetracantha	Relic	Springs.
Hydrodictyon sp.nov.	END (DD)	Kloof.

Species	Conservation Status	Habitat
END – Endemic to the Bushmanland Inselberg Centre of Endemism; NT – Near Threatened. VU – Vulnerable (IUCN Red List); (DD) represent undescribed species (*sp.nov.*) and are considered within this report as Data Deficient in terms of the IUCN Red List criteria.		

Faunal Species Importance

Studies of the faunal communities have not revealed any highly threatened species.

Two undescribed ant species (*Camponotus sp.nov.* and *Messor sp.nov.*) were found, but are thought to be endemic to the Bushmanland Inselberg Region, and are thus treated as Data Deficient in terms of the IUCN Red List criteria. There is a possibility that a newly discovered invertebrate sub-order of Heelwalkers (Mantophasmatodea) may occur but has not been confirmed. The study site supports a high scorpion diversity which includes at least four species protected under provincial legislation (GroundTruth, 2013).

Baseline studies have revealed that the Gamsberg supports a high reptile diversity which includes three range-restricted endemic species, namely Haacke's Gecko, Namaqua Mountain Gecko and Desert Mountain Adder and one Red List species (Good's Gecko: Vulnerable). Bird diversity for the Gamsberg is high relative to the greater area and includes one recently confirmed Near Threatened bird, namely the Lanner Falcon. Other Red Listed birds have been recorded in older surveys. Other provincially protected species present in the project area include Greater Kestrel, Jackal Buzzard, Southern Pale Chanting Goshawk and Cape Eagle-Owl. A rich diversity of mammals is present in the area and includes two Bats and two rodents classified as Near Threatened. A mix of medium-sized mammals is present (possibly as a result of a long-term restriction on livestock grazing and limited access to the area), which include four antelope, one primate and 12 carnivores including Brown Hyaena and Leopard. The larger carnivores and raptors exist at the top of their food chains and their numbers are thus typically exist as few wide-ranging individuals worthy of conservation efforts.

Verraeux's Eagles, a provincially protected species appear to have active nest sites in the Gamsberg. Loss of resident Verreaux's Eagle from the Gamsberg could have significant ecosystem-level impacts for vegetation. Rock Dassies have the ability to alter the structure of vegetation where populations explode in the absence of predators, especially Verreaux's Eagle. The impact is reversible once disturbance ceases.

A number of species within the Gamsberg are considered to be at risk due to the proposed mining activities. The species that are at risk based on an assessment by GroundTruth (2013) are shown in *Table 9.22.*

Table 9.23 Faunal Species at Medium to High Risk as a Result of the Proposed Mining Activities in the Gamsberg (GroundTruth, 2013)

Species and Common Name	IUCN Red List Status	Threatened Habitat Dependence	Intensity of Impact	Species Impact Significance	Offset Potential (GroundTruth 2013)
Invertebrates					
Camponotus sp.nov. (AFRC-ZA-52) Undescribed ant	(DD)	Medium (H1 & H2)	High	Medium	Medium (RR)
Messor sp.nov. (AFRC-ZA-01) undescribed ant	(DD)	High (H2)	Medium	**High**	Low (RR & may be CR)
Herpetofauna					
Strongylopus springbokensis Namaqua Stream Frog	LC	Medium (H1 & H2)	High	Medium	Medium (RR)
Pachydactylus goodi Good's Gecko	VU	Medium (H1 & H2)	Medium	Medium	Medium (RR)
Pachydactylus haackei Haacke's Gecko		Medium (H1 & H2)	Medium	Medium	Medium (RR)
Pachydactylus montanus Namib Mountain Gecko		Medium (H1 & H2)	Medium	Medium	Medium (RR)
Bitis xeropaga Desert Mountain Adder		High (H2)	Medium	**High**	Medium (RR)
Birds					
Polemaetusbellicosus Martial Eagle	VU	Medium (H1 & H2)	High	**High**	High
Mammals					
Rhinolophus capensis Cape Horseshoe Bat	NT	Medium (H1 & H2)	High	**High**	Medium (Endemic)
Rhinolophus darlingi Darling's Horseshoe Bat	NT	Medium (H1 & H2)	High	**High**	High
Parotomys littledalii Littledale's Whistling Rat	NT	Medium (H3)	Medium	Medium	Medium
Petromus typicus Dassie Rat	NT	High (H1) Habitat specialist	Medium	**High**	Medium

CR – Critically Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern.
H1 – Irreplaceable habitats; H2 – Constrained habitats; H3 – Flexible habitats; RR – Range restricted.
Offset potential describes the ease with which a species could be included within an offset.

Aquatic Diversity

Aquatic diversity was assessed in four sites covering springs and the Kloof habitat. These aquatic systems are not listed under the national freshwater ecosystem priority areas (FEPA) database of important wetland sites. No sensitive aquatic species were found and both diatom and macro-invertebrate indices indicated the ecological integrity of these systems to be in a poor state. These results are thought to be the result of stagnant pools being assessed and a shortage of flowing freshwater habitats. The aquatic systems are essential to sustaining irreplaceable habitats; but their loss is assessed in Section 9.3.3.

Table 9.24 Impact Characteristics: Loss of Floral and Faunal Species Diversity

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Habitat loss and degradation; dispersal barriers and habitat fragmentation; reduced access to water; uncontrolled collecting and illegal hunting.		
Impact Type	Both direct and indirect negative impacts.		
Sensitive Receptors Affected	Vulnerable, endemic, rare, relic and undescribed plant species (*Table 9.21*) Threatened, endemic, undescribed and protected faunal species, also predators and scavengers at the apex of their food chains. Species at high risk of impacts (*Table 9.22*).		

Box 9.16 Summary of Impact: Loss of Floral and Faunal Species Diversity

Nature: Mining-related activities will have both **direct and indirect negative** impacts on the diverse biodiversity within associated with the Gamsberg.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium to High.**
Irreplaceability: **Yes**, many species are threated and or endemic. The population status of various undescribed species is not adequately understood. These species can be considered **irreplaceable**.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **Regional**, as populations of threatened, rare and endemic species would be regionally affected.
Duration: The expected impact will be **Long-term** to **Permanent**.
Scale: The impact could result in **Notable** changes to the receptor.
Frequency: The frequency of the impact will be **Ongoing.**
Likelihood: The likelihood of the loss of a threatened, endemic or undescribed species is **Possible**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE to MAJOR.**

Degree of Confidence: **Medium.**

Mitigation Measures

There are a number of measures that will be implemented to minimise the impact on fauna and flora. These actions will be captured as part of a detailed Biodiversity Management Plan (BMP) and include the follows:

Measures to reduce at site:

- Barriers to terrestrial faunal movement, eg fine mesh fences, walls, trenches, a raised concrete base along a conveyor, will be avoided where possible, and measures implemented to reduce their fragmentation impacts, as discussed in Section 9.3.4.
- The following activities will be prohibited by staff and contractors:

- Hunting of wildlife within the mine property or mine controlled areas;
- Purchase, sale or transport of any wildlife products from local communities or passing traders;
- Collection of any plants or animals or products thereof for consumption, medicinal use, cultivation or keeping as pets;
- Keeping pets within the Gamsberg mine property, either domestic animals such as cats or dogs, or native wildlife; and
- Intentional killing of any animals including snakes, lizards, birds or other animals.

- All trenches and pits that are excavated for pipelines, caballing etc will be backfilled as soon as practically possible to avoid acting as a trap for small fauna.

- Escape routes for fauna will be provided within pitfall features and concreted drainage lines, and potentially dangerous situations inspected regularly to save trapped species.

- All new power line infrastructure should be bird-friendly in configuration (eg pylon designs that widely separate live wires to reduce electrocution of vultures and other large raptors) and adequately insulated (Lehman *et al.* 2007) [(1)] to minimise the loss of raptors and other large birds. These activities should be supervised by someone with experience in this field.

- Power lines will be positioned as far as practically possible away from water bodies (including artificial ponds and the waste water treatment works at Aggeneys where flamingos and a diversity of waterbirds are at risk and incorporate visibility devices for birds (eg flappers) on long lengths of exposed lines.

- Redundant infrastructure will be removed at the earliest opportunity and these areas rehabilitated.

- Speed restrictions (suggested maximum of 40km/hr) will be enforced on all roads within the mine properties and mine controlled areas to minimise the incidence of faunal road kills.

- Driver training will be provided to sensitise them to the importance of avoiding faunal road kills and the mine site, within the mine properties and on public roads.

(1) Lehman, R.N., Kennedy, P.L., Savidge, J.A. (2007): The state of the art in raptor electrocution research: A global review. Biolog. Conserv. 136: 159-174.

Measures to repair or remedy:

- Translocation of flora is not viewed as an ecologically viable mitigation measure, as translocation of plants to others areas in the Bushmanland Inselberg Region can lead to genetic pollution that is undesirable. Translocation for trade is not acceptable. Development of a detailed plant translocation plan will form part of the Biodiversity Management Plan (Section 0). Translocation of plants will only be considered under the following circumstances:
-
    - Translocation only from areas about to be destroyed through clearing of vegetation cover;
    - For research purposes (eg to botanical gardens);
    - For landscaping purposes around the mine;
    - Species with very limited numbers and of high conservation value (eg *Aloe microstigma*) will be translocated within the Gamsberg; and
    - In some cases (eg calcrete gravel patches) translocated plants will be used to restore degraded habitat within the offset area.

- Trained mine personnel with capacity to safely capture and translocate dangerous snakes from construction sites and mine operational areas to safe areas of similar habitat within the mine property. Other non-dangerous faunal species at risk form construction activities will be captured and translocated to safe areas as appropriate.

- Ongoing development of an inventory of species diversity within the mine sites will be maintained. BMM will collaborate with competent NGOs or academic institutions with adequate competence to conduct research and monitor unexpected changes to the faunal baseline. Emphasis should be placed on the species considered to be at high and medium risk (*Table 9.22)* although not only restricted to these species. Such research may lead to improved mitigation to conserve the natural environments and species diversity.

- BMM will strive to improve knowledge gaps through a detailed regional study of key fauna and better inform both offset requirements and opportunities. BMM will collaborate with independent NGO's or academic institutions to conduct and interpret regular faunal monitoring studies to both expand on the current baseline study. The following aspects will be considered:
    - There is a possibility that summer-active species of Mantophasmatodea (heelwalkers) may be present, and should be investigated during a well-timed wet season survey; and

- Determine key habitat requirements for and distribution of the undescribed ant species of the *Camponotus* and *Messor* genera to enable formal conservation (IUCN Red List) assessments to be carried out, to allow potential offsets to be evaluated and to allow detailed rehabilitation requirements to be specified.

Additional conservation enhancement measures:

There are a number of measures that BMM could consider in improving the general conservation status of the area. These include the following:

- Efforts will be supported to promote an appreciation of biodiversity features of the mine property and mine controlled areas among staff, contractors and their dependents as mentioned in the BMP.

- Incorporating islands or platforms above the water level within the Waste Water Treatment Works would provide safe refuge for waterbirds and improve the quality of the habitat for them.

- Introduction of catfish (Barbel) to the secondary ponds of the Waste Water Treatment Works would facilitate the consumption of unwanted biotic components and would provide possible prey for fish eagles and cormorants, thereby increasing the diversity of birds attracted to the site. Fishing at the site will be prohibited.

Residual Impact

Prior to the application of mitigation, the significance of loss of species diversity was assessed as MODERATE to MAJOR due to the high diversity of species present, but particularly the very high diversity of endemic, rare, threatened, protected and some undescribed species that are currently not adequately understood. A host of mitigation measures are presented that will improve protection of the biodiversity and raise the understanding of the diversity and abundance of species within the project area and vicinity. Key mitigation measures include a conservation set aside area (Section 0), implementing a biodiversity protection policy and avoiding dangerous situations for fauna.

Effective implementation of these measures will reduce the impact to a MODERATE significance (*Table 9.24*). Biodiversity offsets will be considered to remedy these and other residual impacts on biodiversity. Special consideration needs to be given towards choice of an offset that includes the plant and animal species of conservation concern (*Table 9.21* and *Table 9.22* respectively); offset areas required to remedy residual negative impacts on habitat and flora may be sufficient to address the offset needs of fauna. Rare and undescribed plant and animal species may not be widespread and if not present in an offset, additional precautions to protect their populations *in situ* will be necessary to comply with the Vedanta Standards for natural and critical habitats.

Table 9.25 Pre- and Post- Mitigation Significance: Loss of Species Diversity

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post-mitigation)**
Construction	**MODERATE (-ve)**	**MINOR (-ve)**
Operation	**MAJOR (-ve)**	**MODERATE (-ve)**
Decommissioning and Post Closure	**MAJOR (-ve)**	**MODERATE (-ve)**

9.3.6 Impacts from Encroachment of Alien Species

Threats to biodiversity from alien plant species are currently low. Scattered individuals of the tree *Prosopis glandulosa* (Mesquite) are currently present in the river and wash systems around the mountain but not in the basin or kloof. This tree represents a dormant threat that has the potential to become significant in riparian areas if not eradicated. Russian thistle, *Salsola kali*, is widely present in disturbed places in the veld. This alien shrub is practically naturalised in Karoo vegetation and does not pose a significant threat at this time.

Within the last decade fountain grass (*Pennisetum setaceum*) has become established throughout Aggeneys town, especially within water run-on areas such as road culverts. This species represents a real and significant threat for the aquatic ecosystems of the Gamsberg. Increased traffic movement from Aggeneys to the mountain will increase opportunities for seed dispersal to the site, and increased water availability from dust mitigation activities will create ample opportunities and niches for this species to establish on the mountain. Once established in the physical mining area it is highly likely that this species could colonise the seeps and springs in the kloof resulting in further indirect loss of biodiversity in the kloof, although groundwater losses there may reduce their spread.

Table 9.26 Impact Characteristics: Encroachment of Alien Species

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	General Vehicle movements. Land clearing. Watering for dust mitigation along roads and other areas.	Watering for dust mitigation along roads and other areas. Rehabilitation programmes.	Rehabilitation programmes.
Impact Type	Indirect Negative (all mine phases).		
Sensitive Receptors Affected	Kloof habitat and road sides.		

Box 9.17 *Summary of Impact: Encroachment of Alien Species*

Nature: Construction and mine operation activities invariably lead to vegetation clearing and ongoing disturbance of land, which creates opportunities for alien species to establish. This results in an **Indirect Negative** impact on the local ecology.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low to Medium.**
Irreplaceability: Disturbed areas where alien plants species are likely to establish are **Not Irreplaceable**, however alien infestations can subsequently spread into vulnerable and irreplaceable habitats such as the Kloof.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **On-site to Local**, as the dry inhospitable climate is not conducive to infestation from a diversity of species.
Duration: The expected impact will be **Long Term to Permanent** but can be reversed.
Scale: The impact will result in **Notable** changes to the species composition and thus ecological functionality receptor of affected habitats.
Frequency: The frequency of the impact will be **Ongoing.**
Likelihood: The likelihood of the impact occurring is **Possible**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MINOR to MODERATE.**

Degree of Confidence: **Medium to High -** Alien species are present in the greater vicinity.

Mitigation Measures

Measures to reduce at source:

- Use only approved indigenous species for all workplace and new housing landscaping projects. The introduction of foreign plant species must be controlled.

Measures to repair or remedy:

- Develop and implement an Alien Plant Control Plan as part of the BMP. This plan will identify all problem alien and invasive plant species and map their distributions. The plan will prioritise the species for control and present the most effective control measures based on available technology and levels of infestation.

- Presence of alien fauna, such as feral dogs and cats that threaten the local ecology will be monitored. Ethical control measures will be implemented if an increase in their presence is detected.

Residual Impact

Prior to the application of mitigation, the significance of alien species encroachment was assessed as MINOR to MODERATE. Mitigation measures are presented to implement alien plant control and avoid the possible introduction of species that may pose a new threat. Effective implementation of these measures will reduce the impact to a NEGLIGIBLE significance (*Table 9.26*). The spread of alien species represents a displacement of naturally occurring species, and effective alien plant control is thus important to achieve the Vedanta Standard for natural habitats.

The construction phase will result in considerable vegetation clearance yet stabilisation and rehabilitation will most likely be delayed. Implementation of an effective alien control programme is similarly expected to be delayed, and therefore no reduction in the significance of the impact during the construction phase is expected.

Table 9.27 ***Pre- and Post- Mitigation Significance: Encroachment of Alien Species***

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post-mitigation)**
Construction	**MODERATE (-ve)**	**MODERATE (-ve)**
Operation	**MODERATE (-ve)**	**NEGLIGIBLE (-ve)**
Decommissioning and Post Closure	**MINOR (-ve)**	**NEGLIGIBLE (-ve)**

9.3.7 Impacts of Human Influx on Biodiversity

The exclusion of domestic livestock from the Gamsberg for the last three decades has resulted in the mountain currently supporting the best examples of the respective habitats regionally. A comparison of the calcrete gravel plains within the project site to similar habitats outside the site revealed the floral species diversity within the mine site to be in orders of magnitude larger, which was attributed to the long-term absence of high grazing intensity. The healthy natural vegetation cover has similarly encouraged the development of natural wildlife populations, with klipspringer and other small antelope being prominent there. These have in turn supported a carnivore population evidenced by the occasional sightings of leopard and the presence of brown hyaena.

The influx of people during mine construction and operation will be significant and could impact on vegetation if site access outside of the construction/mining footprint area is not regulated. Typical impacts include ad-hoc collecting of rare and endemic plants; illegal hunting of wildlife, litter and creation of off-road tracks. Tracks can have significant impacts for flora as gravel patches are especially attractive to off-road enthusiasts. Natural recovery of the vegetation is extremely slow and evidence of off-road driving can remain from over a hundred years in these gravel habitats.

Historically, the Gamsberg has been a popular botanical destination given the habitats and species present at the site. The effect of illegal collecting on plant populations at the site has not been quantified, but it does have the potential to be significant for some species with very restricted populations or high horticultural desirability.

The Gamsberg has been readily accessible and while avoidance of other land uses has benefited the natural habitats and species, illegal hunting and collection of plants may have resulted in some destruction. Implementing controlled access to the Gamsberg provides an opportunity to alleviate these problems and the potential for a positive port-mitigation impact.

Table 9.28 Impact Characteristics: Human influx Impacts on Biodiversity

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Off-road driving, uncontrolled access to natural areas during all phases of the project.		
Impact Type	Indirect Negative.		
Sensitive Receptors Affected	All natural habitats, threatened, endemic and rare succulent species, naturally occurring wildlife.		

Box 9.18 Summary of Impact: Human influx Impacts on Biodiversity

Nature: Construction and operation of the mine will attract increasing numbers of people to the area, which could have an **Indirect Negative** impact on the diversity and functionality of ecological environments. However improved security by the mine and restricted access may lead to a **Positive** impact within the mine concession area.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium.**
Irreplaceability: The impact could result in limited habitat degradation and loss of individual plants or animals, but is **Not Irreplaceable**.

Impact Magnitude: **Small to Medium.**
Extent: The extent of the impact is **Regional**, as the increase in population will extend to Aggeneys, other towns and intermediate areas.
Duration: The expected impact will be **Long term**.
Scale: The impact will result in **Slight** changes to the affected environments.
Frequency: The frequency that the impact may occur would be **Occasional.**
Likelihood: The likelihood of the impact occurring is **Possible**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MINOR.**

Degree of Confidence: **Moderate.**

Mitigation Measures

Measures to avoid or reduce at source:

- Grazing of livestock within the mine property and mine controlled areas will be prohibited.

- Implement controlled access to natural areas of the mine property and mine controlled areas. Fencing must be maintained as discussed in Section 9.3.4 with locked gates and no entry signs prominently displayed.

- All forms of off-road driving will be prohibited within the mine property and mine controlled areas. Development of roads and tracks within the natural areas will be minimised but sufficient to allow access to key areas.

Measures to abate at site:

- Occasional patrolling of the mine property and mine controlled areas will be conducted by the mine security to watch for evidence of illegal livestock grazing, encroachment of settlements and vagrants, presence of unauthorised persons and evidence of hunting or plant collecting.

Additional conservation actions:

- Collaboration should be considered between the mine security and Northern Cape Conservation authorities for sharing of skills for patrolling the natural areas of the mine property and mine controlled areas.

Residual Impact

The pre-mitigation significance of the impacts on biodiversity resulting from a human influx has been assessed as MINOR to MODERATE. Mitigation measures are presented to implement and enforce access control and prohibit off-road driving. These measures will improve the current protection of the biodiversity of the Gamsberg, which together with effective implementation of a BMP will change this negative impact into a positive impact of MINOR significance (*Table 9.28*). As mentioned in Section 0, this will contribute towards demonstrating an "on the ground" net gain of biodiversity values as required by the Vedanta Standard for critical habitats.

Table 9.29 Pre- and Post- Mitigation Significance: Human Influx Impacts on Biodiversity

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post–mitigation)**
Construction	**MODERATE (-ve)**	**MINOR (-ve)**
Operation	**MINOR (-ve)**	**MINOR (+ve)**
Decommissioning and Post Closure	**MINOR (-ve)**	**MINOR (+ve)**

9.4 SUMMARY OF BIODIVERSITY IMPACTS

9.4.1 Cumulative Impacts on Biodiversity

The loss and degradation of habitats resulting from the mine footprint, dust deposition and groundwater drawdown have a cumulative effect on selected habitats as presented in *Table 9.12*. Additional biodiversity-related impacts may occur through surface water impacts (flow, pollution), a groundwater pollution plume and acrid rock drainage effects. Of particular concern is the irreplaceable Headwater Seep and Kloof habitat that are located within the footprint of the mine. Dust emissions and close to the lowest groundwater drawdown areas will affect the remainder of these two habitats as well as other irreplaceable habitats on the site. This cumulative impact is thus expected to result in a severe loss of habitat and ecosystem function within the mine site.

Cumulative impacts on the biodiversity beyond the borders of the Project area could occur from habitat fragmentation. BMM have an existing mine in the adjacent concession where habitat loss and fragmentation effects will similarly interrupt the movement of species. The influx of people to the area will increase as a result of both mining operations and similarly represents a cumulative impact.

Renewable energy projects, current (and possibly increased) livestock grazing in the area and the broad effects of climate change will contribute cumulative impacts on the high biodiversity of the Bushmanland Inselberg Region and the greater biome.

9.4.2 *Residual Negative Impacts and Potential for Offsets*

Ecologically sustainable development is enshrined in South Africa's Constitution and laws. The need to conserve biodiversity is directly or indirectly referred to in a number of Acts, not least the NEMA, which is fundamental to the notion of sustainable development. The Act requires that impacts on biodiversity and ecological integrity are avoided, and if they cannot altogether be avoided, are minimised and remedied.

All currently available guidelines within South Africa (1) (2) (3) as well at the IFC Performance Standard 6 emphasise that biodiversity offsets represent a last resort in the mitigation hierarchy and are an option to be pursued only when significant residual impacts on biodiversity remain after all other options (ie avoidance, minimisation and rehabilitation) have been thoroughly explored.

Biodiversity offsets are applicable where the residual impacts on biodiversity are assessed by a competent specialist to be of moderate to high significance, but are not usually applied to situations with a residual impact of low significance. The biodiversity loss cannot be offset where the residual impact is assessed as very high. (4)

An overview of the residual impacts on biodiversity is presented in *Table 9.29*. Three impacts are identified where a biodiversity offset would be appropriate

(1) Western Cape Guidelines (2011).
(2) Draft KZN Guidelines (2009).
(3) SAMBF (2012).
(4) Western Cape Guidelines (2011).

through a like-for-like based approach. Only two impacts can be adequately mitigated to a level that offsetting is not required.

The combination of impacts leading to habitat loss cannot be adequately mitigated, and remain with high residual impacts; ie impacts from the mine footprint, dust and groundwater drawdown. Uncertainties exist around the significance of the dust impacts. A conservative approach has been followed in the assessment of that impact, and an adaptive management style will need to be adopted.

Table 9.30 Overview of the Pre-mitigation and Residual Significance of Impacts on Biodiversity of the Gamsberg

Impact on Biodiversity	Pre-mitigation Significance	Residual Significance	Offset required
Habitat loss caused by the mine footprint.	**MAJOR(-ve)**	**MODERATE (-ve) to MAJOR (-ve)**	Yes
Habitat degradation from dust deposition (Low confidence).	**MAJOR (-ve) (high uncertainty)**	**MAJOR (-ve) (high uncertainty)**	Yes
Habitat degradation from groundwater drawdown.	**MAJOR (-ve)**	**MAJOR (-ve)**	Yes
Habitat fragmentation.	**MAJOR (-ve)**	**MODERATE (-ve)**	Yes
Loss of species diversity.	**MAJOR (-ve)**	**MODERATE (-ve)**	Yes
Encroachment of alien species.	**MODERATE (-ve)**	**NEGLIGIBLE (-ve)**	No
Human influx impacts on biodiversity.	**MINOR (-ve)**	**MINOR (+ve)**	No

Options for offsetting of these impacts need to be explored, however the impacts involve some loss of irreplaceable habitat. It is not possible to offset impacts on biodiversity that are of 'very high' significance; the loss of 'irreplaceable' biodiversity generally implies that impacts would not be 'offsetable' since no measure could effectively compensate that loss. The only option in this case is to provide an alternative form of compensation or positive contribution to conservation (as opposed to an offset). Opportunities for offsetting are available, are discussed in *Section 13*. The practicalities of acquiring land in South Africa require that predefined farms are purchased and non-target land is thus likely to be included. Opportunities for non-target land to accommodate the uncertain "dust offset" should be explored. The full extent of the dust offset may not be required based on the outcomes of monitoring programmes, but would only be apparent after the mine operational phase is established. Offsetting options will need to be finalised prior to establishment of the mine, however offsetting of the dust impacts should be considered necessary until the uncertainty is removed.

The dust impacts result in degradation of habitats and not necessarily total loss of habitat. The estimated extent of the loss of sensitive habitats is presented in *Table 9.30*.

Table 9.31 Estimation of Areas of Habitat Loss and Degradation

Habitat Sensitivity	Extent of Habitat Loss / degradation (ha)
Irreplaceable (critical) habitat.	1 186
Constrained (natural) habitat.	1 044
Flexible (natural) habitat.	4 627
TOTAL AREA (ha)	**6 857**

It is not possible to compensate the loss of some habitats as they're irreplaceable and there is insufficient remaining 'like' habitat to provide compensation that would prevent undermining of conservation targets.

The impact of habitat fragmentation can also only be partially offset as this impact relates to disruption of a regional biodiversity corridor that cannot be precisely quantified or ascribed to the discrete management unit of the Gamsberg Mine. The impact could only be quantified in terms of dimensions of that corridor in current systematic conservation plans, and alleviated through seeking a substitute corridor incorporating remaining inselbergs that could be protected in perpetuity.

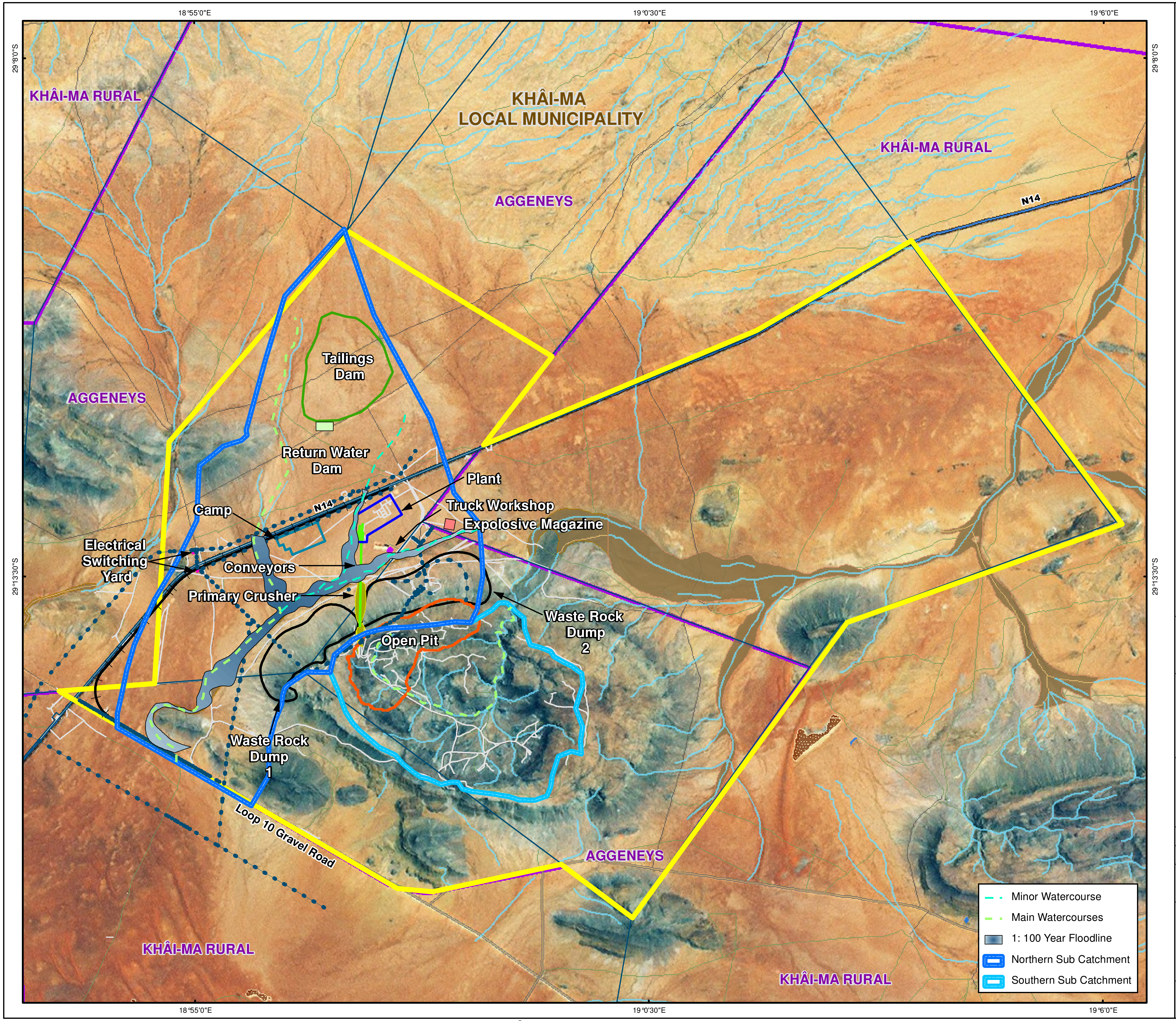
As mentioned above, an offset is accepted as a last resort mitigation measure, and therefore does not alleviate the necessity of applying previously mentioned mitigation measures to avoid, minimise or rehabilitate impacts within the Gamsberg and neighbouring areas.

9.5 IMPACT ON SURFACE HYDROLOGY

This section provides a description of the potential impacts the Project may have on surface water hydrology. The key receptors or resources considered are all affected sub-catchments and watercourses.

9.5.1 Removal and Alteration of Natural Water Courses

Figure 9.10 illustrates the Project layout in relation to sub-catchment boundaries, project infrastructure, on-site watercourses and associated floodlines.



Legend

- Non-Perennial River
- Dry Water Course Centre Line
- Dry Water Course Floodplain
- Dam
- Dry Pan
- National Route (N14)
- Main Road
- Secondary Road
- Other Road
- Track/Footpath
- Railway
- Electrical cables
- Haul Roads
- Main Watercourses
- Minor Watercourse
- Northern Sub Catchment
- Southern Sub Catchment
- 1: 100 Year Floodline
- Town Boundary
- Cadastral Boundaries
- Open Pit
- Contractors Camp
- Conveyor
- Electrical Switching Yard
- Explosive Magazine
- Plant
- Primary Crusher
- Return Water Dam
- Tailings Dam
- Truck Workshop
- Waste Rock Dump 1
- Waste Rock Dump 2
- Mineral Rights Area

SCALE:

0 1 2 3 4

Kilometres

N

TITLE:

Figure 9.10: Proposed Project layout in relation to sub-catchment boundaries, project infrastructure and watercourses and associated floodlines

CLIENT:

vedanta

BLACK MOUNTAIN MINING (PTY) LTD

DATE: Apr 2013	CHECKED: MP	PROJECT: 0164903
DRAWN: AB	APPROVED: SHC	SCALE: 1 : 70 000

DRAWING: Hydrology.mxd

REV: 0

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
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Projection: Transverse Mecator, CM19. Datum : WGS84
Source: Chief Directorate National Geo-Spatial Information. Black Mountain Mining (Pty) LTD
Inset Map: Esri Data & Maps

SIZE: A3

T:\Gis Projects\0164903_Gamsberg\Mapping\MXD\Report\April2013\Hydrology.mxd

The section below provides an assessment of the extent to which natural river courses within the Project area will need to be altered or removed as a result of the construction of project infrastructure and facilities.

Table 9.32 Impact Characteristics: Impact of the Removal and Alteration of Natural Water Courses on Catchment Response

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	Construction of the following infrastructure and/or facilities: • The open pit; • The explosives magazine; • The process plant; and • The truck workshop.	N/A	N/A
Impact Type	Direct.	N/A	N/A
Stakeholders/ Receptors Affected	Affected ephemeral river courses. Downstream users. Fauna and flora that use the affected water courses. Groundwater.	N/A	N/A

Construction Phase Impacts

As the proposed layout of the open pit covers a significant portion of the southern catchment, it is inevitable that certain existing water courses that collect and convey surface water runoff from the western section of this catchment would be removed or altered. In this regard, certain of the minor water courses in this sub-catchment would be permanently removed by the development of the open pit, while the longest collector, which governs catchment response, would be curtailed (refer to *Figure 9.10*). Despite this, the circular shape of this catchment, its mountainous character and the number of ephemeral watercourses present, means that the construction of the pit is only expected to result in a marginal change over time to its concentration and other catchment characteristics. In this regard, a comparison between baseline and post-development catchment characteristics demonstrates that the post-mitigation hydrological response of the southern catchment is similar to that of the baseline scenario (refer to *Table 9.32*). As such, the anticipated decrease in time of concentration is expected to be negligible.

Table 9.33 A comparison Between Baseline and Projected Post-development Catchment Characteristics

Sub-Catchment	A_e (km²)	L (km)	L_C (km)	S_L (m/m)	S_A (m/m)	T_C (h)	T_L (h)
Baseline catchment characteristics							
North	38.7	11.0	6.5	0.0075	0.0155	4.6	2.1
South	13.1	6.4	3.1	0.0198	0.1172	1.8	1.1
Post-development catchment characteristics							
North	35.4	11.0	6.5	0.0075	0.0155	4.6	2.1
South	9.0	5.3	2.8	0.0236	0.1172	1.7	1.0

Notwithstanding the above, the proposed explosives magazine, which covers a large area on the north-eastern plateau of the inselberg, would also affect several minor watercourses in the southern catchment. With respect to this, the proposed footprint of this facility measures roughly 320 m² and transects three watercourses. However, it is predicted that these watercourses could be maintained in their current location if suitable culverts are installed. In this regard, the culverts would convey surface water beneath the explosives magazine along its natural routes.

Finally, ephemeral watercourses in the northern catchment area would not require removal or alteration; however the proposed location for the processing plant and the truck workshop (the plain to the north of the inselberg) protrudes into the 100 year floodplain. These facilities will need to be reconfigured or relocated such that they fall outside of the floodplain.

Impact Assessment and Description

The construction of the above mentioned facilities and infrastructure will have a **direct negative** impact on affected natural water courses. The impact will be **irreplaceable**, as some of the minor water courses will be removed permanently. The extent of the impact is **on-site**, as only drainage lines within the Project area will be impacted upon. The expected impact will be **permanent** (ie irreversible) and will result in **notable** changes to the receptor (ie affected ephemeral river courses.). In light of this assessment, the significance of this impact is considered to be **Moderate** during the construction phase of the Project. Furthermore, the degree of confidence in this assessment is **High**.

Box 9.19 ***Summary of Construction Impact: Impact of the Removal and Alteration of Natural Water Courses on Catchment Response***

Nature: The construction of the above mentioned facilities and infrastructure will have a **direct negative** impact on affected natural water courses.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low.**
Irreplaceability: The impact will be **irreplaceable**, as some of the minor water courses will be removed permanently.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **on-site**, as only rivers within the Project area will be impacted upon.
Duration: The expected impact will be **permanent** (ie irreversible).
Scale: The impact will result in **notable** changes to the receptor (ie affected ephemeral river courses.)
Frequency: The frequency of the impact will be **once-off.**
Likelihood: The likelihood of the impact occurring is **definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE.**

Degree of Confidence: The degree of confidence is **high**.

Construction Phase Mitigation

- The compromise setback line, as discussed in *Section 4.6.4* will be implemented to limit impacts to the western catchment area of the kloof.
- The explosives magazine on the eastern plateau will be repositioned away from the existing natural watercourses, east of the plant on the plains.
- A detailed stormwater management plan will be produced at preliminary design stage to ensure hydraulic performance and environmental functionality.
- Revised flood levels and flood lines should be calculated for all main water courses, both natural and man-made, once the layout of the Project has been finalised. This information would be used to determine floodplain boundaries and define ecological buffer zones.

Operational Phase Impacts

No new infrastructure will be constructed during the operation phase of the Project. As such, the removal and alteration of natural water courses is not expected. No further assessment is thus required.

Operational Phase Mitigation

The water quality of drainage lines and the proposed canals should be monitored on a monthly basis as described in the operational management plan.

Decommissioning and Post Closure Phase Impacts

No new infrastructure will be constructed after the operation phase of the proposed Project. As such, the removal and alteration of natural water courses is not expected. No further assessment is thus required.

Decommissioning and Post Closure Phase Mitigation

The water quality of drainage lines and the proposed canals should be monitored on a regular basis.

Residual Impact

With the implementation of the above mitigation, impact intensity and magnitude will be reduced in the southern catchment during the construction phase. The impact significance would accordingly reduce to **MINOR**. The degree of confidence in this assessment is **HIGH**.

Table 9.34 Pre- and Post- Mitigation Significance: Removal and Alteration of Natural Water Courses

Phase	**Significance (Pre-mitigation)**	**Residual Significance (Post–mitigation)**
Construction	**MODERATE (-ve)**	**MINOR (-ve)**
Operation	**N/A**	**N/A**
Decommissioning and Post Closure	**N/A**	**N/A**

9.5.2 *Impact of Reduced Peak Runoff and Discharge Volumes on Water Courses*

This section assesses the extent to which post-development peak runoff flows and discharge volumes will be altered as a result of the Project.

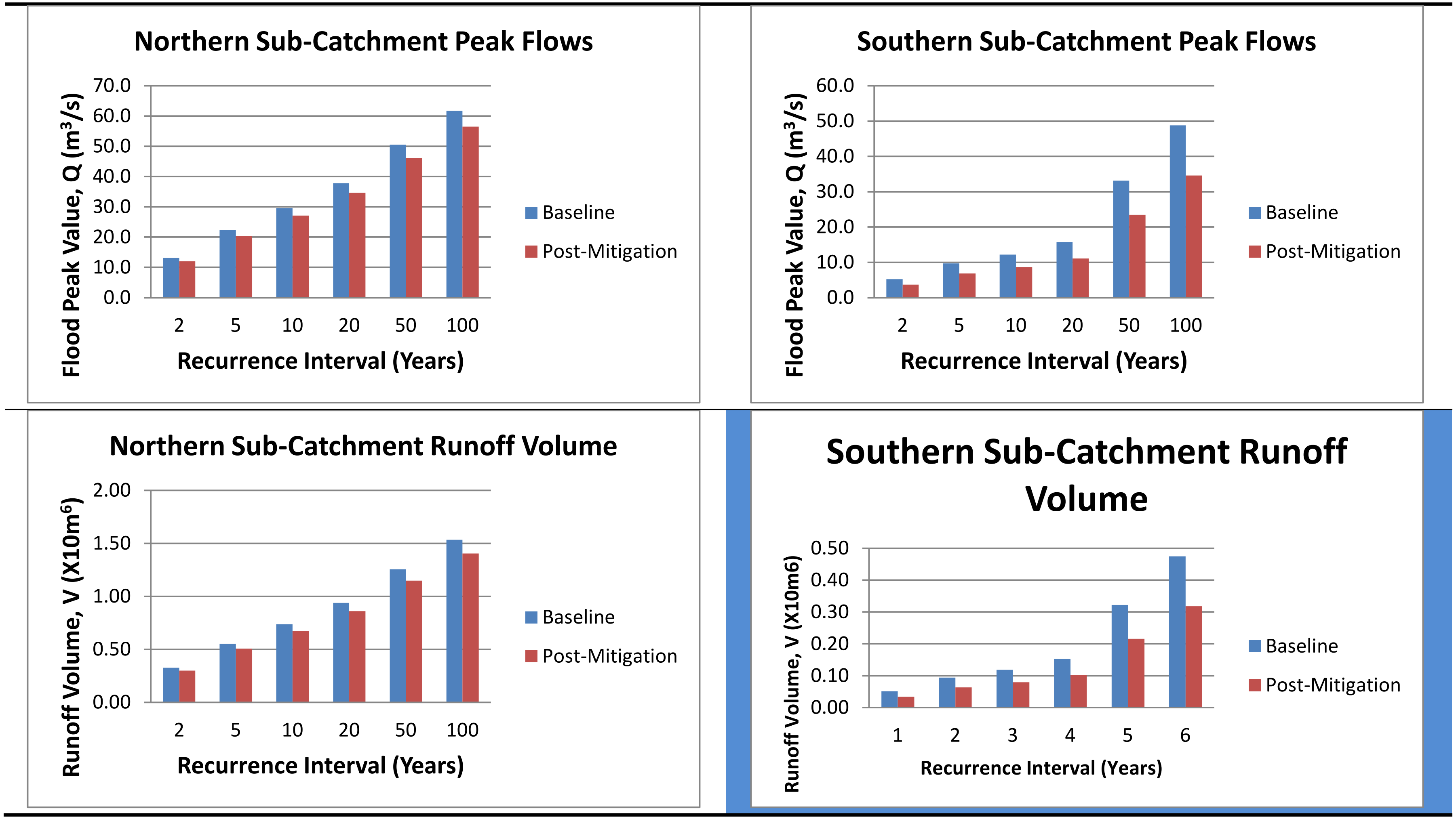
Table 9.35 Impact Characteristics: Impact of Reduced Peak Runoff and Discharge Volumes on Water Courses

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	Project facilities and infrastructure that capture rainfall (ie dams).	Project facilities and infrastructure that capture rainfall (ie dams).	Project facilities and infrastructure that capture rainfall (ie dams).
Impact Type	Direct.	Direct.	Direct.
Stakeholders/ Receptors Affected	Adjacent landowners. Fauna and flora in close proximity to the Project site. Groundwater.	Adjacent landowners. Fauna and flora in close proximity to the Project site. Groundwater.	Adjacent landowners. Fauna and flora in close proximity to the Project site. Groundwater.

Construction, Operation and Decommissioning Phase Impacts

The Project will require the excavation of a large open pit and the construction of a tailings dam, pollution control dams, process plant and other ancillary infrastructure. Being classified as 'dirty' areas, rain falling onto this infrastructure will be captured and contained. Consequently, the quantum of surface water runoff would reduce. Post-development storm peak flows and volumes have been calculated and compared to baseline values, as can be seen in *Table 9.35* below. Here it is evident that post-development storm peak flows and volumes have reduced in relation to existing baseline values. Furthermore, it is clear that the northern sub-catchment is not as severely impacted than the southern sub-catchment, and a comparison between the baseline and post-mitigation values reveal an average net decrease of roughly 8.5% in both peak flow and volume. The expected decrease in peak flow and volume is approximately 30% for the southern sub-catchment.

Table 9.36 Comparison Between Baseline and Post Development Storm Peak Flows and Volumes



Impact Assessment and Description

In summary, the calculated reduction in peak runoff and discharge volumes is viewed as a **direct positive** impact as the risk of damage to downstream communities, property, operations or infrastructure would be reduced. However, it is important to note that the concomitant reduction in mean annual runoff (MAR), is considered a **direct negative** impact and is presented in *Section 9.5.3* below.

The impact will be **irreplaceable**, as some of the minor water courses will be removed permanently. The extent of the impact is **local**, as the impact may extend just beyond the site boundaries. The expected impact will be **permanent** (ie irreversible) and will result in **notable** changes to the receptor (ie adjacent landowners). In light of this assessment, the significance of this impact therefore considered to be **Moderate** during all phases of the Project. The degree of confidence in this assessment is **Medium**.

Box 9.20 Summary of Operation Impact: Impact of Reduced peak Runoff and Discharge Volumes

Nature: The calculated reduction in peak runoff and discharge volumes is viewed as a **direct positive** impact as the risk of damage to downstream communities, property, operations or infrastructure would be reduced.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low.**
Irreplaceability: The impact would result in an **irreplaceable** loss of surface water resources.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **local**.
Duration: The expected impact will be **permanent** (ie irreversible).
Scale: The impact will result in **notable** changes to the receptor (ie adjacent landowners).
Frequency: The frequency of the impact will be **once-off.**
Likelihood: It is **likely** that the impact will occur.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE.**

Degree of Confidence: The degree of confidence is **medium**.

Construction, Operation and Decommissioning Phase Mitigation

No mitigating measures proposed.

Residual Impact

It is unlikely that the ineffective areas giving rise to the reduction in flood peaks would be removed in the closure phase. Consequently, the residual impact is **MODERATE**. The degree of confidence in this assessment is **MEDIUM**.

Table 9.37 Pre- and Post- Mitigation Significance: Impact of Reduced Peak Runoff and Discharge Volumes on Water Courses

Phase	Significance (Pre-mitigation)	Residual Significance (Post–mitigation)
Construction	MODERATE (+ve)	MODERATE (+ve)
Operation	MODERATE (+ve)	MODERATE (+ve)
Decommissioning and Post Closure	MODERATE (+ve)	MODERATE (+ve)

9.5.3 *Impact of Reduction in Mean Annual Runoff*

This section assesses the extent to which the Project is expected to result in the reduction of mean annual runoff (MAR).

Table 9.38 Impact Characteristics: Impact of Reduction In mean Annual Runoff (MAR)

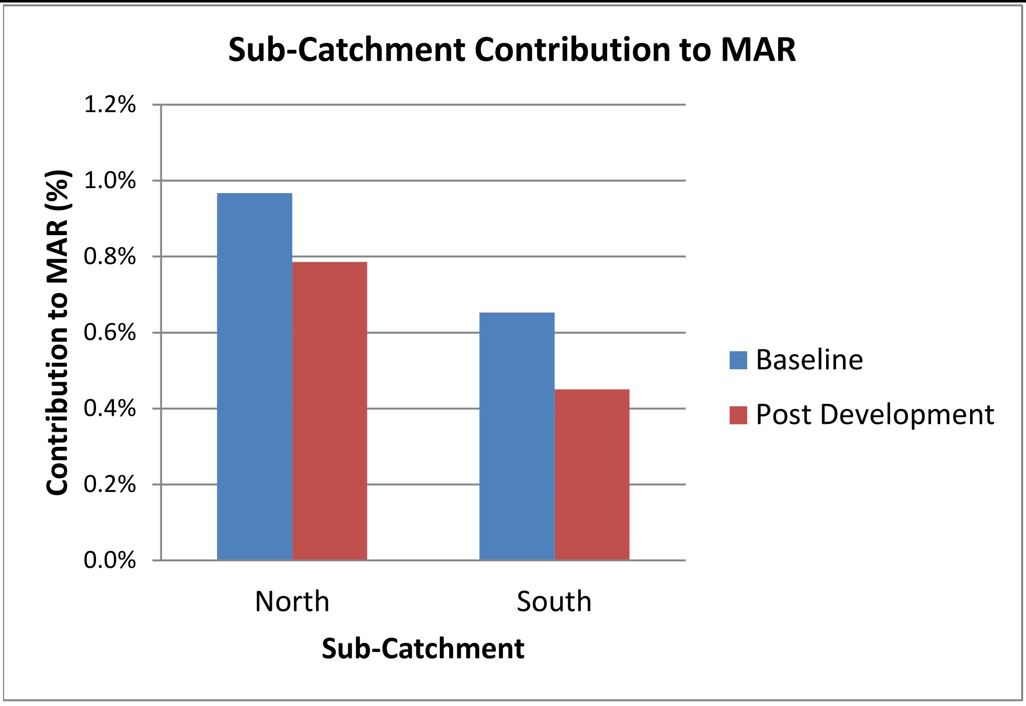
Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Project facilities and infrastructure that capture rainfall (ie dams).	Project facilities and infrastructure that capture rainfall (ie dams).	Project facilities and infrastructure that capture rainfall (ie dams).
Impact Type	Direct.	Direct.	Direct.
Stakeholders/ Receptors Affected	Ephemeral ecosystems within the affected quaternary catchment.	Ephemeral ecosystems within the affected quaternary catchment.	Ephemeral ecosystems within the affected quaternary catchment.

Construction, Operation and Decommissioning Phase Impacts

As discussed in the previous section, the Project will require the excavation of a large open pit and the construction of a tailings dam, pollution control dams, process plant and other ancillary infrastructure. Being classified as 'dirty' areas, rain falling onto this infrastructure will be captured and contained. Consequently, the quantum of surface water runoff will be reduced. Whereas the resultant reduction in peak runoff and discharge volumes, which corresponds to large storm events, is seen as a positive impact (refer to section above), the resultant reduction in marginal annual runoff (MAR) is instead considered as a negative impact. The reason for this apparent contradiction is that smaller storm events generally have a natural, restorative function in ephemeral ecosystems. While large storm events, can often be more destructive in nature.

The total reduction in MAR can either be viewed in terms of the greater quaternary catchment or assessed at the local sub-catchment level. In this regard the resultant MAR reduction in the quaternary catchment is predicted at approximately 0.2% (refer to *Box 9.22*), which is considered to be negligible. However, at the sub-catchment level future MAR is expected to reduce by 8% in the case of the northern sub-catchment, and 31% for the southern sub-catchment (refer to *Table 9.38*). The latter represents the sensitive Inselberg kloof.

Box 9.21 Comparison between Baseline and Post-Development Contribution to MAR



Post-development MAR would be 4,050 m³ per annum if surface runoff from the north-western ridge is allowed to enter the pit. This quantity of surface water would exit via the kloof. This implies that an estimated 1,820 m³ of surface water would enter the pit annually. Should surface runoff from the north-western ridge be diverted away from the pit towards the kloof, the post-development MAR leaving the Inselberg catchment via the kloof would be approximately 4,520 m³ per annum. This would represent a 23% reduction in sub-catchment MAR, but only a 0.2% reduction in quaternary catchment MAR. Surface water entering the pit annually would amount to roughly 1,350 m³.

Technically it would be very difficult to divert surface water runoff from the north-western ridge towards the kloof without causing extensive ecological damage to that part of the sub-catchment. This risk of damage would negate any benefits this intervention may hope to achieve. Accordingly, it would be preferable for this small area to be allowed to enter the pit. The above findings verify that there certainly would be no noticeable impact on the larger quaternary catchment. Similarly, the local impact on the kloof would be only marginally worse (ie 31% reduction in MAR as opposed to 23%).

Table 9.39 Anticipated Post-Development Reduction in MAR

Sub-Catchment	Post-Development Sub-Catchment MAR (X10³ m³)	Reduction in Sub-Catchment MAR (%)	Sub-Catchment Contribution to MAR (%)
North	7.09	8%	0.2%
South	4.05	31%	0.2%

The 31% calculated reduction of MAR in the southern sub-catchment will cause irreversible change to the Inselberg kloof, as aquatic biota and reliant flora will receive less than three quarters of their current allotment of surface water flow.

Impact Assessment and Description

The calculated reduction in MAR is viewed as having a **direct negative** impact particularly on affected ephemeral ecosystems. The impact will be **irreplaceable**, as it is unlikely that the ineffective areas giving rise to the reduction in MAR would be removed in the closure phase. The extent of the impact is **local**, as the impact may extend just beyond the site boundaries. The expected impact will be **permanent** (ie irreversible) and will result in **notable** changes to the receptor. In light of this assessment, the significance of this impact therefore considered to be **MODERATE** during all phases of the Project. The degree of confidence in this assessment is **High**.

Box 9.22 Summary of Operation Impact: Impact of reduction in mean annual runoff (MAR)

Nature: The calculated reduction in MAR is viewed as having a **direct negative** impact on affected ephemeral ecosystems within the inselberg kloof area.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium.**
Irreplaceability: The impact would result in an **irreplaceable** loss of surfacewater resources.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **local**.
Duration: The expected impact will be **permanent** (ie irreversible).
Scale: The impact will result in **notable** changes to the receptor (ie ephemeral ecosystems within the inselberg kloof area).
Frequency: The frequency of the impact will be **periodic.**
Likelihood: The likelihood of the impact occurring is **definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE.**

Degree of Confidence: The degree of confidence is **High**.

Construction, Operation and Decommissioning Phase Mitigation

It is not viable to relocated the pit although the incorporation of a setback line reducing the extent of the pit has been accepted as a project adaptation, which may reduce this impact.
An alternative suggestion could be to supply piped fresh water of similar quantity and quality to the kloof watercourse. This water would replace the lost MAR and provide artificial replenishment. However, groundwater investigations indicate that these features depend on baseflow seepage from groundwater and artificial replenishment would not replace the groundwater resource.

Residual Impact

The implementation of the setback line would reduce the impact on MAR. Accordingly, the impact significance on local downstream water resources could be classified as **MINOR** during the all phases of the Project. The degree of confidence in this assessment is **HIGH**.

Table 9.40 Pre- and Post- Mitigation Significance: Impact of Reduction in Mean Annual Runoff

Phase	Significance (Pre-mitigation)	Residual Significance (Post–mitigation)
Construction	**MODERATE (-ve)**	**MINOR (-ve)**
Operation	**MODERATE (-ve)**	**MINOR (-ve)**
Decommissioning and Post Closure	**MODERATE (-ve)**	**MINOR (-ve)**

9.5.4 *Impact of Increased Sediment Yield on Surface Water Quality*

This section assesses the extent to which Project activities are expected to result in increased sediment yield and the impact that this may have on affected receptors (ie ephemeral rivers within the Project site).

Table 9.41 Impact Characteristics: Impact of Increased Sediment Yield on Surface Water Quality

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Removal of vegetation and the stripping of topsoil.	The use of haul roads, and general operation activities such as blasting, loading and hauling.	Removal of vegetation and the stripping of topsoil.
Impact Type	Direct.	Direct.	Direct.
Stakeholders/ Receptors Affected	Local soils. Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.	Local soils. Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.	Local soils. Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.

Construction, Operation and Decommissioning Phase Impacts

Given the erosion potential of the local soils, it is likely that the construction and operational phases of the proposed development would cause an increase in erosion. Thus an increase in sediment deposition could be expected along slow moving water courses. In order to limit the environmental impact on faunal and floral communities, it is essential that sediment yield be reduced as far as is possible.

Notwithstanding the arid, sparsely planted terrain, the proposed mine infrastructure would require removal of vegetation and the stripping of topsoil. This would increase the erosion potential of the sub-catchments and subsequently result in increased sediment deposition in water courses. Furthermore, the construction of haul roads, and general mining activities such as blasting, loading and hauling would increase the quantity of airborne dust. This dust would settle on the ground surface where it would present an additional source of sediment during rain events.

Impact Assessment and Description

The calculated increase in sediment yield is expected to have a **direct negative** impact on the water quality of nearby surface water bodies. The extent of the impact is **local**, as it is expected to extend just beyond the boundaries of the Project site. The expected impact will be **long-term** as it will last for the entire Project lifespan (ie Life of Mine is expected to be approximately 20 years). The impact will result in **notable changes** to the receptor (ie ephemeral ecosystems). The frequency of the impact will be **periodic**. In light of this assessment, the significance of this impact therefore considered to be **MODERATE** during all phases of the Project. The degree of confidence in this assessment is **High**.

Box 9.23 Summary of Operation Impact: Impact of Increased Sediment Yield on Surface Water Quality

Nature: The calculated increase in sediment yield is expected to have a **direct negative** impact on the water quality of nearby surface water bodies.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium.**
Irreplaceability: The impact will not result in loss of an **irreplaceable** resource.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **local,** as it is expected to extend just beyond the boundaries of the Project site.
Duration: The expected impact will be **long-term** as it will last for the entire Project (ie Life of Mine is expected to be approximately 20 years).
Scale: The impact will result in **notable** changes to the receptor.
Frequency: The frequency of the impact will be **periodic.**
Likelihood: The likelihood of the impact occurring is **definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE.**

Degree of Confidence: The degree of confidence is **High**.

Construction, Operation and Decommissioning Phase Mitigation

- Pollution control dams should be constructed to contain surface water runoff from all dirty areas, such as waste rock stockpiles. Dirty runoff should be directed towards these dams though a well-designed system of berms and channels. The dams should be designed to accommodate and retain transported sediment. It is therefore important that dams are designed to have adequate dead storage volume.

- The runoff from bare areas, such as haul roads, would need to be collected and conveyed by adequate side drains. This water, which would be high in TSS content, should be attenuated and retained sufficiently to allow sediment to settle prior to the discharge of the sufficiently clean supernatant.

- Dust mitigation should be implemented in accordance with the air quality impact assessment forming part of this ESIA.

- The quality of runoff in watercourses should be monitored on a regular basis depending on flow and corrective actions taken as appropriate.

- During the decommissioning phase, all unnecessary bare surfaces and developed zones should be removed and, as far as is possible, restored to their natural state.

Residual Impact

Should the above mitigation measure be accepted, the anticipated decrease in water quality attributable to increased sediment load could be greatly reduced. Accordingly, the impact significance on local downstream water resources could be classified as **MINOR** during the all phases of the project. The degree of confidence in this assessment is **HIGH**.

Table 9.42 Pre- and Post- Mitigation Significance: Impact of Reduction in Mean Annual Runoff

Phase	Significance (Pre-mitigation)	Residual Significance (Post–mitigation)
Construction	**MODERATE (-ve)**	**MINOR (-ve)**
Operation	**MODERATE (-ve)**	**MINOR (-ve)**
Decommissioning and Post Closure	**MODERATE (-ve)**	**MINOR (-ve)**

9.5.5 Impact of Increased Pollutant Load on Surface Water Quality

This section assesses the impact associated with the expected increase in pollutant load on surface water resources as a direct result of activities undertaken during all phases of the Project.

Table 9.43 Impact Characteristics: Impact of Increased Pollutant Load on Surface Water Quality

Summary	Construction	Operation	Decommissioning/ Post Closure

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	The construction of a Waste Water Treatment Works (WWTW). Construction of mining infrastructure and facilities. Accidental spillages.	Operation of the Waste Water Treatment Works (WWTW). Operation of mining infrastructure and facilities. Accidental spillages.	Mining infrastructure. Accidental spillages.
Impact Type	Direct.	Direct.	Direct
Stakeholders/ Receptors Affected	Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.	Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.	Local fauna and flora habitats. Ephemeral ecosystems within the affected quaternary catchment.

Construction, Operation and Decommissioning Phase Impacts

The proposed construction of a Waste Water Treatment Works (WWTW) would inevitably increase the risk of surface water resources being contaminated by untreated sewerage. This contamination could be caused by insufficient maintenance of the WWTW, or as a consequence of blocked sewer mains or manholes. Furthermore, raw sewerage spillages could occur in the event of power outages affecting foul sewer pump stations or the WWTW.

By their very nature, metallurgical processes are dirty and a major source of pollutants. Whilst the proposed mining infrastructure has been classified as either "clean" or "dirty," it is imperative that surface water runoff from the dirty areas we captured and adequately treated. Wherever possible, treated water should be reused in the mining process.

Hydrocarbons, such as oils and petroleum fuels, represent a threat to surface water quality. As such, the potential impact of accidental spillages should be assessed and mitigated.

Impact Assessment and Description

The calculated increase in pollutant load is expected to have a **direct negative** impact on the water quality of nearby surface water bodies. The extent of the impact is **local,** as it is expected to extend just beyond the boundaries of the Project site. The expected impact will be **long-term** as it will last for the entire Project (ie Life of Mine is expected to be approximately 20 years). The impact will result in **notable** changes to the receptor. The frequency of the impact will be **periodic**. In light of this assessment, the significance of this impact therefore considered to be **MODERATE** during all phases of the Project. The degree of confidence in this assessment is **High**.

Box 9.24 Summary of Operation Impact: Impact of Increased Pollutant Load on Surface Water Quality

Nature: The calculated increase in pollutant load is expected to have a **direct negative** impact on the water quality of nearby surface water bodies.

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Medium.**
Irreplaceability: The impact will not result in loss of an **irreplaceable** resource.

Impact Magnitude: **Medium.**
Extent: The extent of the impact is **local,** as it is expected to extend just beyond the boundaries of the Project site.
Duration: The expected impact will be **long-term** as it will last for the entire Project (ie Life of Mine is expected to be approximately 20 years).
Scale: The impact will result in **notable** changes to the receptor (ie ephemeral ecosystems within the inselberg kloof area).
Frequency: The frequency of the impact will be **periodic.**
Likelihood: The likelihood of the impact occurring is **definite**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **MODERATE.**

Degree of Confidence: The degree of confidence is **High**.

Construction, Operation and Decommissioning Phase Mitigation

- A thorough, regular inspection and maintenance regime should be implemented by the operator of the proposed Waste Water Treatment Works (WWTW).
- Pump stations should be inspected, serviced and cleaned on a monthly basis, and manholes and underground pipes inspected and cleaned every six months.
- The WWTW and all sewer pump stations should be equipped with emergency generators, or adequate emergency storage. Typically, four hours' storage should suffice.
- An emergency response unit should be established to undertake urgent maintenance and repair work after hours.
- It is imperative that surface water runoff from the dirty areas (*eg* process plant, waste rock stockpiles, tailings dam) be captured and wherever possible, reused in the mining process. Pollution control dams should be deployed as indicated on Figure 3. Dirty runoff should be directed towards these dams though a well-designed system of berms and channels.
- Dirty water not used in the mining process should be adequately treated prior to release. Treatment should be undertaken in the prescribed manner, as detailed in the Operational Management Plan.

- All areas where hydrocarbons, such as oils and petroleum fuels are handled (*ie* workshops should be bunded and strictly controlled to minimise the risk of accidental spillages.

- The quality of runoff into watercourses should be monitored on a monthly basis when water is present and corrective actions taken as appropriate. Baseline water quality is described in Section 3.8 of this report.

Residual Impact

Should the above mitigation measure be accepted, the anticipated decrease in water quality attributable to increased pollutant load could be greatly reduced. Accordingly, the impact significance on local downstream water resources could be classified as **MINOR** during the all phases of the project. The degree of confidence in this assessment is **HIGH**.

Table 9.44 Pre- and Post- Mitigation Significance: Impact of Increased Pollutant Load on Surface Water Quality

Phase	Significance (Pre-mitigation)	Residual Significance (Post–mitigation)
Construction	MODERATE (-ve)	MINOR (-ve)
Operation	MODERATE (-ve)	MINOR (-ve)
Decommissioning and Post Closure	MODERATE (-ve)	MINOR (-ve)

9.6 NOISE AND VIBRATION IMPACTS

This section describes the predicted noise and vibration impacts associated with the Project determined through noise modelling. The main impacts associated with the Project include noise and vibration levels around the processing plant site, the mining pit (including blasting), the relevant overburden dumping as well as generation of additional road traffic due to the workers and processed zinc transportation to Loop 10.

Impact Assessment

The noise and vibration modelling indicated that noise levels above the daytime rural guideline level (45 dB(A)) and the night-time level (35 dB(A)) are well inside the site boundaries. This is attributed primarily to the fact that the plant and the mining pit are located at least 3 km from the site boundary, as well as the ground formation around the pit. The expected noise level increase anticipated above the rural district guideline of 45 dB(A) for daytime and 35 dB(A) for night-time can be seen in *Figure 9.11* and *Figure 9.12* respectively.

Figure 9.11 Noise Level Differences of the Project Minus Existing Day-time

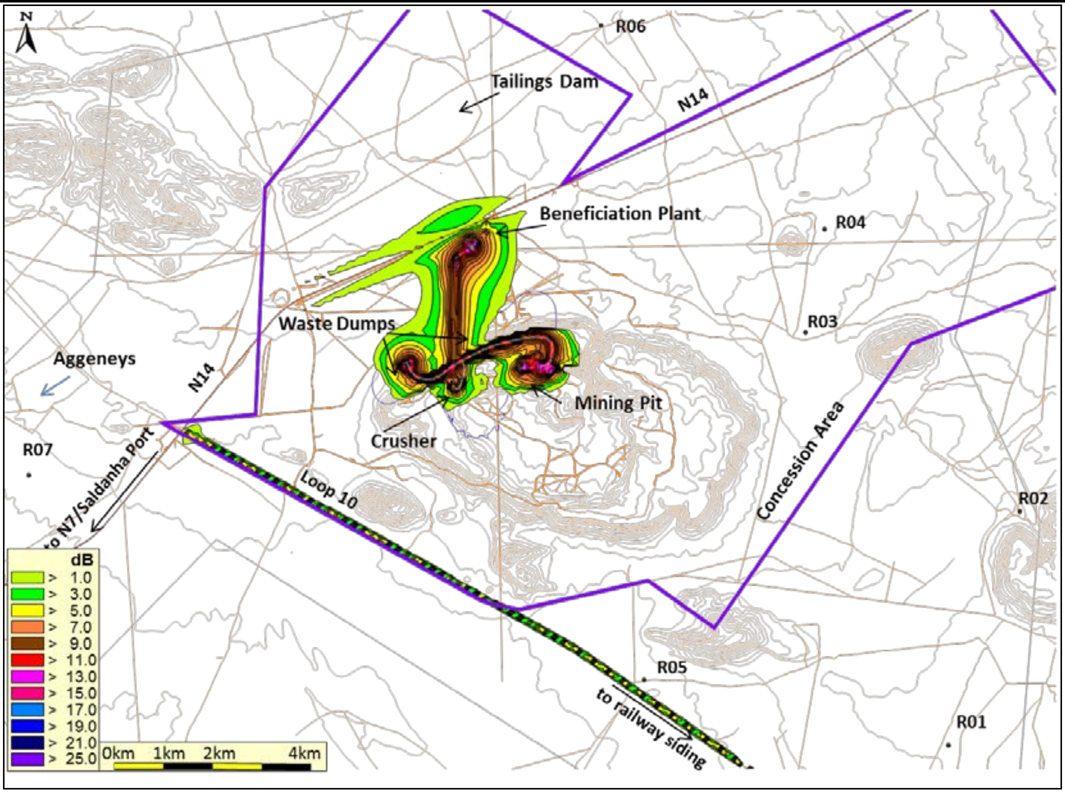
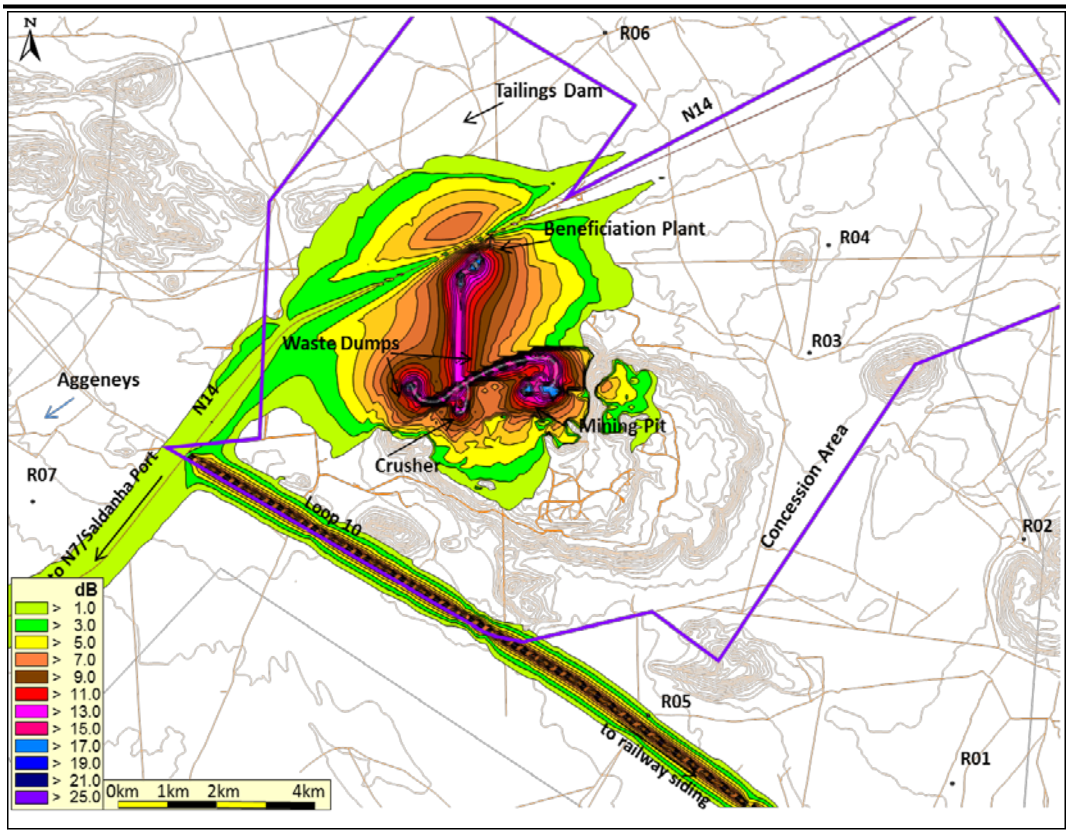


Figure 9.12 Noise Level Differences of the Project Minus Existing Night-time



During daytime the expected 3 dB(A) increase above the 45 dB(A) level will not reach any of the mine licence area boundaries, and is well away the farm houses around the mine and the town of Aggeneys. The noise increase due to Project operation beyond a 1km zone will be below 1 dB for the daytime. During night-time a 3 dB noise increase is expected to reach 2.5 km around the plant. There are no sensitive receptors within these zones.

The Project will introduce additional vehicles on the N14 and Loop 10 roads. The noise impact of this additional traffic will be minor, since the daytime noise level increase from the existing situation and the 45 dB(A) guideline will be below 1 dB(A) along the N14 road (see *Figure 9.13*). The night-time increase above the 35 dB(A) guideline is expected to be approximately 1 dB(A) within a 500 m zone (see *Figure 9.14*).

Figure 9.13 Future Day-time Noise Contours around the Project

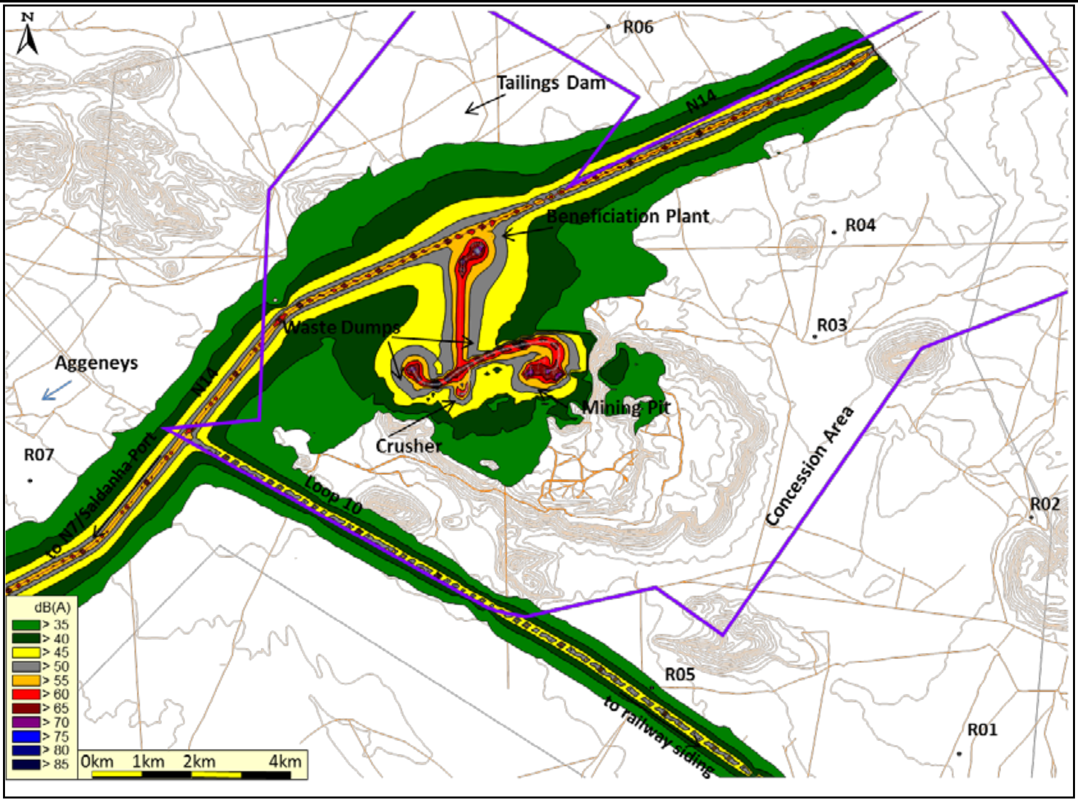
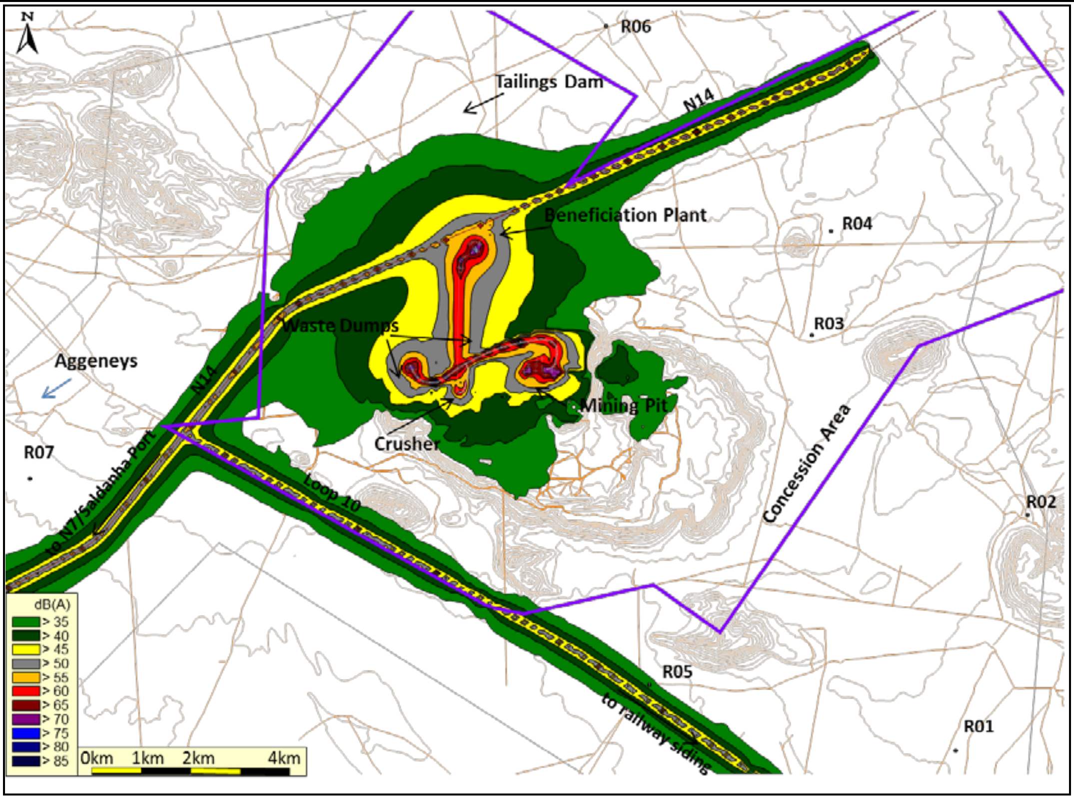


Figure 9.14 Future Night-time Noise Contours around the Project



Around Loop 10 the daytime increase above 45 dB(A) will be below one beyond a 100 m zone around the road. The night-time noise level increase above the rural guideline of 35 dB(A) will reach 3 dB within 300 m from the road. Around Loop 10 there are very few scattered farm houses, with most of them situated at more than 600 m from the road.

9.6.2 *Noise and Vibration Impact*

The noise and vibration impacts associated with the Project are discussed below.

Table 9.45 Impact Characteristics: Noise and Vibration Impact

Summary	Construction	Operation	Decommissioning/ Post Closure
Project Aspect/ activity	Noise and vibration generation through site clearance, road upgrade and establishment of the camp, laydown and assembly areas.	Mining operations, including drilling, blasting, hauling, crushing and ore processing.	The removal of operational infrastructure, equipment and waste management of hazardous substances.
Impact Type	Direct.	Direct.	Direct.
Stakeholders/ Receptors Affected	Noise levels and sensitive receptors.	Noise levels and sensitive receptors.	Noise levels and sensitive receptors.

Construction

The construction activities at receptors outside a 1,000 m zone from the main working area will be noticeable but will not constitute a disturbing noise. For receptors located at greater distances than a 1.5 km radius, the construction noise will be barely audible. Since the closest receptor is more than 5 km away this impact is expected to be Negligible.

The vibration during the site construction is not considered to have a significant impact on the surrounding receptors, as the closest one has a more than 5 km separation distance from the site.

The impact rating for the construction phase are summarised in Box 9.25, below.

Box 9.265 Construction Impact: Noise and Vibration Impact

Nature: Construction activities would result in a **negative direct** impact on existing noise levels in the mining area

Sensitivity/Vulnerability/Importance of Resource/Receptor: **Low.**

Impact Magnitude: **Small.**
Extent: The extent of the impact is **local**.
Duration: The expected impact will be **short-term**.
Scale: The impact will not result in notable changes to the receptor.
Frequency: The frequency of the impact will be **periodic.**
Likelihood: The impact is **likely**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **NEGLIGIBLE.**

Degree of Confidence: The degree of confidence is **high**.

Mitigation

No specific mitigation measures are required during construction.

Operational Phase

The 45 dB(A) daytime and 35 dB(A) night-time noise levels will be primarily contained within the mine licence area and these levels will not be exceeded in any of the scattered farm houses around the mine nor in Aggeneys. The exception is the unoccupied farm house R05, which is situated within 300 m from the Loop 10 road.

Along the Loop 10 road, most of the scattered farm houses are located more than 500 m from the alignment, and as such the expected level contribution due to the trucks will be below 34 dB(A), which is considered to be of low significance (see *Box 9.276*).

Box 9.286 Operational Impact: Noise and Vibration Impact

<u>Nature</u>: Operational activities would result in a **negative direct** impact on noise levels in the mining area and surrounding areas, including along the Loop 10 road.

<u>Sensitivity/Vulnerability/Importance of Resource/Receptor</u>: **Low.**

<u>Impact Magnitude</u>: **Small.**
<u>Extent:</u> The extent of the impact is **local**.
<u>Duration:</u> The expected impact will be **long-term**.
<u>Scale:</u> The impact will result in **notable** changes to the receptor.
<u>Frequency:</u> The frequency of the impact will be **periodic.**
<u>Likelihood</u>: The impact is **likely**.

IMPACT SIGNIFICANCE (PRE-MITIGATION): **NEGLIGIBLE.**

<u>Degree of Confidence</u>: The degree of confidence is **high**.

Mitigation Measures

No specific mitigation measures are required.

Monitoring

Noise and vibration monitoring will be performed on an annual basis along the site boundaries and at four selected locations within the farm houses closest to the mine and the Loop 10 road.

Decommissioning

The noise impacts associated with decommissioning are anticipated to similar to construction impacts associated with activities on site and movement of vehicles.

Residual Impact

Pre-mitigation impacts were rated negligible for construction, operation and decommissioning. The pre- and post-mitigation impacts are compared in *Table 9.3* below.

Table 9.46 Pre- and Post- Mitigation Significance: Impact on Noise and Vibration

Phase	Significance (Pre-mitigation)	Residual Significance (Post-mitigation)
Construction	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Operation	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**
Decommissioning	**NEGLIGIBLE (-ve)**	**NEGLIGIBLE (-ve)**

9.7 CLIMATE CHANGE IMPACTS

ERM was commissioned to undertake a Climate Change Specialist study as part of this ESIA process to inform/identify climate change impacts associated with the Project. The study comprised of two distinct parts, including:

- a Climate Risk Assessment (CRA); and
- a Greenhouse Gas (GHG) Assessment.

While the GHG assessment aims to identify and mitigate the impacts of the Project (ie GHG emissions) on the environment, the CRA looks at the impacts of the environment (and projected climate change) on the Project. There are a number of key drivers for conducting a CRA and GHG assessment alongside an ESIA process for a new development. These include the following:

- Climate change impacts (as identified through the CRA) may have implications on the environmental performance of a Project.

- Integrating CRA input into the design and conceptual phases of the process can help improve the climate resilience of projects and can help to avoid the maladaptation of projects to climate change. Projects failing to consider climate change risks at the planning stages could face severe financial, safety and operational impacts in the future if climate change impacts bring about the damage or disruption of operations, assets, infrastructure, and energy supply.

- Conducting a CRA and GHG assessment to inform the ESIA process offers a valuable opportunity for information on climate change risks, opportunities and implications to feed into project design considerations. The earlier climate change (including the need to minimise carbon emissions) considerations can be considered, the easier and less costly it is likely to be to adapt projects to the impacts of climate change, and the lower the climate change-induced liability will be on the project.

- Projects conducting a CRA and GHG assessments are likely to be identified by stakeholders as being forward looking and responsible, bringing about reputational benefits.

The following sections provide the key findings and recommendations derived from the CRA and GHG assessment studies conducted. There is some uncertainty in the GHG estimates that have been made given the early stage of Project design. As such, it should be noted that the GHG emission sources and estimated volumes assessed herein are considered to reflect a worst-case scenario.

9.7.1 Climate Change-induced Risks on the Project

Overview

This section presents the findings of the climate risk assessment (CRA) and review of adaptation (impact mitigation) options for the Project. In this regard, the objectives of the CRA were to:

- identify the principal climate-related risks associated with the proposed Project across the timescale of the Project;

- prioritise the principal climate-related risks; and

- identify potential mitigation measures (ie climate change adaption measures [(1)]) that could reduce risk or take advantage of opportunities.

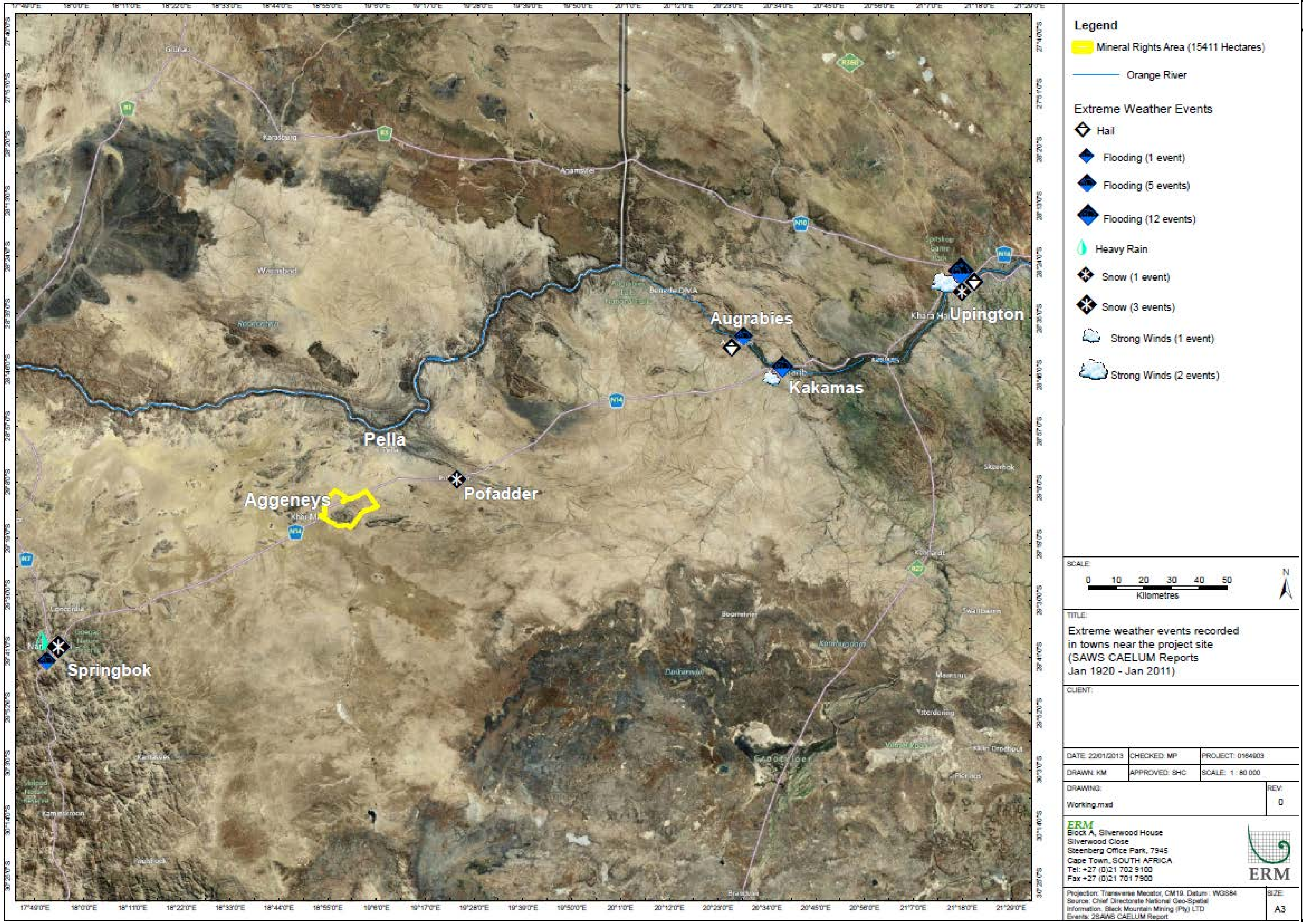
Please note that this CRA impact assessment section does not follow the standard format used in the rest of the Impact Assessment Chapter. This is owing to uncertainties that exist with regard to the accuracy of simulated climate change predictions, specifically due to the early stage of project design and that (in many cases) available information was insufficient to determine significant change to the baseline risk profile. As such, a conservative approach has been adopted and estimated values are considered to reflect worst-case scenarios.

Projected Climate Change

As mentioned in the Biophysical Receiving Environment Chapter (refer to *Chapter 5*), the climate in the Project area is typically hot and dry with limited precipitation throughout the year. There is also a low incidence of flooding and other extreme weather events in the area, particularly in close proximity to the Project area. With respect to this, most of the significant events recorded have occurred at settlements located along the banks of the Orange River (*Figure 9.15*). A full summary of the climate baseline for the Project area is provided in Section 5.

(1) Climate change adaptation in the context of capital project development can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering physical design of the Mine site or infrastructure, implementing business procedures, and altering operating patterns.

Figure 9.15 Recorded Weather Events around the Project Site (SAWS, 2011)



Year	Month	Event	Place
1920	Feb	FLOODS	Upington
1925	Mar	FLOODS	Upington
1934	Jan	FLOODS	Upington
1941	Jan	FLOODS	Kakamas
1941	Jan	FLOODS	Upington
1948	Apr	FLOODS	Upington
1953	Jul	SNOW	Springbok
1955	Feb	FLOODS	Kakamas
1957	Sep	FLOODS	Kakamas
1964	Feb	STRONG WIND	Upington
1965	Mar	STRONG WIND	Upington
1966	Jan	FLOODS	Upington
1967	Feb	FLOODS	Kakamas
1967	Feb	FLOODS	Upington
1974	Mar	FLOODS	Kakamas
1974	Mar	FLOODS	Upington
1976	Mar	FLOODS	Upington
1981	Aug	SNOW	Pofadder
1981	Aug	SNOW	Upington
1985	Dec	STRONG WIND	Kakamas
1988	Feb	FLOODS	Augrabies
1988	Feb	FLOODS	Upington
1988	Apr	FLOODS	Upington
1988	Jul	SNOW	Springbok
1991	Oct	HAIL	Augrabies
1994	Feb	FLOODS	Springbok
1994	Feb	FLOODS	Springbok
1994	Feb	FLOODS	Upington
1994	Jun	SNOW	Springbok
1996	Apr	FLOODS	Kakamas
2002	Dec	HAIL	Upington
2006	May	HEAVY RAIN	Springbok
2011	Jan	FLOODS	Upington

In terms of expected Climate Change projections, the CRA study proposes that the Project area is likely to get hotter and drier, with increasingly variable precipitation, as a result of climate change. Furthermore, flooding along the Orange River is projected to become more common given expected increases in precipitation over the River's source and catchment area.

Table 9.46 below summarises the key predicted scenarios for the Project area.

Table 9.47 Climate Baseline and Climate Change Scenarios

Climate Risk Source	Climate Change Scenario
Precipitation Intensity	Precipitation intensity unlikely to change significantly.
Average Precipitation (mm/month)	Precipitation projections for the project area are inconsistent. Average precipitation is likely to remain low. Increasing temperatures may result in increased evaporation levels, thereby reducing surface water availability.
Average Precipitation (mm/month)	Precipitation projections for the project area are inconsistent. While some sources report that at the amount of precipitation received within the project area is unlikely to change. Others, suggest that on average precipitation will increase over the summer months by 3 mm per month and will decrease over the winter months by 3.7 mm per month (The World Bank Group, 2013).
Average Air Temperature (°C)	Average air temperatures are projected to increase across all seasons, possibly leading to an increase in evaporation levels. By 2020 – 2039, average temperatures in January are projected to reach 27°C compared with a baseline of 26°C (1990 – 2009). Overall, air temperatures are expected to increase by 2.5°C over the summer months by 2070 – 2100 compared with a baseline from 1975 – 2005.
Wind Speeds (m/s)	Very minor changes in wind speed are expected, but the direction of such change is unknown (there is some model disagreement). Average annual eastward winds are projected to change by - 0.13 m/s to + 0.04 m/s by 2011 to 2030 against the baseline from 1961 to 1990 according to three different GCMs (IPCC, 2012). There is model disagreement on the direction of change for each month.
Relative Humidity (percent)	The change in relative humidity is unknown. However, an increase in temperature and reduction in precipitation could lead to a reduction in humidity.
Dry Spells	Dry spells within the proposed Project area are likely to increase in duration and occur on a more frequent basis. The median duration of dry spells for the mid-21st Century over the western and northern regions of South Africa is expected to increase between spring and autumn, compared with the period from 1961 to 1990. It is also projected that dry spells of relatively long duration may be expected to occur more frequently (SARVA, 2012).
Flooding	Flooding of the Orange River is expected to occur more frequently; however limited information is available to assess the frequency or intensity of such flooding, as well as the nature of such flash flooding episodes and how they are expected to change. Precipitation within the catchment area of the Orange River is expected to increase across all seasons and by 10 - 50 mm during spring and summer by 2046 – 2065. As a result, flooding of the lower reaches of the Orange River can be expected to occur more frequently.

Assessment of Impacts under Future Projected Climate Change Conditions

As a result of the prevailing arid climate associated with the Project area, the likelihood of identified impacts occurring and having negative consequences on the Project are generally low. This specifically relates to the degree of climate change that is expected within the timescale of the Project (ie Life of Mine of 20 years). As such, none of the future projected climate change conditions were assessed to pose major risks to the Projects viability. Despite this, there are a number of climatic changes projected that could result in disruptions to mining operations, without proper management/forward planning. Specific climatic changes that could pose some risk include the following:

- predictions of higher mean annual temperatures;
- lower mean annual rainfall;
- increases in high magnitude precipitation events (eg flooding);
- increased dry spells;
- increased evaporation; and
- stronger winds.

These are expected to impact the Project in the following manner:

<u>Higher Mean Annual Temperatures</u>

- affecting staff health (ie changes in distribution of vector-borne diseases, (such as malaria) and could lead to dehydration or heatstroke);
- reducing worker productivity; and
- reducing the efficiency of equipment.

<u>Increased Dry Spells</u>

- may threaten water security/availability and lead to water restrictions, which could lead to reduced production.

<u>Increased High Magnitude Precipitation Events</u>

- may damage the pumps on the river or result in them having to be pulled out of the river to avoid being damaged. This would lead to reduced production as a result of water abstraction capabilities being compromised.

- leading to erosion and flooding in pit and surrounding area causing disruption to operations and posing health and safety risks to workers and contractors;

- rehabilitation efforts may be hampered by an increase in the frequency and/or magnitude of heavy rainfall/flooding events (and also through slope failure).

Adaption Measures

'Climate Adaptation' in the context of capital project development can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering the physical design of the mine site or infrastructure, implementing business procedures, and altering operating patterns.

Successful adaptation will encompass a variety of physical, operational, management or strategic measures and will include a strong on-going review element, which needs to be undertaken in order to re-visit and confirm the climate science projections and assumptions that underlie the original risk assessment. A number of applicable adaptation measures (listed under relevant climate change projections) which could be implemented as part of the Project to mitigate risks associated with predicted climate change are listed below. These include:

<u>Increased Dry Spells:</u>

- Reduce, reuse and recycle water on-site.
- Install rainwater harvesting measures.
- Introduce innovative water recycling measures.
- Roll-out community-based adaptation programmes, which address issues such as improving community food security under climate change conditions (including the introduction of drought adapted farming techniques and materials), in order to improve the resilience of the community.
- Investigate alternative dust management/suppression options that do not involve the use of water.

<u>Increased Number of High Magnitude Precipitation Events/Flooding:</u>

- Erect flood protection measures around the Pella Water Board (PWB) abstraction pump station, if necessary.
- Design the PWB abstraction pumps to withstand more frequent flooding of the Orange River.
- Install early warning systems so that the PWB abstraction pumps can be protected effectively.
- Develop and implement appropriate flooding control measures.

- Vegetate slopes along Orange River to prevent slope failure during flooding events. Otherwise, implement structural measures to secure such slopes (netting etc).

- Install flood protection measures in and around the mine.

- Seek alternative access routes to utilise when normal routes are flooded.

- Undertake regular drain maintenance to reduce the flooding risks.

- Design dams in such a manner as to prevent over-flow during periods of high precipitation.

- Install flood protection measures around areas harbouring waste materials.

Increased Mean Annual Temperatures:

- Prevent working under very hot conditions.
- Ensure availability of cool drinking water for staff on-site.
- Change working hours to prevent working at the heat of the day.
- Review and adjust, if possible, the operating temperature for equipment.
- Increase maintenance schedule to prevent slow/shut downs.

9.7.2 *Impact of Project GHG Emissions on South Africa's National Emissions*

This section provides an assessment of the potential impacts associated with the Project's contribution to climate change through 'greenhouse gas' (GHG) emissions. To determine this, the operational phase carbon footprint [1] of the Project has been estimated in a Climate Change Specialist Study.

Please note that, although the construction and decommissioning phases of the Project are sources of GHG emission, at the scale at which this study was commissioned they were excluded for this Study for following reasons:

- Inherent uncertainty in emission factors around land use change;

- Inherent uncertainty and reliability on emissions from the limited Scope 1[2] and Scope 2[3] sources within these phases of the Project. The major sources of emissions during this phase would also be attributed to Scope 3[4] emission sources. These have been excluded from the Study due to the fact that there is considerable uncertainty with respect to estimating

(1) A carbon footprint is a measure of the estimated greenhouse gas emissions caused directly and indirectly by an individual, organisation, event or product.
(2) Scope 1 emissions relate to direct emissions from sources owned or under the operational control of the company.
(3) Scope 2 emissions relate to indirect emissions from the consumption of purchased electricity.
(4) Scope 3 emissions relate to indirect emissions of an optional reporting category, which allows for other indirect emissions associated but not controlled by the company to be included, such as contractor activities.

contractor activity and employee business travel. Furthermore, this data was not available at the stage of writing the report; and

- The materiality of the contribution of GHG emissions compared to the operational activities emissions over the life of the mine.

As such, this GHG emissions assessment only presents forecast estimates for Scope 1 and Scope 2 emissions for the Operational phase of the Project.

This process is also complicated further by the fact that the impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time. As such, it is not possible to link emissions from a single source (ie the Project facilities and infrastructure) to particular impacts that may occur within the broader study area. Subsequently, the GHG emissions assessment does not consider the physical impacts of climate change resulting from increased project GHG emissions, but rather the impact of the Project on South Africa's National GHG Inventory and the implications associated with this.

For a detailed overview of the methodology and approach used in calculating the Projects carbon footprint please refer to the Climate Change Specialist report in *Annex G9*.

Table 9.48 Impact Characteristics: Greenhouse Gas Emissions

Summary	**Construction**	**Operation**	**Decommissioning/ Post Closure**
Project Aspect/ activity	N/A	Emissions sources (see *Table 9.48* below).	N/A
Impact Type	Direct and indirect.	Direct and indirect.	Direct and indirect.
Stakeholders/ Receptors Affected	The impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time.	The impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time.	The impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time.

Operational Phase Impacts

Project Emission Sources

Table 9.48 below summarises the key emission sources that will be present on site during the operational phase of the Project. These emission sources are all included in calculations to determine the operational carbon footprint associated with the Project.

Table 9.49 Summary of Key Emission Sources

Emission category	**Emission Source**
Mobile combustion	• Fuel used in vehicles including cars, buses etc. • Fuel used in mobile equipment.

Emission category	Emission Source
Stationary combustion	• Diesel used for power generation such as generators. • Diesel used for stationary equipment.
Non-combustion	• Use of lubricant oils and greases in machinery.
Refrigerants	• Leakage/use of refrigerant gases in air conditioning units in vehicles and offices/accommodation in air conditioning units.
Explosives	• Explosives used in the blasting of rock in the core activity of the open cast mining activity of this operation.
Waste Emissions	• Methane emissions from waste. • Methane emissions from waste water (sewage) treatment.
Electricity	• Emissions associated with the total electricity consume.

Operational Carbon Footprint for the Project

The operational carbon footprint for the Project is predicted to be approximately 552 449 tCO_2e per annum from 2015 onwards. *Table 9.49* below breaks down emissions for each source during a year of 'normal' operations, once construction has ended. It should be noted that emissions associated with Scope 2 activities (ie electricity usage) account for 496 980 tCO2e, which is approximately 90% of the total emissions predicted. Scope 1 emissions will account for 55 469 tCO2e, which makes up the final 10% of the total emissions estimated. It is also important to note that these estimates do not include additional activities, which may come into play in the future.

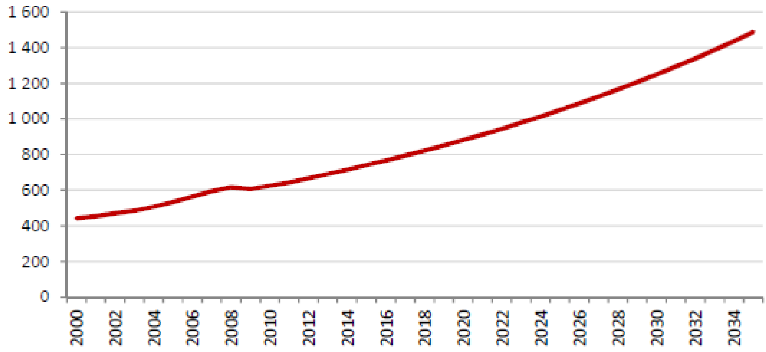
Table 9.50 Gamsberg Estimated Annual Operational Carbon Footprint

Emission Source	Estimated Operational Emissions (tCO2e)	Percentage of total emissions
Mobile Combustion	44 246	8.01%
Stationary Combustion	1 630	0.3%
Non Combustion	178	0.0%
Refrigerant Usage	1 170	0.2%
Explosives	362	0.1%
Waste	7 883	1.4%
Electricity	496 980	90.0%
Total CO_2e Emissions	552 449	100%

Comparison of Projected Project Emissions Against National Emissions

The impact of the Project's estimated operational emissions against South Africa's national GHG inventory has been assessed by comparison with an emissions trajectory from 2011 to 2035, which has been determined based on historic and projected economic growth and development pathways represented in terms of *Figure 9.16.* According to the most recent national GHG inventory, total emissions in South Africa in the year 2015 (the commencement of the operational phase of the Project) are predicted to amount to approximately 740.31 million tCO_2e. This is expected to increase to 1,436.37 million tCO_2e by the year 2034, given the estimated rate of growth of the Country.

Figure 9.16 South Africa's National Emissions (MtCO2e) Based on GDP Growth



The estimated emissions of GHG into the atmosphere from the Project, as well as the associated increase in South Africa's national emissions are shown in *Table 9.50*. From this, it is evident that the Project will result in a minor (≤0.07%) increase to annual emissions; however the impact will be over a long period of time (life of mine is predicted to extend for 19 years).

Table 9.51 Comparison of Gamsberg with Projected National Emissions (tCO2e)

Year	SA National Emissions (excl. Gamsberg)	Gamsberg estimated emissions	SA National Emissions (incl. Gamsberg)	% Increase in national emissions
2015	740 313 419.21	552 449	740 865 868	0.07%
2016	766 594 545.59	552 449	767 146 995	0.07%
2017	793 808 651.96	552 449	794 361 101	0.07%
2018	821 988 859.11	552 449	822 541 308	0.07%
2019	851 169 463.61	552 449	851 721 913	0.06%
2020	881 385 979.56	552 449	881 938 429	0.06%
2021	912 675 181.84	552 449	913 227 631	0.06%
2022	945 075 150.79	552 449	945 627 600	0.06%
2023	978 625 318.65	552 449	979 177 768	0.06%
2024	1 013 366 517.46	552 449	1 013 918 966	0.05%
2025	1 049 341 028.83	552 449	1 049 893 478	0.05%
2026	1 086 592 635.35	552 449	1 087 145 084	0.05%
2027	1 125 166 673.91	552 449	1 125 719 123	0.05%
2028	1 165 110 090.83	552 449	1 165 662 540	0.05%
2029	1 206 471 499.06	552 449	1 207 023 948	0.05%
2030	1 249 301 237.27	552 449	1 249 853 686	0.04%
2031	1 293 651 431.20	552 449	1 294 203 880	0.04%
2032	1 339 576 057.00	552 449	1 340 128 506	0.04%
2033	1 387 131 007.03	552 449	1 387 683 456	0.04%
2034	1 436 374 157.78	552 449	1 436 926 607	0.04%
2035	1 487 365 440.38	552 449	1 487 917 889	0.04%

Benchmark Against Other Zinc Mines

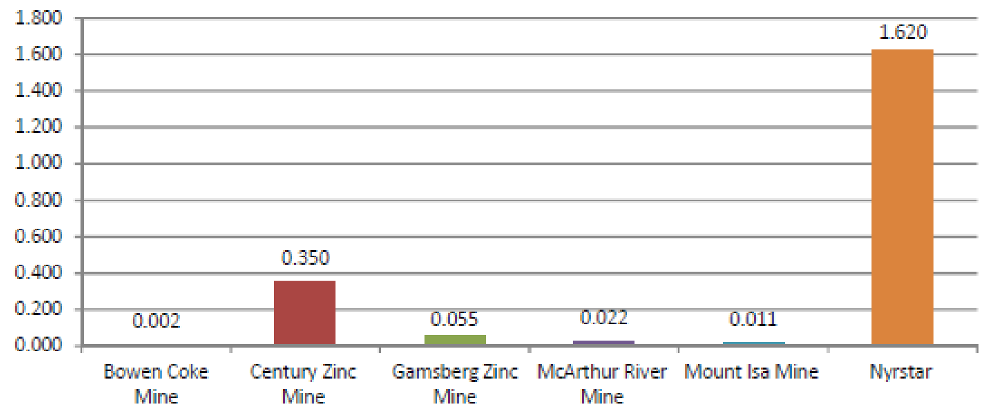
Benchmarking emissions intensity of the Project against other Zinc mines provides a measure of its performance against the industry average. The emissions intensity of zinc mines is influenced by a range of internal (technological) and external (environmental/geographic) factors as indicated in *Table 9.51*.

Table 9.52 Factors Influencing Greenhouse Gas Emissions Intensity

Internal	**External**
Choice of mining technology.	Spatial characteristics influencing vehicle usage.
Assumptions regarding the amount of flaring that may be required.	Electricity from the national supply is – coal has a high carbon content.
Power generation – choice of energy source, technology and configuration.	Economy affecting the price of equipment and vehicles .
Efficiency of equipment and vehicles.	Available alternative energy opportunity.

The production capacity of the Project is 10 million tonnes of zinc ore per annum. With an estimated annual carbon footprint of 552 449 tCO_2e for Project activities, this is equivalent to 0.055tCO_2e/tonne zinc ore. This is compared with the intensity of other zinc ore mining projects under operation around the world, and is illustrated in *Figure 9.17*.

Figure 9.17 Emissions Intensity of Gamsberg and other International Zinc Ore Mines



Impact Assessment

The potential magnitude of the impact is highly uncertain and involves unique/unknown risks. However, according to current designs, there is high confidence that the significant greenhouse gas emissions from the Gamsberg Facility would have a **moderate** impact on South Africa's national emissions.

Box 9.297 Summary of Operational Impact: Greenhouse Gas Emissions

Nature:

Sensitivity/Vulnerability/Importance of Resource/Receptor – **High.**
Irreplaceability: The activity will result in the long term changes to climate change, which is **irreversible** and **irreplaceable**.

Impact Magnitude – **Medium.**
Extent: The extent of the impact is **national** as it is South Africa's greenhouse gas emissions that are directly increased due to the impact of the project. Although the greenhouse effect is **transboundary** and global emissions are directly affected, this project assesses the impact on South Africa's emissions.
Duration: The duration of the impact is regarded as **permanent** as science has indicated that the persistence of carbon dioxide in the atmosphere is said to range between 100 and 500 years and therefore continues beyond the life of the project.
Scale: The substantial increase in South Africa's national greenhouse gas emissions and the long residence time in the atmosphere would indicate that the impact would have a **medium** scale during operations. Functions and natural process will be **notably altered** in the long term.
Frequency: The substantial increase in South Africa's national greenhouse gas emissions will be **constant/periodic** as the Gamsberg project will be operational for 20 years.
Likelihood: The probability of the impact of increased levels of greenhouse gas emissions with the proposed project is regarded as **certain**.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – **MODERATE.**

Degree of Confidence: The degree of confidence is **high**.

Operational Phase Mitigation

Given its global nature, mitigation of the impact of climate change takes the form of reducing the concentration of greenhouse gases in the atmosphere. BMM has an opportunity to influence the overall impact of the Gamsberg Facility and associated activities on GHG emissions by ensuring that the final design includes the most energy efficient and low emissions options available. This section identifies a number of best practice options to be considered for the Project in order to increase the energy efficiency and/or emissions intensity of its activities in South Africa and thereby reduce Scope 1, 2 and 3 emissions.

Given the early stage in the design of the project, it was not possible to accurately estimate the abatement potential of each option. These activities will, however, contribute towards the sustainability of the project, reducing the greenhouse gas emissions, and reducing costs (eg fuel use for electricity generation).

Recommendations regarding the Project include the following:

- Consider effective driving and vehicle use to optimize transport as well as heavy (mining) vehicle use.
- Consider minimising business travel.

- Optimise transport logistics.

- Incorporate 'green building' features in the design of offices and accommodation; particularly the type of refrigerant to be used when choosing cooling technology by considering the global warming potential of the selected refrigerant.

- Implement at outset a high efficiency equipment purchasing policy on maintenance and replacement policy on motors and pumps.

- Consider alternative energy technologies for electricity supply.

- Consider the development of a waste to energy plant for non-hazardous, carbon-based waste.

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