Appendix 2 Detailed Assessment of Environmental Impacts

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1 INTRODUCTION

This section provides reference to the impact assessment outcomes as per the environmental impact assessment undertaken in support of the approved EMPr. It must be noted that impacts were assessed in consideration of the proposed sinter and mine expansion. Where Assmang as elected to postpone or not proceed with particular expansion activities, the impacts thereof will be avoided and possibly not require mitigation as stipulated. The specialist reports attached to that EIA remain relevant and are summarised but not repeated herein.

1.1 IMPACT ASSESSMENT METHODOLOGY

The following criteria and methodology is employed to determine the significance of environmental impacts caused by the current and proposed activities.

1.1.1 TYPE OF IMPACTS

Potential environmental impacts may either have a positive or negative effect on the environment, and can in general be categorised as follows:

a) Direct/Primary Impacts
Primary impacts are caused directly due to the activity and generally occur at the same time and at the place of the activity.
b) Indirect/Secondary Impacts
Secondary impacts induce changes that may occur as a result of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken.
c) Cumulative Impacts
Cumulative impacts are those that result from the incremental impact of the proposed activity on common resources when added to the impacts of the other past, present or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time, and can include both direct and indirect impacts.

2 DETERMINING SIGNIFICANCE

The following criteria are used to determine the significance of an impact. The scores associated with each of the levels within each criterion are indicated in brackets after each description [like this].

2.1.1 NATURE

Nature (N) considers whether the impact is:
- positive [- ¼]
- negative [+1].

2.1.2 EXTENT

- Extent (E) considers whether the impact will occur:
- on site i.e. with the BRMO boundaries [1]
- locally: within 5 km vicinity of the site [2]

- regionally: within the local municipality [3]
- provincially: across the province [4]
- nationally or internationally [5].
-

2.1.3 DURATION

Duration (D) considers whether the impact will be:

- very short term: Less than a month [1]
- short term: Up to a year [2]
- medium term: up to two years [3]
- long term: up to 10 years [4]
- very long term, or permanent: 10 years or longer [5].

2.1.4 INTENSITY

Intensity (I) considers whether the impact will be:

- negligible: there is an impact on the environment, but it is negligible, having no discernible effect [1]
- minor: the impact alters the environment in such a way that the natural processes or functions are hardly affected; the system does however, become more sensitive to other impacts [2]
- moderate: the environment is altered, but function and process continue, albeit in a modified way; the system is stressed but manages to continue, although not with the same strength as before [3]
- major: the disturbance to the environment is enough to disrupt functions or processes, resulting in reduced diversity; the system has been damaged and is no longer what it used to be, but there are still remaining functions; the system will probably decline further without positive intervention [4]
- severe: the disturbance to the environment destroys certain aspects and damages all others; the system is totally out of balance and will collapse without major intervention or rehabilitation [5].

2.1.5 PROBABILITY

Probability (P) considers whether the impact will be:

- unlikely: the possibility of the impact occurring is very low, due either to the circumstances, design or experience [1]
- likely: there is a possibility that the impact will occur, to the extent that provisions must be made for it [2]
- very likely: the impact will probably occur, but it is not certain [3]
- definite: the impact will occur regardless of any prevention plans, and only mitigation can be used to manage the impact [4].

2.1.6 MITIGATION OR ENHANCEMENT

Mitigation (M) is about eliminating, minimising or compensating for negative impacts, whereas enhancement (H) magnifies project benefits. This factor considers whether –
A negative impact can be mitigated:

- unmitigated: no mitigation is possible or planned [1]

- slightly mitigated: a reduction in the impact is likely however the residual impact will be significant [2]
- moderately mitigated: the impact can be substantially mitigated to the point where is it within acceptable limits, but the residual impact is still noticeable or significant (relative to the original impact) [3]
- well mitigated: the impact can be mitigated to the extent that the residual impact is negligible or non-existent [4]

A positive impact can be enhanced:

- un-enhanced: no enhancement is possible or planned [1]
- slightly enhanced: a small enhancement in the benefit is possible [2]
- moderately enhanced: a noticeable enhancement is possible, which will increase the quantity or quality of the benefit in a significant way [3]
- well enhanced: the benefit can be substantially enhanced to reach a far greater number of receptors or recipients and/or be of a much higher quality than the original benefit [4].

2.1.7 REVERSIBILITY

Reversibility (R) considers whether an impact is:

- irreversible: no amount of time or money will allow the impact to be substantially reversed [1]
- slightly reversible: the impact is not easy to reverse and will require significant resources, taken immediately after the impact, and even then, the final result will not match the original environmental state prior to the impact [2]
- moderately reversible: much of the impact can be reversed, but action will have to be taken upon cessation of the activity and significant resources committed to achieve an acceptable degree of rehabilitation [3]
- mostly reversible: the impact can practically be reversed, rehabilitation can generally be achieved quite easily at any time [4].

3 CALCULATING IMPACT SIGNIFICANCE

The table below summarises the scoring for all the criteria. Impacts are scored in order to provide a reproducible semi-quantitative means of determining significance.

Table 3-1 Scoring for Significance Criteria

CRITERION	**SCORES**					
	- ¼	**1**	**2**	**3**	**4**	**5**
N-nature	positive	negative	-	-	-	-
E-extent	-	Site boundary	Within 5 km of boundary	Local Municipality	provincial	National or wider
D-duration	-	very short	short	moderate	long	very long
I-intensity	-	negligible	minor	moderate	major	severe
P-probability	-	very unlikely	unlikely	likely	very likely	-
M-mitigation	-	none	slight	moderate	good	-
H-enhancement	-	none	slight	moderate	good	-
R-reversibility	-	none	slight	moderate	good	-

Impact significance is a net result of all the above criteria. The formula proposed to calculate impact significance (S) is:

- For a negative impact:

$$S = \frac{N \times (E+D) \times I \times P}{½(M+R);}$$

- For a positive impact:
- S = N x (E+D) x I x P x (H)

Negative impacts score from 2 to 200. Positive impacts score from – ½ to -200.

3.1 UNDERSTANDING IMPACT SIGNIFICANCE

The following is a guide to interpreting the final scores of an impact (for negative impacts):

Table 3-2: Final Significance Scoring

Final score (S)	**Impact significance**	
0 – 10	Negligible	the impact should cause no real damage to the environment, except where it has the opportunity to contribute to cumulative impacts
10 – 20	Low	the impact will be noticeable but should be localized or occur over a limited time period and not cause permanent or unacceptable changes; it should be addressed in an EMP and managed appropriately
20 – 50	Moderate	the impact is significant and will affect the integrity of the environment; effort must be made to mitigate and reverse this impact; in addition the project benefits must be shown to outweigh the impact
50 – 100	High	the impact will affect the environment to such an extent that permanent damage is likely and recovery will be slow and difficult; the impact is unacceptable without real mitigation or reversal plans; project benefits must be proven to be very substantial; the approval of the project will be in jeopardy if this impact cannot be addressed
100 – 200	Severe	the impact will result in large, permanent and severe impacts, such as local species extinctions, minor human migrations or local economic collapses; even projects with major benefits may not go ahead with this level of impact; project alternatives that are substantially different should be looked at, otherwise the project should not be approved

4 CONSTRUCTION PHASE

4.1 INTRODUCTION

This phase of the project involves all those activities related to preparation of the site and subsequent construction/establishment of the various project structures and associated infrastructure thereon once prepared (e.g. vegetation stripping, topsoil stripping, earthworks/levelling/excavations/foundations, borrow pits, plant/shaft establishment, building construction and engineering services installation, etc.).

4.2 AIR QUALITY

4.2.1 INTRODUCTION

During construction, the undertaking of earth and civil works leads to the generation of vehicle and wind entrained particulate matter (dust). Although the impact is likely to be localised to the site, dust suppression techniques such as wetting roads, or application of dust palliatives, are required. Other emissions, e.g. construction vehicle and machinery exhausts are not anticipated to be significant. Vegetation stripping exposes bare soils surfaces to wind action, such that dust generation may increase where development areas are stripped of vegetation. It must, however, also be noted that the extent of vegetation cover in naturally vegetated habitat of this area is low when compared to other vegetation types (i.e. % bare ground is significant for the *status quo*). Any vegetation stripping will still contribute to cumulative dust generation, particularly in windy conditions, irrespective of the nominal natural vegetation cover.

4.2.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The impact will be of a low intensity and isolated to the site and its immediate surrounds. Effective mitigation, in the form of accepted dust suppression techniques, can be applied, but will not likely mitigate the potential occurrence of the impact in its entirety (i.e. residual impacts may be noticeable, but will be negligible relative to the original impact). The residual impacts will occur up until the point at which construction activities cease and when concurrent rehabilitation of applicable affected areas has been completed (i.e. some areas affected by vegetation clearance and topsoil stripping could feasibly be rehabilitated immediately thereafter once construction ceases).

Table 4-1: Impacts on Air Quality – Significance Rating			
Nature (N)	Negative impact on ambient air quality.		1
Extent (E)	Locally: Localised to the site and immediate surrounds		2
Duration (D)	Medium term: Construction phase (conservatively anticipated for up to a year)		3
Intensity (I)	Minor: Natural processes or functions will hardly be affected		2
Probability (P)	Likely: Impact will likely occur, to the extent that provisions must be made for the mitigation thereof		2
Mitigation (M)	Well mitigated: Effective dust suppression methods readily available		4
Enhancement (H)	N/A		-
Reversibility (R)	Irreversible: Not practical to reverse the impact once it has occurred		1
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Negligible**	8
Significance Rating without Mitigation -	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	20

Table 4-1: Impacts on Air Quality – Significance Rating			
Negative Impact (S)			
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.2.3 MANAGEMENT ACTIONS

The proponent will institute effective dust suppression measures on all un-surfaced access and haul roads for the duration of the construction phase. Compliance thereto will be measures against the national dust control regulations and associated thresholds.

4.3 CONSTRUCTION AND INSTALLATION WASTE GENERATION (CONTRIBUTION TO LANDFILL)

4.3.1 INTRODUCTION

Waste will be generated during the construction of the proposed project structures/infrastructure and installation of equipment. The waste would predominantly comprise of building rubble, packaging and fabrication waste/s. Steel and electric cabling waste, and packaging waste is also expected from installation. It is likely that most, if not all, of the waste generated would be non-hazardous/general waste. The generation of significant quantities of general waste could indirectly impact on the operational lifespan of the Black Rock waste disposal facility, through the permanent occupation of remaining available airspace at this facility. The same principle would apply to the applicable hazardous landfill facility/ies to which hazardous waste generated during construction will be taken for disposal. Note: Impacts of temporary onsite waste storage on surface- and ground water quality will be assessed under 'surface- and ground water quality'.

4.3.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The impact will have National extent; where hazardous wastes are concerned (i.e. in the absence of a suitably licensed hazardous landfill facility in the Northern Cape). The intensity of the impact will, however, be low relative to cumulative National and regional waste generation volumes (general and hazardous waste generation).

Table 4-2: Impacts of Construction Waste Generation – Significance Rating		
Nature (N)	Indirect negative impact on landfill airspace availability.	1
Extent (E)	National: Use of hazardous landfill beyond the provincial boundary	5
Duration (D)	Medium term: Construction phase (conservatively anticipated for up to a year, or possibly two)	3
Intensity (I)	Negligible: The anticipated impact will be negligible, with no discernible effect on relative airspace availability.	1
Probability (P)	Definite: The generated of waste during the construction phase is largely unavoidable (the amount generated can, however, be managed)	4
Mitigation (M)	Slightly: A small reduction in the volumes of waste	2

Table 4-2: Impacts of Construction Waste Generation – Significance Rating			
	generated can likely be effected during construction		
Enhancement (H)	N/A		-
Reversibility (R)	Moderately reversible through reuse, recovery and/or recycling initiatives: Where the impact relates to contribution to landfill, any measure implemented to reuse, recover, or recycle such waste would constitute the reversal of the impact		3
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	12.8
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	16
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.3.3 MANAGEMENT ACTIONS

Contractors will be required to provide a method statement specific to waste minimisation, reuse, recovery and recycling, as well as temporary storage and disposal; where such plans would need to be signed off by competent site environmental personnel/environmental control officer prior to the start of construction activities.

All construction and installation waste will be stored temporarily in a way that protects surface- and groundwater, and appropriately disposed of at the permitted Black Rock disposal site (i.e. where the waste in question is classified as general waste), or stored temporarily prior to collection by a suitably licensed waste disposal contractor in the event that hazardous waste is generated. Temporary waste storage areas will be sited under the guidance of site environmental personnel prior to the start of construction activities. Construction personnel will be trained in their correct use and the sites will be regularly inspected to ensure that they are being appropriately managed.

4.4 TOPOGRAPHY

4.4.1 INTRODUCTION

The primary relevance of assessing the project impacts on topography is to determine the indirect impacts thereof on site surface water run-off; where alterations to the storm water regime of the site could in turn influence soil erosion and rainwater infiltration rates (i.e. in the absence of any storm water controls). The sandy soils typical of the preferred site alternative generally do not facilitate significant surface water run-off, but rather infiltration thereof over short distances at surface following rainfall events. The flat nature of the subject terrain, furthermore, limits the extent (i.e. quantity and velocity thereof) to which significant surface storm water run-off is anticipated. None the less, any alteration to the natural topography of the site could negatively influence the *status quo*, particularly where alteration of topography comprises raised, compacted, floor establishment, or extensive excavations associated with borrow pit establishment.

4.4.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The projects impacts on site topography will likely be realised through the establishment of borrow pits (i.e. excavations targeting aggregate material/s for fill applications), as well as fill applications relating to the establishment/levelling of suitable founding conditions for site structures, infrastructure and equipment (e.g. sinter plant complex, surface shaft complexes, rail infrastructure, TSF, etc.).

The creation of steep slopes through alteration of the relatively flat natural topography of the site may increase surface water run-off volumes and velocities, thereby potentially increasing the potential for surface soil erosion and disturbing natural infiltration rates/distributions.

Table 4-3: Impacts on Topography – Significance Rating			
Nature (N)	Indirect negative impact on surface storm water regime.		1
Extent (E)	On site		1
Duration (D)	Life of Mine: Approximately 30 years		5
Intensity (I)	Minor: ‘Borrow’, as well as ‘fill’, applications will alter the environment, but natural hydrological processes are hardly affected.		2
Probability (P)	Definite: Natural site topography will be altered through proposed construction activities.		4
Mitigation (M)	Moderately mitigated: Effective mitigation can be applied to managing altered surface water run-off, but the impact may still be noticeable relative to the original impact.		3
Enhancement (H)	N/A		-
Reversibility (R)	Mostly reversible at end of life of mine through shaping and rehabilitation efforts corresponding to end land use planning at the end of life of mine		4
Significance Rating -Negative Impact with mitigation (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	13.7
Significance Rating -Negative Impact without mitigation (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	19.2
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.4.3 MANAGEMENT ACTIONS

The proponent will, to the greatest extent practical and feasible, borrow material from areas where other site structures and infrastructure are proposed for establishment (i.e. if the underlying parent material at those locations is suitable for required ‘fill’ applications elsewhere on the project). These opportunities will be explored with particular reference to the proposed establishment of the TSF and other dams; where such would require excavations for their establishment in any event. The extent of cumulative excavations and alterations to natural topography will thus be minimised in this manner.

Furthermore, a system of storm water diversion berms and cut-off trenches will be implemented to avoid surface water run-off over artificially created, steep, slopes and to divert storm water flows away from depressions created through borrowing activities. In principle, such mechanisms will aid in promoting natural infiltration and free drainage of rainwater into sandy soil surfaces, as well as the diversion of storm water away from 'dirty' work areas.

The proponent will, furthermore, be required to return the mine site to as close to its original condition (i.e. with respect to pre-development topography and vegetation cover). The pre-development surface water hydrological regime of the development terrain should be restored at closure. Rehabilitation efforts at closure should be such that the proposed end-use planning for the mine is achieved.

4.5 SURFACE- AND GROUNDWATER QUALITY

4.5.1 INTRODUCTION

The inappropriate storage, management and handling of fuel, oil and other potentially hazardous chemicals and substances during the construction period could result in potentially negative impacts on surface- and ground water quality; where spillages of such could enter the groundwater environment in particular, through the ready infiltration of contaminated surface run-off into the groundwater environment. Poorly managed vehicle workshops and wash bays too will impact negatively on ground- and surface water quality. Contamination of this nature, associated with the construction phase of a project of this magnitude, would typically be hydrocarbon based (i.e. petrol, diesel and oil leaks and spillages to bare soil surfaces). Temporary concrete batching plants can also impact negatively on

Poor placement and maintenance of temporary sanitary arrangements (i.e. portable toilets) can also result in detrimental impacts on water resources in one or another of the following ways (Fuggle and Rabie, 2009), depending on the nature and extent of potentially affected water resources:

- Eutrophication – referring to "*the enrichment of water with nutrients, such as nitrates and phosphates, which give rise to excessive growth of aquatic algae and cyanobacteria in surface water resources in particular*";
- Nitrification – referring to "*the contamination of drinking water supplies with elevated levels of nitrates;* and
- Microbial contamination – referring to the contamination of drinking water supplies with harmful pathogenic agents, such as *E. coli* bacteria and other faecal coliforms.

Groundwater contamination would generally be restricted to the confines of the site, or in severe cases the immediate surrounds of the site. The presence of a major aquifer system beneath the site makes groundwater pollution prevention essential during the construction phase. In the absence of a significant, continuous, point source of pollution, a groundwater pollution plume would likely develop and extend (i.e. in terms of lateral geographic extent) slowly within the underlying geo-hydrological regime.

In addition, during construction, temporary stockpiles of building material, excavated sand and rock, as well as waste, will be produced. It is important that these stockpiles are located in a centralised area where temporary measures such as berms will prevent sediment run-off, specifically during heavy rainfall episodes. This would be particularly important until the site's storm water management system has been completed. These particular waste streams are, however, not expected to be hazardous, or pose a contamination risk to groundwater.

A groundwater contamination assessment for BRMO was undertaken in 2016 by GeoPollution Technologies which encompassed mine wide operations as well as the proposed Nchwaning 2 tailings expansion (GPT Reference Number: EEESB-16-1806, refer to Appendix 14 for this report). The risk assessment in the report states:

"Based on the numerical model it is evident that no human health effects are likely to occur at any monitoring boreholes within the assumed 100 year mining scenario. From the previous studies and the monitoring reports it can be seen that none of the water samples exceeded the screening values indicated by the DWS water quality guidelines for domestic use. Leachate from the tailings material samples was also found not to exceed any of the screening values indicated by the DEA Waste Classification Screening Values.

The potential sources of contamination were identified as the Existing Nchwaning Tailings, Gloria Tailings, Gloria Historical Waste Storage, Nchwaning Historical Tailings, Nchwaning Proposed Tailings, Black Rock Tailings, Black Rock Landfill, Historical Tailings and Nchwaning Proposed Tailings.

It has been displayed through leach testing of tailings material and other waste rock material that the materials have a low contamination potential, i.e. it poses a low risk to the groundwater environment (GPT, 2015).

Coupled with low precipitation and high evaporation rates, lack of groundwater users and the ~70 m thick unsaturated zone underlying the site, the transportation of contaminants sourced from the solid and liquid waste areas is foreseen as a low risk to the groundwater environment."

4.5.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The anticipated extent of potentially contaminated surface water run-off will be negligible. This is as a result of the sandy nature of the underlying soils; where surface water will readily infiltrate soil surfaces in close proximity to the point of contamination, as opposed to travelling any significant distance at surface. The potential for the contamination of any surface water resources through contaminated surface water flows during construction is thus deemed negligible. The potential for water resource contamination would take place primarily at the level of the ground water environment, acknowledging the potential inter-relationship thereof with sub-surface flows and surface water recharge associated with the Gamagara River system. Should groundwater contamination occur, the impact would persist almost into perpetuity/forever.

Table 4-4: Impacts on Surface- and Ground Water Quality – Significance Rating		
Nature (N)	Negative impacts on surface- and ground water quality.	1
Extent (E)	Site and immediate surrounds: Ready infiltration of storm water into sandy underlying soils will limit the extent of the potential impact to the site itself (i.e.	2

Table 4-4: Impacts on Surface- and Ground Water Quality – Significance Rating			
	groundwater environment)		
Duration (D)	Long term: Treatment of groundwater contamination (i.e. once occurred) is a long and arduous process		4
Intensity (I)	Major: Adjacent farmers/farming communities reliant on groundwater for their livelihood		4
Probability (P)	Likely: Impact likely to occur, to the extent that provisions must be made for it		2
Mitigation (M)	Well mitigated: A comprehensive range of effective mitigation measures is readily available		4
Enhancement (H)	N/A		-
Reversibility (R)	Irreversible: No amount of time or money will sustainably reverse the impact		1
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	19.2
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	48
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.5.3 MANAGEMENT ACTIONS

The remediation of contaminated groundwater is a long, arduous and costly process. Any such remediation efforts may also likely leave significant residual contamination, despite any such remediation attempts (dependant on the nature and extent of the contamination itself). As such, the proponent's management actions should focus on the prevention of any such potential hydrocarbon contamination, rather than post impact remediation thereof. A comprehensive range of effective, proven, mitigation measures will be implemented in this regard, which are in principle as follows:

- All hazardous substances to be stored within appropriately sized, impermeable, bund walls;
- Storm water control measures to be implemented that prevent the free movement of 'clean' storm water run-off through the aforementioned storage areas, as well as any service yards and wash bays;
- Hazardous substances spill kits to be readily available at all points where hazardous substances will be stored and/or transferred (e.g. refuelling points);
- Vehicle and plant servicing to only take place in dedicated service yards on impermeable surfaces coupled with appropriate 'dirty' water containment systems/sumps and oil/water separators; and
- Drip trays to be appropriately placed under vehicles and plant that over-night on bare soil surfaces.

The proponent is also required to establish an extensive groundwater monitoring network for BRMO operations that will act to determine if any groundwater pollution is resulting from the proposed project. Contractors will also be required to provide a method statement in respect of how they propose to manage fuel storage and workshop areas to minimise the potential for groundwater pollution. Such a method statements would need to be signed off by competent site environmental personnel/environmental control officer (Environmental Control Officer), prior to the start of construction activities.

4.6 GAMAGARA RIVER SURFACE HYDROLOGY

4.6.1 INTRODUCTION

The proposed construction of a railway bridge over the Gamagara River could negatively impact on the surface hydrology of this river system. The Gamagara River last flowed at surface over 25 years ago, despite heavy rainfall in January 2011. The potential impacts on the surface hydrology of the river have none the less been assessed from the following perspectives:

- Potential disturbances to biodiversity;
- Potential disturbances to the hydrological regime, particularly during flood events; and
- Potential impacts on ground- and surface water during construction related activities.

The potential impacts on archaeological and palaeontological resources has been duly assessed under section 8.1.9 of the EIA Report. The assessment of the aforementioned potential impacts took the current ecosystem state of the Gamagara River along the applicable section thereof, as well as the presence of redundant bridge remnants adjacent to the existing bridge into account; inclusive of prior railway alignment, redundant bridge supports and associated existing disturbances (Shown in Red in Figure 4-1).

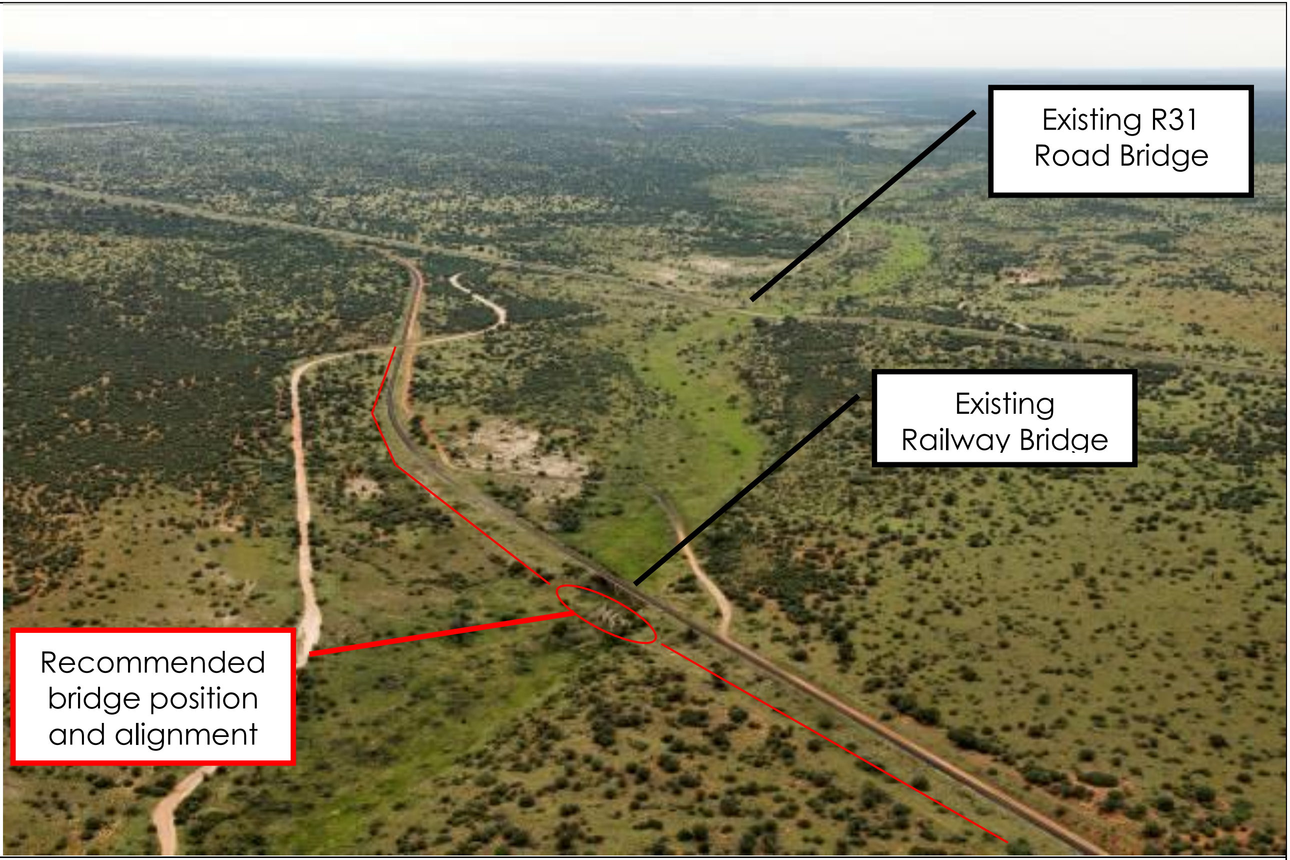


Figure 4-1: Aerial photo showing recommended bridge position and alignment

A comprehensive site visit and review of aerial photographs of the site show evidence of a previous railway alignment and associated bridge crossing (i.e. remaining support columns) to the north of the current bridge and railway alignment (Figure 4-1). The extent of the realised impact from constructing a new bridge could to a large degree be bated by using this prior alignment; where a degree of disturbance has already taken place. That is not to say that the redundant support columns to the north of the existing bridge can necessarily be used in the construction of a new bridge, but rather that the alignment thereof is recommended.

The riparian zone and associated wetland of the Gamagara river are described, in terms of both present ecological state and ecological management class, as Class D- largely modified; where alien invasive species dominance and up-stream dewatering have been the primary drivers to such a classification (SAS, 2011).

4.6.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The proposed bridge will not likely effect the hydrology of the Gamagara river to any significant extent from the current *status quo*, provided that the recommended alignment is utilised and that final engineering design is such that the bridge support columns do not result in the attenuation/ 'pooling' of water up-stream of the bridge in flood events. Bridge design should allow flood waters to drain freely beneath the bridge itself and between the associated support columns.

The use of the alignment north of the existing railway line will be advantageous (relatively speaking) from the following perspectives:

- It exploits existing ecological disturbance; where post construction rehabilitation and alien invasive management programmes could ultimately improve site biodiversity; and
- The topography of the recommended alignment requires the 'borrowing' and deposition of significantly less fill material, such that indirect bio-physical and topographical impacts are reduced through diminished requirements for borrow pit establishment.

Table 4-5: Impacts on Gamagara River Surface Hydrology		
Nature (N)	Negative: Potentially negative impact on surface flow regime	1
Extent (E)	Locally: The proposed bridge crossing could affect the realised extent of up-stream flooding, if not designed properly	2
Duration (D)	Permanent: The bridge will not likely be demolished at the end of lie of mine, but utilised by mining houses north of the site.	5
Intensity (I)	Minor: The impact alters the hydrological regime and ecosystem functioning of the environment in such a way that the natural processes or functions are hardly affected; the system does however, become more sensitive to other impacts (i.e. flood potential).	2
Probability (P)	Likely: There is a possibility that the impact will occur, to the extent that appropriate civil engineering design provisions must be made to mitigate such.	2
Mitigation (M)	Well mitigated: The potential for the impact can be mostly mitigated/avoided in the design thereof and	4

Table 4-5: Impacts on Gamagara River Surface Hydrology			
	the residual impact is negligible or minor.		
Enhancement (H)	-		-
Reversibility (R)	Irreversible: No amount of time or money can reverse a significant flood.		1
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	11.2
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	28
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.6.3 MANAGEMENT ACTIONS

The primary required management action relates to 'impact avoidance' through appropriate civil design of the proposed bridge crossing. To this end, a competent civil engineer must sign off on the final design of the bridge crossing; where such a design must be shown not to significantly attenuate flood waters behind the bridge in flood events. The final engineering design need to be submitted to the respective competent authorities prior to the commencement of construction activities.

The BRMO alien invasive plant species management plan must be given due consideration and be in implementation phase during the construction of the bridge crossing.

4.7 BIODIVERSITY

4.7.1 INTRODUCTION

According to Fuggle and Rabie (2009) the loss of biodiversity brings significant costs through damage to the services that ecosystems provide. Biodiversity conservation efforts in South Africa are largely species, or area, based. In the former, legal protection is given to species by providing prohibitions or restrictions to listed threatened or protected species (Fuggle and Rabie, 2009). In support of the above, no person in South Africa may "*carry out a restricted activity (e.g. remove, destroy, transport or trade) involving a specimen of a listed threatened or protected species without a permit*".

Project implementation will require the stripping of large tracts of indigenous vegetation (in excess of 20 ha) during the construction phase for subsequent earthworks and the construction of structures and infrastructure; where the referenced structures and infrastructures relate to the proposed sinter plant complex, TSF, surface shaft complexes, rail infrastructure and other ancillary infrastructure supportive of the project (e.g. conveyors, pipelines, dams, roads, etc.).

Two protected tree species have been identified in significant numbers throughout the proposed development site (*Acacia erioloba* and *Acacia haematoxylon*), as well as two protected plant species (*Ammocaris coranica* and *Harpagophytum procumbens*). Proposed development areas that have already been subjected to anthropogenic activities (mining/extensive agricultural practices) show a significant decrease in natural biodiversity, and are thus considered of low ecological sensitivity. Areas included within the low sensitivity grouping are the existing railway line and access road between Gloria and Nchwaning II Mines, associated servitudes as well as the extreme northern portion of the proposed northern fines conveyor, situated within existing mining footprint. The middle section of the northern fines conveyor, located between the existing mining footprint and the proposed TSF, is considered of moderate to low ecological condition. This is mainly due to impacts from existing mining activities, but which are not considered as severe as areas within the low sensitivity area. The remainder, and majority, of the proposed development areas have seen less anthropogenic activity, with only some grazing impacts noted, and are considered to be in a moderate ecological condition as a result.

The construction phase of the project will have both direct and indirect impacts on indigenous site flora and fauna, as follows:

- Reduction in floral biodiversity:
    - Fire related impacts (informal, unmanaged/indiscriminate, fires/burning regime by site contractors and construction personnel);
    - Soil and indigenous vegetation disturbances, leading to proliferation of alien vegetation; where such aliens would compete for space and available resources;
    - Removal/destruction of Red Data Listed (RDL) and protected floral species through site preparations (i.e. vegetation clearance);
    - Increased harvesting pressures on known medicinal plant species associated with the presence of contractors on site; and
    - Increased harvesting of protected tree species, such as *Acacia erioloba, by* contractors for firewood.
- Reduction in faunal biodiversity:
    - Fire related impacts (i.e. indiscriminate fires by contractors may lead to veld fires and the subsequent destruction of habitat to indigenous faunal species);
    - Increased human activity associated with construction activities (contractors and construction workers) may lead to increased poaching and trapping;
    - Clearance of vegetation results in the destruction of suitable faunal habitat;
    - Impacts on faunal habitat may lead to loss of migratory routes for more mobile faunal species;
    - The potential proliferation of alien invader floral species as a result of poorly managed construction activities could influence the relative availability of food for grazing and browsing fauna; and
    - Noise generated through mining activities may impact on relative faunal distribution and faunal population integrity.

Figure 4-2: Ecological sensitivity mapping for the development sites

4.7.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The specialist Biodiversity Impact Assessment (BIA) undertaken for the subject study area concluded that "*any impacts which occur as a result of the project will affect the local area for a long duration and are likely to affect the receiving environment. If mitigation measures are implemented* (i.e. as prescribed in the said specialist assessment)*, the likelihood of impacts occurring and the consequence of the impacts are significantly reduced to a low level and the duration of impacts becomes significantly reduced*".

The BIA assesses each of the impacts identified in the preceding introductory section according to the specific merits of each. The assessment methodology utilised is detailed in the attached BIA. The following impact significance table is aimed at providing an indication of the project's broad-scale impacts on biological diversity (i.e. by the EAP) and conservatively incorporates the principle findings of the BIA assessment for each individual impact identified by the specialist consultant (Scientific Aquatic Services Report Reference: SAS 211022).

Table 4-6: Impacts on Biodiversity – Significance Rating		
Nature (N)	Negative impacts on site biological diversity	1
Extent (E)	Nationally: Four floral species identified on site are afforded protection, in terms of law, on a National scale.	5
Duration (D)	Very long term: The impact will be largely reversed at the end of life of mine, but it may take several decades thereafter for floral species (particularly	5

Table 4-6: Impacts on Biodiversity – Significance Rating			
	woody species) to re-establish.		
Intensity (I)	Major: The disturbance to site flora and fauna will disrupt functions and processes at a localised level, thereby reducing diversity. Required removal of protected floral species.		4
Probability (P)	Definite: Vegetation clearance is required for the establishment of site structures and supporting infrastructure		4
Mitigation (M)	Moderately mitigated: The impact can be substantially off-set/mitigated through the establishment of an indigenous tree nursery LED project, and 'ecological off-set' area establishment, as well as concurrent rehabilitation respectively, but the residual impact will still be noticeable or significant, relative to the original impact		3
Enhancement (H)	N/A		-
Reversibility (R)	Mostly reversible: Rehabilitation efforts at closure will largely reverse the impact, although this may never entirely return the site to its 'natural', pre-development, condition		4
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	45.71
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**High**	64
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.7.3 MANAGEMENT ACTIONS

It is the opinion of the specialist ecologists that the proposed development of the 'subject property' be considered favourably, provided that the recommendations below are adhered to by the proponent:

- The existing integrity of flora surrounding the proposed development should be upheld and no activities should be carried out outside the required footprint of any construction areas;
- Educate construction personnel about the importance of the floral and faunal species and also how to identify red data listed (RDL) species;
- If any RDL species are to be disturbed, ensure effective relocation of such species that can be relocated to suitable off-set areas;
- Obtain relevant permits for cutting and destroying, or the rescue and relocation, of each protected or endangered floral species identified within the proposed expansion area;
- Use of a contractor specializing in the removal of protected tree species should be made. The contractor should provide a detailed rescue and relocation plan which should be overseen by a suitably qualified ecologist. Future tender documents should include rescue and relocation plans for protected plant species;

- An environmental control officer should oversee the rescue and relocation of all protected flora to be moved;
- Designated sensitive areas must be off-limits to construction personnel. All un-authorised collection of firewood and medicinal plants must be prohibited; and where collection is to take place, it must be overseen by a suitably qualified staff member;
- All areas affected by construction should be rehabilitated upon completion of the construction phase of the development. Areas should be re-seeded with indigenous grasses as required;
- As much vegetation growth as possible should be promoted within the proposed development area in order to protect soils and to reduce the percentage of the surface area which is paved. In this regard special mention is made of the need to use indigenous vegetation species as the first choice during landscaping;
- In terms of the amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 and Section 28 of the National Environmental Management Act, 1998, landowners are legally responsible for the control of invasive alien plants on their properties and it is, therefore, recommended that declared weed and invader species be removed from the subject property;
- Vehicles should be restricted to travelling only on designated roadways, in order to limit the ecological footprint of the proposed development activities;
- No fires whatsoever should be lit within the subject property;
- No animal trapping should be allowed during development activities;
- No dirty water run-off must be permitted to reach surface water resources, with specific reference to the Gamagara River; and
- An indigenous tree nursery and biodiversity off-set implementation plan must be formulated by an appropriately qualified specialist and accordingly implemented at the BRMO.

4.8 SOIL

4.8.1 INTRODUCTION

Soil is susceptible to various types of degradation brought about by mining and mine related activities, which can result in a potential decline in associated soil quality from a physical, chemical and biological perspective (Fuggle and Rabie, 2009). Topsoil conservation is of particular importance where it will be used to facilitate the rehabilitation of disturbed areas during subsequent phases of the project. Topsoil stripping and the subsequent stockpiling thereof is common-place during the construction phase mining projects; where topsoil is stripped from pre-determined surface development footprints prior to the construction/establishment of proposed mining structures and infrastructure.

The services of a specialist soil scientist (Professor Andries Claasens) were commissioned to assess the potential project impacts with respect to:

- establishing the appropriate depth to which the site topsoil should be stripped in preparation of construction activities, in order to ensure adequate subsequent preservation thereof for rehabilitation efforts at mine closure;
- requirements for topsoil stockpiling;
- requirements for topsoil remediation; for reuse thereof in rehabilitation after mine closure; and
- providing a broad overview of the soil types/characteristics on all the farms comprising the greater BRMO mine lease area.

4.8.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

Table 4-7: Impacts on Soils – Significance Rating			
Nature (N)	Potentially negative impacts on topsoil structure and suitability for use in rehabilitation of disturbed areas at closure.		1
Extent (E)	Site: The impact will be isolated to the development site		1
Duration (D)	Very long term: Topsoil stockpiled for the life of the mine following the stripping thereof during construction		5
Intensity (I)	Minor: The stripping (i.e. during construction) and subsequent replacement thereof (i.e. at mine closure and rehabilitation) will result in alterations to the post-development environment, in terms of topsoil integrity, that will hardly effect natural processes.		2
Probability (P)	Definite: Topsoil will be stripped and stockpiled		4
Mitigation (M)	Well mitigated: Well established topsoil conservation measures readily available to the proponent for implementation		4
Enhancement (H)	N/A		-
Reversibility (R)	Mostly reversible: Any reduction in soil quality (chemical and biological) resulting from the stockpiling thereof can be easily reversed prior to replacement thereof over disturbed areas,		4
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	12
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	19.2
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.8.3 MANAGEMENT ACTIONS

4.8.3.1 Stripping depth:

Because the A horizon is relatively thin (20 cm), with a very low organic content, no specific recommendation are made on how deep the topsoil should be excavated prior to the commencement of construction. The excavation could be deeper than 20 cm. The normal practice is to excavate to 30 cm before the surface is prepared for construction is acceptable. A variable topsoil stripping depth of 20-30 cm is thus advocated.

4.8.3.2 Handling of stockpiled soil:

Because of the texture of the soil and the size distribution of the different sand fraction of the soil, the soil will not tend to compact and become cemented when stockpiled. No special arrangements are thus deemed necessary for stockpiling, in terms of height restrictions applicable to such. The above is true with respect to the preservation of soil structure. The degree to which naturally occurring 'seed banks' are preserved in the stockpiled material will, however, be indirectly influenced by the height of the stockpile material. As such, the proponent should aim to stockpile topsoil to within 3m above ground level as far as is practical. Appropriate storm water control measures must be implemented to minimise erosion of the stockpiles.

4.8.3.3 Soil preparation for remediation:

Although the subject topsoil is not very fertile, the stockpiled soil can be used as is to reclaim disturbed areas at mine closure. No fertilizer program is recommended, because it is assumed that the disturbed areas will be re-vegetated with naturally occurring grass species which are adapted to the local environment. Stockpiled topsoil should be replaced at closure to the depth at which it was initially stripped prior to the establishment of mine structures and infrastructure. As such, the depth to which topsoil was stripped needs to be recorded at the time of stripping and mapped accordingly for the purposes of sound rehabilitation of disturbed areas at closure.

A soil testing programme, undertaken by an appropriately qualified soil and pant nutrition specialist, will need to be instituted prior to the use of stockpiled material in rehabilitation. The study will confirm the suitability of stockpiled topsoil as medium for plant growth, as well as any potential amelioration required upon reuse thereof, in rehabilitation of disturbed areas. Preliminary specialist investigations, however, suggest that no such amelioration will be required.

4.9 HERITAGE RESOURCES

4.9.1 INTRODUCTION

The assessment of project impacts on elements of cultural/heritage importance relates primarily to the occurrence of such elements in the vicinity of the Gamagara River; where the proponent proposes the establishment of a new rail bridge at this location, adjacent to the existing rail bridge. That is not to say that the potential occurrence of elements of archaeological importance underlying the remainder of the proposed development site can be ruled out; where excavations required for the construction of other project elements may unearth such material.

4.9.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

A number of archaeological sites were identified and recorded in the vicinity of the proposed rail bridge (Figure 4-1), all dating to the Stone Age (SA - mainly middle SA/late SA), with some early SA occurrences. Most of the sites are situated in erosion dongas or gullies, on the river banks, in calcrete formations under red Aeolian sands and is represented by scatters, or concentrations, of stone artefacts of varying density.

With little, or no, archaeological research having been done in the area in the past, the identified archaeological sites are fairly important and at least of regional significance. Although most sites will not be likely directly impacted on by the proposed development, and no sites were identified in the river bed close to the new rail crossing, it is envisaged that the development will more than likely uncover stone tools, and possibly *in situ* sites, in the river banks and sand dunes and calcrete formations around the area where the rail crossing will be constructed. It is likely that, due to the bridge's proposed alignment directly south of the existing bridge, that only sites 2 and sites 14 will be impacted upon during construction relate activities (Figure 4-1).

At the request of the South African Heritage Resources Agency, Dr. Bruce Rubidge of Wits University was asked to provide inputs, at desktop level, as to the possible effects of the bridge construction on the palaeontological heritage of the site. To this end Dr, Rubidge provided the following input:

- "*The area affected is situated on rocks of the Precambrian Ongeluk Formation of the Transvaal Supergroup, and the Olifantshoek Supergroup, which are in turn covered by Tertiary and Quaternary calcrete and sand deposits;*
- *The rocks of the Ongeluk Formation of the Transvaal Supergoup and Olifantshoek sequences, which are Precambrian in age, are unlikely to contain fossils. There is a slight, but unlikely, possibility of fossils being present in the unconsolidated Tertiary and Quaternary alluvial deposits; and*
- *It is unlikely that the proposed development will have an impact on palaeontological heritage, but it is essential that if fossils are uncovered in the Tertiary and Quaternary alluvial deposits in the process of development activities, that a professional palaeontologist be consulted to access the situation*".

Table 4-8: Impacts on Heritage Resources – Significance Rating			
Nature (N)	Negative Impacts on Elements of Cultural/Heritage Significance		1
Extent (E)	Regionally: Archaeological elements of regional significance		3
Duration (D)	Very long term: Disruption of archaeological elements will be permanent		2
Intensity (I)	Major: Archaeological elements of regional significance to be disturbed. Only sites of lesser relative significance, however, will be disturbed. Not all sites to be damaged/disturbed.		4
Probability (P)	Likely: Impact likely to occur, to the extent that provisions must be made for it		2
Mitigation (M)	Moderately mitigated: Effective specialist mitigation can be applied to managing the impact, although it may still be noticeable relative to the original impact.		3
Enhancement (H)	N/A		-
Reversibility (R)	Irreversible: Not reversible		1
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	20
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	40
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.9.3 MANAGEMENT ACTIONS

It is recommended by the heritage specialist who undertook the HIA that Phase II mitigation measures be undertaken before the development commences. This will entail the following:

- Mapping of the most significant sites (highest density of material) in the area. Sites 6 and 12 are recommended. With Site 6 located outside the area earmarked for development activities, Site 12 must therefore be mapped; and
- Controlled sampling of material in order to obtain a representative sample of the Stone Age material in the area. This will be in the form of blocks on the site, which will be mapped and material in these blocks will then be sampled.

Although no other sites of cultural heritage significance were identified in the area, they could be present, or could have been missed as a result of the grass and vegetation cover in certain areas making visibility difficult at the time of the assessment. This is especially true for low stone packed, or unmarked graves. Two historical graveyards in the larger BRMO geographical area were identified in during a 2009 HIA, and a lookout should be kept for similar sites during the construction period. Where either archaeological or palaeontological finds are made during the construction phase, works in those areas should cease until such time as a relevant specialist has been consulted as to the significance and potential regulatory implications thereof.

4.10 NOISE

4.10.1 INTRODUCTION

The holder of a mining right must comply with the provisions of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996), as well as any other national norms and standards regarding noise management (Fuggle and Rabie, 2009). Predominant construction related noise impacts are anticipated from the following sources:

- Heavy vehicle movement and operation associated with ground works and building activities (i.e. dump trucks, excavators, TLBs, cranes, graders, earth compacters, etc.); and
- Drilling and blasting (i.e. structural works and shaft sinking respectively).

4.10.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

General construction

Two aspects are important when considering the potential noise impacts of a project and these are as follows:

- The anticipated increase in the ambient noise level; and
- The overall ambient noise level produced.

The aforementioned activities will be development site specific and the construction equipment that will be used during the construction phase, as well as the anticipated line of sight noise reductions associated with each, is given in Table 4-9.

Table 4-9: Construction Vehicle Line-of-sight Estimated Noise Level Attenuation – dBA (m)

Equipment	**Line-of-sight Estimated Noise Level Attenuation – dBA (m)**						
	5	**10**	**20**	**40**	**80**	**160**	**320**
Cumulative	**5**	**15**	**35**	**75**	**155**	**315**	**635**

distance from source							
Excavator 12000	78.3	68.3	58.3	52.3	46.3	40.3	34.3
Dozer D155	83.3	73.3	63.3	57.3	51.3	45.3	39.3
Grader 140H	97.4	87.4	77.4	71.4	65.4	59.4	53.4
VolvoA40	85.6	75.6	65.6	59.6	53.6	47.6	41.6
HD 325	91.3	81.3	71.3	65.3	59.3	53.3	47.3
TLB	94.4	84.4	74.4	68.4	62.4	56.4	50.4
Lighting Plant	85.8	75.8	65.8	59.8	53.8	47.3	41.3
Bell B40	86.1	76.1	66.1	60.1	54.1	48.1	42.1

The noise reduction calculated in Table 4-9 are for direct line-of-sight and medium to hard ground conditions. The combined noise level at the distance 635 m from the source, should all the above machinery operate at one time, will be 49.4 dBA. A realistic figure will, however, be 46.8 dBA as all the machinery is not likely to operate at one time and in one area. Engineering control measures and topography can have an influence on how the noise level is perceived by the receptors in vicinity of the site.

Blasting/Shaft Sinking

Blasting during the construction phase is only anticipated to potentially take place in relation to the sinking of vertical and vent shafts associated with the proposed Gloria and Nchwaning vertical and vent shafts. Human reaction to vibration will be in response to the resulting effects of both ground and airborne vibration, and in particular the combined effects of such vibrations. The closest non-mining related structures in the vicinity of the proposed shafts are the Schoonspruit mine village approximately 550 m south of the new Nchwaning shaft and the Acacia Guesthouse, approximately 2 km east thereof.

The blasting process is the biggest contributor to vibration. Routine blasting operations regularly generate air over pressure levels at 15 m from the blast site of approximately 120 dB. A constant wind velocity of 5 m/s will generate the pressure equivalent of 120 dB at 15 m from the blasting area. At 140 dB the wind velocity will increase to 8 m/s. Wavelength differences associated with this frequency range mean that any effects of topography are likely to be pronounced for the audible component of air over pressure levels rather than the concussive component. A topographic barrier (i.e. an earth berm or rock face) will play an important role in reducing the audible effect rather than the concussive effect.

The resultant shock waves have a relatively high dominant frequency and the energy contained in the shock wave will reduce rapidly as the resultant energy will be subjected to geometric and natural attenuation. Rock formations absorb the blast vibrations and/or the distance from the source which will result in the shock wave to be attenuated by 6 dB in the doubling of distance from the source. The blast design chart suggested in Rock Slope Engineering by Wyllie and Mah (2004) can be used to quantify damage potential to residential properties. It is generally accepted that residential buildings of sound structural integrity can safely withstand peak particle velocity (PPV) 50 mm/s. Poorly constructed buildings should, however, not be subjected to PPV's of more than 10 mm/s. Figure 4-3 illustrates the typical vibration control diagram where the charge per delay is combined with the distance from the blast to indicate the safe and damage zones and when damage to structures can be expected.

Meteorological conditions such as wind speed, direction, temperature, cloud cover and humidity will affect the intensity of the air over pressure levels perceived at a distance from the blasting area. A blast in a motionless atmosphere will reduce the air over pressure level by 6.0 dB as the distance from the source doubles. The air over pressure levels at the source should be minimized in order for the energy to be within acceptable criteria at a distance. This could be achieved by proper blast design. In general, individual blasts should not exceed 50 mm/s in the vicinity of properly constructed buildings and the average level should not exceed 10 mm/s in the vicinity of poorly constructed buildings. These levels conform to the British Standards 6472 and the USA Bureau of Mine Standards, RU 8507.

The anticipated increase in the noise level at radius of 400 m from the blasting area at the surface shaft complexes will be approximately 35.0 dB, which will be for a period of 5 seconds, only after which the prevailing noise level will be maintained. The noise level will reduce dramatically the deeper the shafts become because of the rock face that will absorb the noise. The ground vibration for an underground blast at BRMO was measured at 1.5 mm/s at 400 m from the blasting area, which is below the ground vibration level where structural damage to buildings can occur.

Table 4-10: Impacts of Construction Noise – Significance Rating

Nature (N)	Negative impacts of construction related noise on sensitive receptors		1
Extent (E)	Locally: Within the vicinity of the site		2
Duration (D)	Medium term: Construction phase/shaft sinking (bulk of work conservatively anticipated for up to a year, or possibly two)		3
Intensity (I)	Minor: Sensitive receptors hardly affected		2
Probability (P)	Likely: There is a possibility that the impact will occur, to the extent that provisions must be made for it.		2
Mitigation (M)	Slightly mitigated: Limited avoidance and minimisation through design and blast criteria standards		2
Enhancement (H)	N/A		-
Reversibility (R)	Irreversible: Blast waves and noise irreversible once generated		1
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Low**	13
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	20
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

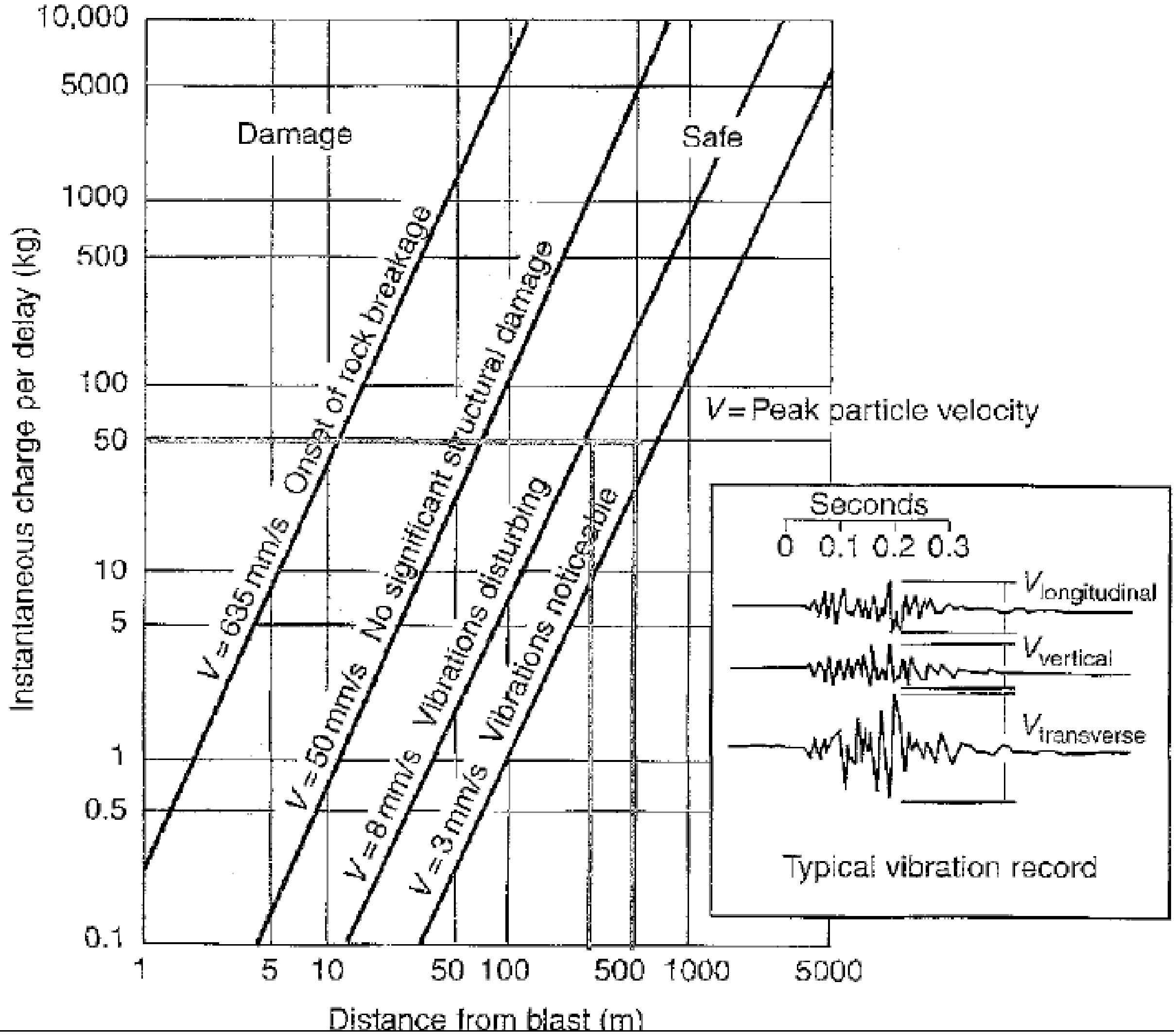


Figure 4-3: Blast Design Chart

4.10.3 MANAGEMENT ACTIONS

The following measures must be considered by the proponent prior to the acquisition of earthmoving equipment:

- Enclosure of engine bays;
- Modification of radiator fan design and materials;
- Installation of louvers on radiator and hydraulic cooling fans; and
- Re-engineering of exhaust systems.

The following are the Environmental, Health and Safety Guidelines of the IFC of the World Bank, which should be taken into consideration during the construction phases of the project:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment causing radiating noise;
- Installing vibration isolation for mechanical equipment;
- Re-locate noise sources to areas which are less noise sensitive, to take advantage of distance and natural shielding;
- Taking advantage during the design stage of natural topography as a noise buffer; and

- Develop a mechanism to record and respond to complaints.

The following vibration screening measures for the control of vibration must be provided:

- The air over pressure levels and vibration level, (audible and the inaudible concussion noise), to be monitored and controlled during each blasting operation. The standards implemented by the USA Bureau of Mine Standards, RU 8507, are used as a guideline to monitor and control blasting operations in South Africa, as follows:
- The limit for ground vibration should not exceed 10 mm/s at the nearest residential property;
- An over pressure limit of 134 dB should not be exceeded. Near schools and churches not to exceed 128 dB; and
- No blasting to take place when there are windy conditions.

The Regulations under the Mines Health and Safety Act require the owner of the operation to ensure that the health and safety of employees and people will not be affected during blasting.

Blasts must be designed so that ground vibration and air over pressure levels are adhered to. The following measures should be implemented:

- A scheme of vibration and air over pressure monitoring to be implemented;
- A scheme by which air over pressure is controlled;
- Days and times of blasting operations to be established;
- Ensure that the correct design relationship exists between burden, spacing and hole diameter;
- Ensure the maximum amount of explosive on any one day delay interval, the maximum instantaneous charge, is optimized by considering:
  - Reduce the number of holes per detonator delay interval;
  - Reduce the instantaneous charge by in-hole delay techniques;
  - Reduce the bench height or hole depth; and
  - Reduce the borehole diameter.
- Always attempt to minimize the resulting environmental effects of blasting operations and to recognize the fact that the perception of blasting events occurs at levels of vibration well below those necessary for the possible onset of the structural damage, but nevertheless at levels that can concern occupants abutting the mining area; and
- Be aware that relatively small changes in blast design can produce noticeable differences in environmental emissions. It is very often in response to changes in these emissions rather than their absolute value that complaints are made.

Scheme of vibration monitoring must include the following:

- The location and number of monitoring points;
- The type of equipment to be used and the parameters to be measured;
- The frequency of monitoring;
- The method by which such data are made available to management; and
- The method by which such data are used in order to ensure that the site vibration limit is not exceeded and to mitigate any environmental effects of blasting.

4.11 TRAFFIC

4.11.1 INTRODUCTION

The R31 between Kuruman and Hotazel has experienced significant traffic growth of between 20% and 30%, year on year, for the period 2006-2011. Heavy vehicle growth contribution to the aforementioned figures is estimated at 60-70% increases year on year. The current traffic loading on this road section far exceeds the original designed volume, which is the probable reason why the road is presently in a poor condition (Figure 4-4).

Poor road condition and user safety is attributed to varying incidences/degrees of the following road conditions along the applicable 63 km road section:

- Road edge breaks;
- Poor quality of edge break repairs;
- Block cracking;
- Dry and brittle condition of road surface;
- 'Crocodile cracks' and 'pumping';
- Rutting;
- Surface water ponding;
- Severe shoulder drop-offs;
- Poorly maintained/non-existent guard rails;
- Stray animal occurrence; and
- Narrow road width (2.8 m per lane) relative to design standard appropriate to the type of vehicles traversing the R31 (3.7 m per lane), which is further exacerbated by edge break effects.

The establishment of the structures and infrastructure proposed as part of the project would require the transport of construction materials and large pieces of equipment, pre-fabricated elsewhere, to the site. This, in addition to the daily transport of construction workers, would lead to an increase in heavy vehicle traffic to the site, although temporary in nature (i.e. during construction). The increased traffic volumes and/or slow moving heavy vehicles could cause a nuisance to other road users, as well as contributing toward further degradation of the condition of the R31 road, as well as inferred road user safety.

	
Severe edge breaks	**High shoulder drop-off**

	
Poorly maintained guardrail/s	**Crocodile cracking**

Figure 4-4: Photographic examples of deteriorated R31 road condition

4.11.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

It is evident that the present poor condition of certain sections, as well as overall inadequate design, of the R31 already impacts upon road users, and particularly their safety. Several complexities arise through out of an assessment of the individual project's impacts on traffic and road user safety during the construction period. These are detailed as follows:

- In isolation, the impacts of the project on traffic and road user safety could be seen as significant, but relative to the existing traffic volumes and present poor condition of the R31, the cumulative negative impact could be viewed as being relatively insignificant;
- There are several mines and industrial operations within a 10 km radius of BRMO that make substantial use of the R31 between Kuruman and Hotazel. Any impact of the specific project on the localised road network and users thereof thus needs to be viewed as a relative additive contribution to the impacts of other existing operations on the overall cumulative impact. Such an approach is made cumbersome and impractical at the level of an EIA undertaken for single operation;
- Assigning responsibility, in terms of the required upgrade/repair and ongoing maintenance of the R31, cannot be laid solely at the door of any one individual mining house, or industrial operation, in the area; and
- The relevant district and local municipalities are essentially responsible for the up-keep of the R31. Any strategic initiative by private entities to upgrade the R31 needs to be done in close collaboration with, and under consent from, these municipal parties.

Table 4-11: Cumulative impact on R31 Road Condition – Significance Rating

Nature (N)	Additive contribution to negative cumulative impact associated with increased traffic volumes (light and heavy vehicles)	1
Extent (E)	Regionally: Potential impact as far as Kuruman/Kathu	3
Duration (D)	Medium term: Construction phase/shaft sinking (bulk of work conservatively anticipated for up to a year, or possibly two)	3
Intensity (I)	Moderate: The R31 will still be available for use by other	3

Table 4-11: Cumulative impact on R31 Road Condition – Significance Rating			
	road users, albeit with increased construction related traffic thereon.		
Probability (P)	Very likely: It is highly anticipated that existing, regular, road users will experience the increased volumes of traffic as a nuisance, but this is not certain.		3
Mitigation (M)	Slightly mitigated: Restriction of delivery times to off-peak traffic periods, as well as carpooling/bussing of construction workers to the site on a daily basis		2
Enhancement (H)	N/A		-
Reversibility (R)	Slightly reversible: With respect to R31 road condition deterioration.		2
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	27
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	36
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

4.11.3 MANAGEMENT ACTIONS

Assmang has in the past contributed to the up-keep of roads in the area and would continue to do so into the future, to an extent based on proportional road use by their vehicles. A 'Preliminary Status Quo Report' for the Kuruman-Hotazel road (i.e. R31), inclusive of a proposed upgrade strategy, was compiled in April 2011 by VELA VKE Consulting Engineers, at the request of the district municipality, BHP Billiton and Assmang Manganese Mines. The latter two being the more established mining entities in the Hotazel area.

While little project specific mitigation is proposed, or deemed feasible, the proponent should continue to seek strategic solutions to the problem in conjunction with other prominent road users and the relevant local authorities. A potential solution to alleviating the poor road condition and implementing ongoing maintenance of the R31 is put forward in terms of potential immediate (0-1 years), short (1-3 years), medium (3-10 years) and long term (10-20 years) measures in a 2011 VELA VKE road upgrade strategy. It would not be appropriate for this EIA, or associated EMPR, to commit Assmang to the sole implementation of the aforementioned plan, nor would it be appropriate (or have legal standing) to commit other mining houses to the joint implementation of the upgrade strategy. It is, however, in Assmang's and other mining houses' own interest to ensure that the condition of the R31 is upgraded in a sustainable manner that will optimise their own individual operations and improve safety for their own employees along this route.

Seeking a solution to this matter is deemed well beyond the scope of this EIA, as the route of the problem extends well beyond the battery limits of the study and involves several other parties' commitment to such. As such a strategic solution amongst all parties concerned needs to be sought, that partitions relative involvement in implementation.

4.12 CONSTRUCTION CAMP ESTABLISHMENT

4.12.1 INTRODUCTION

Apart from topsoil stripping and the clearance of indigenous vegetation, construction camp establishment and subsequent on-going activities associated with such, have the most potential for environmental impact, if not appropriately positioned and managed. Activities potentially associated with construction of camps are as follows (i.e. those activities with the potential to negatively impact on the environment):

- Concrete batching;
- Temporary ablution facilities;
- Vehicle workshop/cleaning bays;
- Material and fuel storage;
- Waste generation (general and hazardous) and management;
- Lighting of fires (cooking/heating);
- Poaching of indigenous fauna; and
- Vehicle/machinery movement leading to dust generation.

4.12.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The potential impacts of the activities listed above have been assessed as part of one, or another, of the preceding sections. As such no 'construction camp' specific significance rating is provided under this section in order to avoid duplication. The potential for significant impacts as a result of such camps must however be acknowledged and all prescribed mitigation adhered to.

4.12.3 MANAGEMENT ACTIONS

The appointed contractor/s will be required to submit method statements to the project manager (Environmental Specialist) and independent environmental control officer , indicating how they plan to appropriately manage each of the above referenced activities to achieve compliance with the EMPR, conditions of approval and relevant legislation.

4.13 SOCIO-ECONOMICS

4.13.1 INTRODUCTION

A specialist Socio-economic Impact Assessment was commissioned for the EIA process. The expected impact of the project during its construction phase is analysed in this sub-section of the report. The analysis covers a number of aspects, such as the impact of the project on production levels within the Province and the country as a whole, GDP, employment, household income, and pressure on the local service delivery. Due to the specialised nature of some of the equipment and services required for the establishment of the mine and the sinter plant, not all materials and inputs will be sourced from South Africa and those that will be sourced within the country will most probably be coming from various parts of South Africa (i.e. not from within the Northern Cape Province). Therefore, the spill-over effects associated with the domestic capital expenditure will be realised and analysed on a national level, as opposed to the provincial level.

4.13.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The proposed expansion of the mine and establishment of the sinter plant complex will require an investment of R3 940.9 million (2011 prices) and six years from the start of the construction period to reach a full operating capacity. Once100% capacity is achieved, R1 055 million (2011 prices) per annum will be required to support its operations.
The construction and operational phases of the proposed development will have a notable impact on the national and provincial economies during both phases; it however, will also have a negative effect on SA's economy due to the loss of agricultural land (Table 4-12).

Table 4-12: Summary of impacts within the country during construction and operations

Impact	Direct	Indirect	Induced	TOTAL
Impact on SA's economy associated with the proposed project's investment				
During construction (total for five years)				
Impact on balance of payment (R'ml)	-R 472.9	-	-	-R 472.9
Impact on production (R'ml, 2011 prices)	R 3 468.0	R 5 433.0	R 3 891.7	R 12 792.6
Impact on GGP (R'ml, 2011 prices)	R 369.7	R 2 096.6	R 1 720.2	R 4 186.5
Impact on employment	1 910	12 154	8 233	22 297
Impact on income (R'ml, 2011 prices)	R 197.8	R 928.7	R 764.4	R 1 890.9
During operations (annual, at full capacity)				
Impact on balance of payment	Between R 3.3 billion and R 5.3 billion per annum			
Impact on production (R'ml, 2011 prices)	R 1 055.0	R 966.9	R 513.3	R 2 757.7
Impact on GGP (R'ml, 2011 prices)	R 252.0	R 398.0	R 225.4	R 875.3
Impact on employment	846	1 606	1 164	3 617
Impact on income (R'ml, 2011 prices)	R 192.4	R 166.4	R 105.2	R 464.0
Impact on SA's economy associated with the loss of agricultural land (loss)				
Annual loss of production (R'ml, 2011 prices)	-R 0.153	-R 0.053	-R 0.050	-R 0.256
Annual loss of GGP (R'ml, 2011 prices)	-R 0.118	-R 0.023	-R 0.022	-R 0.163
Loss of sustainable employment	-1	0	0	-1
Annual loss of income (R'ml, 2011 prices)	-R 0.077	-R 0.013	-R 0.010	-R 0.101

The construction of the proposed structures and processing facilities will increase the production in the country by R12.8 billion and create R4.2 billion of value added over a period of five years. The increase in demand for goods and services stimulated by the investment and subsequent increase in production volumes will open opportunities for new employment. Consequently, 22 297 FTE jobs will be created over the five year period and R1 890.9 million of income will be distributed to households as a result of this.

In addition to the above positive effects, a few negative aspects could arise as a result of the construction activities.

- Annual loss of production to the value of R0.26 million, loss of value-added to the value of R0.16 million, loss of one permanent employment position at the farm, and annual loss of income to the value of R0.10 million due to the loss of agricultural land;
- Firstly, the establishment of the sinter plant and expansion of the mine will require importation of goods and services to the value of R472.9 million (2011 prices). This

will have a negative effect on the current account balance and could potentially increase the current account deficit. However, the extent of this effect is not considered to be significant enough to alter macro-economic policies and dynamics. Furthermore, this expenditure is required to later generate significantly greater local returns, which makes it justifiable;

- Secondly, the construction activities always attract job seekers. Such activities are also temporary, which means that once construction is completed all job opportunities associated with it are lost. It is likely that the project will attract new people to the area seeking employment opportunities, and it is also possible that some workers coming from outside the area and involved in construction would decide to remain in the area. Such scenarios are associated with an increase in crime and deterioration of health in the long-term as a result of an increase in incidence of HIV/AIDS in the area; and
- Thirdly, the housing and service delivery situation in the district is under significant strain. More and more people are living in informal settlements. If the new workers are brought to the area, the demand for accommodation would spike. Since the current supply and mix of prenatal accommodation cannot meet the existing demand, the situation with information settlements could potentially deteriorate.

Section 5.2 of the attached Socio-economic Impact Assessment provides the specialist's detailed impact assessment on numerous construction related socio-economic aspects. Table 4-13 that follows, as well as the preceding paragraphs, aim to provide readers with a concise summary of the anticipated significance of socio-economic impacts (positive and negative) to potentially result from the project.

Table 4-13: Summary of socio-economic impacts evaluation for the construction period

Impact	Status		Direct		Indirect		Induced	
Impact during construction								
Impact on balance of payment	Negative	BM	Negligible	9	-	-	-	-
		AM	Negligible	9	-	-	-	-
Net impact on production	Positive	BM	Moderate	-40.5	Moderate	-40.5	Moderate	-20.3
		AM	Moderate	-40.5	Moderate	-40.5	Moderate	-20.3
Net impact on GDP-R	Positive	BM	Moderate	-40.5	Moderate	-40.5	Moderate	-20.3
		AM	Moderate	-40.5	Moderate	-40.5	Moderate	-20.3
Net impact on employment	Positive	BM	High	-54	High	-54	Moderate	-20.3
		AM	High	-54	High	-54	Moderate	-20.3
Net impact on income	Positive	BM	High	-60	High	-60	Moderate	-22.5
		AM	High	-60	High	-60	Moderate	-22.5
Impact on skills development	Positive	BM	Negligible	-4.5	-	-	-	-
		AM	Negligible	-9	-	-	-	-
Impact on housing and basic service delivery	Negative	BM	Low	18.7	-	-	-	-
		AM	Low	14	-	-	-	-
Impact on crime	Negative	BM	Negligible	9.3	-	-	-	-
		AM	Negligible	6.2	-	-	-	-
Impact on health	Negative	BM	Negligible	9.2	-	-	-	-
		AM	Negligible	6.2	-	-	-	-

In summary, from a socio-economic point of view, the proposed project offers far greater societal and economic benefits than the current activity, which represents a "no go" option. Thus, it represents the preferred option amongst the two considered (i.e. the "no go" option and the proposed development option).

4.13.3 MANAGEMENT ACTIONS

In order to minimise the negative impact on the balance of payment, it is suggested that where possible local goods and services are procured instead of imported ones. Local goods though in this case need to be readily available and need to be offered at competitive prices.

In order to optimise the stimulation of the economy through direct, indirect and induced effects, the following should be applied where possible:

- Investigation of the procurement of construction materials, goods, and products from local suppliers where feasible to minimise the extent of imported goods and materials sourced;
- Considering engaging with local consulting and design firms, where possible, to include them in the team of international experts that will be employed during the project's execution; and
- Investigate the possibility of providing the commercial farmer (i.e. present land tenant) with an alternative site that could potentially be leased by him to retain its activity at the same level as before the project's inception.

The enhancement of benefits associated with the effects on employment lie in the potential to increase the employment opportunities for local communities in the JT Gaetsewe DM and supporting more jobs through the procurement of local goods than imported materials and inputs where feasible. In this context the following should be considered, where possible:

- Assist the farm worker who would lose his/her job due to the proposed activity in finding an alternative employment position, if feasible;
- Employ labour-intensive methods in construction, where feasible;
- Employ local residents and communities, where possible;
- Sub-contract to local construction companies (in the JT Gaetsewe DM), where possible; and
- Utilise local suppliers, where possible.

The construction of the sinter plant and expansion of the mine will offer opportunities for skills development and knowledge sharing. Encouraging the contractor to make use of local labour force to develop their skills or expand them in other fields could enhance the positive impact on skills development.

The negative impact on housing and service delivery provision pressures could be reduced by:

- Sourcing the majority of construction workers from local communities, thus reducing the need to bring new people into the local area. In this case, the district municipality could be approached with a request to conduct a skills audit of the nearby communities, which will allow the contractor/s to identify people with suitable skills; and
- Providing a temporary camp for the construction workers with access to basic services such as sanitation, water, and electricity.

The influx of construction workers and simply job seekers to the area that will be stimulated by the construction activities on site could increase the incidence of crime in the area during, but most probably, after the construction activities are completed if these people decide to stay without having an alternative employment opportunity. This negative effect will be negligible but still worth noting. To reduce its significance, where possible, the construction activity should aim to employ workers from the local communities, which will reduce the influx of construction workers in the area, and as a result reduce the number of people who could stay in the area without any sustainable income and who could resort to crime and petty theft.

The influx of workers and job seekers in the area could increase the incidence of prostitution, unwanted pregnancies, and HIV/AIDS in the area. Although the significance of this impact is negligible, it cannot be ignored. To mitigate this potential effect on local communities, awareness campaigns in the nearby communities should be conducted on the adverse effects of unprotected sex and potential burden on women and possible deterioration of their standard of living in the case of unwanted pregnancies and subsequent births.

5 OPERATIONAL PHASE

5.1 INTRODUCTION

The operational phase of the project encompasses all those aspects associated with the on-going mining operations at BRMO, from the end of the construction period, up until the closure and decommissioning of the mine. The operational lifespan of the mine is approximately 30 years. This estimate is based on the extent of the remaining available ore body, as well as the rate at which ore will be mined, should the planned mine expansion proceed.

In broad terms, the 'operational phase' of the project life-cycle includes, *inter alia*, the following broad activities:

- Sinter and processing plant operation;
- The continued mining and primary crushing of ore underground, and transfer thereof to the surface for processing;
- Product transfer/hauling and stockpiling;
- Raw material receiving, handling and storage;
- Product loading (road and rail);
- Mine water management/treatment;
- Sewage treatment and sludge management;
- Tailings management/recovery;
- General and hazardous waste management (incl. salvage yard);
- Vehicle/plant servicing, repair and washing; and
- Site access control and security measures.

All of the aforementioned operational activities have the potential to impact on one, or more, environmental parameters, as evaluated and described in the following sections.

5.2 AIR QUALITY

5.2.1 INTRODUCTION

A specialist Air Quality Impact Assessment (AQIA) was commissioned as part of the EIA in order to predict and assess the potential significance of the cumulative impact on ambient air quality associated with the proposed project activities, as well as background emission sources.

The objectives of the specialist Air Quality Impact Assessment study, as formulated during the environmental scoping phase, are:

- High resolution prognostic modelling generating 3 km WRF meso-scale data, as well as geophysical data (land use and terrain data), for the region of interest;
- Compilation of a comprehensive emissions inventory from potentially significant emission sources and the identification of key pollutant compounds associated with the development during the operational phase of the proposed activity;
- Diagnostic meteorological modelling using the CALMET model to generate boundary, site specific and gridded three-dimensional data for the area of interest (modelling domain); and
- Dispersion scenario modelling to predict both ambient concentrations for pollutants of interest and deposition/flux rates (dust fallout) for particulate matter.

The aforementioned activities enabled the development and evaluation of the following aspects for an Air Quality Impact Assessment:

- Assessment of pollutant transport and ambient concentration in relation to sensitive receptors – essentially a compliance assessment for the predicted ambient air pollution concentrations with respect to South African standards for air quality (NEMAQA, GN:263:2009);
- Assess nature, extent, duration, probability & significance of identified impacts requiring further monitoring and investigation;
- Identify and contextualise knowledge gaps, assumptions and limitations of the study;
- Identify and propose emissions reduction opportunities and recommendations regarding mitigation measures (including cost effective emission abatement strategies) to address best case, most probable and worst case scenarios;
- Overall conclusion regarding the potential impact of the proposed project in terms of air quality;
- If necessary (and as part of the AQMP) recommend optimal positioning of air quality monitoring stations based on macro and micro scale sighting criteria; and
- Compilation of a comprehensive Air Quality Impact Assessment report which will document the impact assessment methodology, data inputs, study assumptions and limitations, and the study findings.

An inter-comparative assessment of modelled predictions in relation to measurements from ambient monitoring stations within applicable proximity to the site could not be undertaken, as there are no measuring stations/networks available in close proximity to the proposed facility.

The activities and infrastructure associated with the project that were assessed as part of the aforementioned specialist assessment are as follows:

- Vehicular traffic on mine haul roads;
- Mined material handling and transfer;
- Processing plant operations (crushing and screening);
- Tailings deposits;
- Product stockpiling; and
- Sinter plant operation.

Significant background emission sources contributing to ambient air quality, and which were incorporated into cumulative ambient air quality modelling are as follows (emission parameters used in dispersion modelling were based on information supplied by the respective emitters):

- Delta EMD's Reduction plant (situated immediately east of the Nchwaning II mine boundary); and
- The proposed Kalagadi Manganese's sinter plant - currently under construction a few kilometres south-west of the Gloria Mine.

5.2.2 DISPERSION MODELLING

Atmospheric dispersion modelling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. Atmospheric dispersion models use mathematical algorithms that simulate the dispersion and transformation of pollutants in the atmosphere. They are used to estimate or predict the downwind concentration of air pollutants emitted from various sources. Dispersion models are also used to assist in the design and assessment of various control strategies and abatement technologies for emissions reductions.

Using mathematical algorithms air pollution modelling attempts to describe the relation between emissions and ambient concentrations of pollutants which enable the numerical modelling of pollutant dispersal and reaction. It takes into consideration the factors that have resulted in these concentrations - such as the emission sources, meteorological processes and any physical or chemical transformations. Numerical "models" are used to describe complex systems of interacting physical, chemical, and biological processes. These models consist of sets of mathematical equations that attempt to describe processes observed in nature, allowing scientists to create replicas of natural systems with a computer, so that the causes and effects of system behaviour may be better understood.

The primary focus of dispersion modelling is to estimate the ambient concentrations of primary pollutants that have been emitted in the atmosphere. There are a number of dispersion models that have been developed around the world. The widely used CALPUFF dispersion model, used for this study, is one such example.

5.2.3 PRIMARY POLLUTANTS CONSIDERED IN AQIA

The section that follows provides an overview of the pollutants of potential concern that were modelled as part of the assessment, and which are likely to be generated as a result of the relevant proposed activities.

5.2.3.1 Inhalable Particulate Matter:

The impact of particles on human health largely depends on:

- particle characteristics
    - particularly particle size, and
    - chemical composition;
- exposure
    - duration
    - frequency and
    - magnitude.

The potential of particles to be inhaled and deposited in the lungs is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density, and these affect the potential for deposition in different regions of the respiratory system.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles (PM_{10}) pass through the nasal region and are deposited in the tracheo-bronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which deposits them on the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery *et al*, 1994).

There are various potential sources for the emission of particulate matter. These include but are not necessarily limited to:

- Sintering;
- Vehicle entrainment - notably unpaved roads;
- Wind erosion - open stock piles and exposed surfaces;
- Process fugitives - crushing, screening, etc.;
- Material handling and transfer - loading, off-loading, conveyors, etc.; and
- Underground operations: Drilling, blasting, materials handling etc.

The background sources included in the dispersion modelling scenarios include emissions from Kalagadi Manganese sinter plant, as well as Delta EMD. All dispersion modelling maps to follow (Figure 13-2 to Figure 13-4) for criteria pollutants (with the exception of PM_{10}) include emissions from Kalagadi's sinter plant, Delta EMD and existing operations at the BRMO site. It must be noted here that road palliation of 80% has been applied in all instances.

Product stockpiles consist mainly of particles that are too large to be entrained by wind. Where fines have been deposited in tailings dams, the material forms a crust upon drying and there is no visible entrainment by wind. This was clear from visual inspection, where it was observed that crusts are well consolidated with no significant loose material that has the potential to be wind entrained. Most open or exposed areas are overlain with coarse ore or discard material, consequently there is little potential for wind entrainment.

Due to the large particle size and material density, emissions from crushing and screening operations are not significant. Notably, once the material is wetted the potential for entrainment is substantially reduced. There is also no significant visible emission from these operations.

Emissions from underground are insignificant. Vent shaft concentrations are typically much lower than the occupational health limits as a result of dilution due to clean air leaking into the airflow system and due to the mixing of air from regions with low pollutant loads.

5.2.3.2 Particulate Matter Fallout:

Large particulates which become entrained from the various sources listed in the previous sections generally fall out of suspension within a short distance of the source. These particulates are typically large enough to be caught in the exclusion systems of the upper respiratory tract and as a result they generally do not present a significant health threat. However, they are a nuisance dust due to deposition in human settlements, on plants and the natural environment in general.

5.2.3.3 Sulphur dioxide(SO_2):

SO_2 is a chemical compound released typically by processes that involve the combustion of materials containing sulphur and/or sulphides, in this case the combustion of solid fuels in the proposed sinter plant.

The primary health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease. Major sub-groups of the population that are most sensitive to SO_2 include asthmatics and individuals with cardiovascular disease, or chronic lung disease (such as bronchitis or emphysema) as well as children and the elderly. Emissions of SO_2 can also damage the foliage of trees and agricultural crops. Together, SO_2 and NO_x are the major precursors to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments and reduced visibility.

5.2.3.4 Nitrous Oxides (NO_x):

NO_x is a term used to describe various oxides of nitrogen which are produced during combustion in the presence of nitrogen and oxygen. NO_x emissions from combustion are primarily nitric oxide (NO), with only a small fraction as nitrogen dioxide (NO_2). Nitrous oxide (N_2O) is also emitted at a few parts per million. NO_x formation results from thermal fixation of atmospheric nitrogen in the combustion zone (thermal NO_x) and from oxidation of nitrogen bound in the fuel in use (fuel NO_x). Experimental measurements of thermal NO_x formation have shown that the NO_x concentration is exponentially dependent on temperature and is proportional to nitrogen concentration in the combustion zone, and the square root of oxygen concentration in the flame and the residence time. Of the various chemical species produced NO_2 is typically in the order of only 5% of NO_x emitted from combustion sources. The primary NO_x constituent of these off gases is typically NO (approximately 90% to 95%). NO will eventually be oxidised to NO_2 in the atmosphere, and the rate of conversion is dictated by the kinetics of reaction in the atmosphere (various sources – Cooper et al, Yu et al, Hori et al).

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Nitrogen oxides are important in forming ozone and may affect both terrestrial and aquatic ecosystems. Nitrogen oxides in the air are a potentially significant contributor to a number of environmental effects such as acid rain and eutrophication. Short term nitrogen exposure ranging from 30 minutes to 24 hours, may lead to adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people suffering from asthma. When NO_x reacts with ammonia and moisture, small particles are formed. These particles penetrate deep into sensitive parts of the lungs and can cause or worsen respiratory diseases such as emphysema and bronchitis, as well as aggravate existing heart disease leading to multiple hospital visits and premature death.

5.2.3.5 Carbon monoxide (CO):

During combustion, carbon in the fuel oxidizes through a series of reactions to form first carbon monoxide (CO) and then carbon dioxide (CO_2). High levels of CO output are due to incomplete combustion (Cleaver Brooks, 1998). CO is an odourless and colourless toxic gas. Individuals who suffer from blood disorders like anaemia and those with pre-existing heart and respiratory problems are sensitive to the effects of CO. The health effects related to CO exposure are mainly cardiovascular and neurological as it affects the red blood cells and the central nervous system. Carbon monoxide can have varying effects on humans, depending on the concentration and time of exposure. Symptoms of mild acute poisoning include experiencing light-headedness, confusion, headaches and flu-like symptoms. Large exposures can lead to significant toxicity of the central nervous system and heart, resulting in death. Chronic exposure to low levels of CO can lead to memory loss, depression or confusion.

5.2.3.6 Dioxins and Furans (a.k.a. PCDD's):

A dioxin is any compound containing the di-benzo-p-dioxin nucleus, while a furan is any compound containing the di-benzofuran nucleus. The general formulae for each of these are illustrated in Figure 5-1.

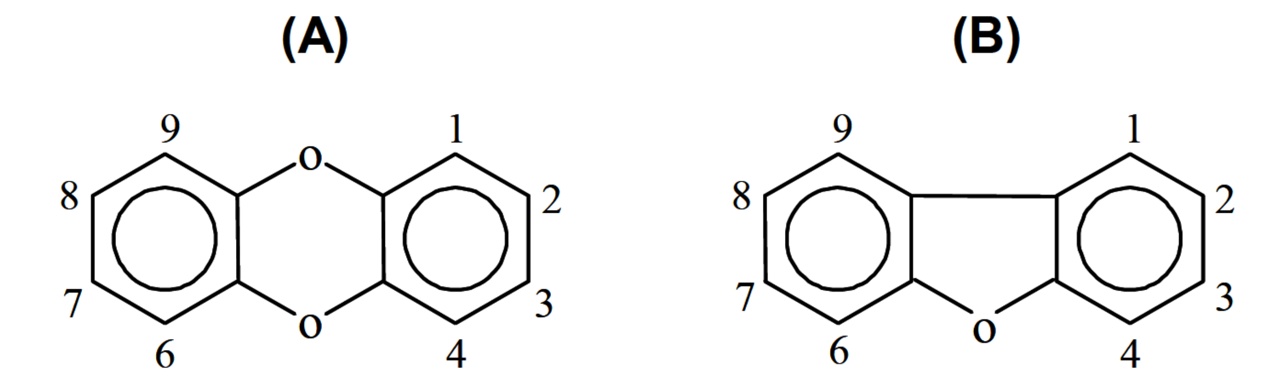


Figure 5-1: General structure for Dioxins (A) and Furans (B)

Dioxins and furans (polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurnas (PCDDS/PCDFs)) are hazardous air pollutants (HAPs). It is generally accepted that dioxins and furans can be formed in thermal processes where chlorine containing substances are burned together with carbon and a suitable catalyst in the presence of excess air or oxygen. Dioxin and furan formation also tends to occur in the zone when combustion gases cool from about 450 to 250 °C (de novo synthesis) and not in the combustion chamber. Copper, iron, zinc, aluminium, chromium, and manganese are known to catalyse PCDD/PCDF formation (UNEP 2005).

Dioxins and furans can cause a number of health effects. The U.S. Environmental Protection Agency (EPA) has noted that they are likely to be cancer causing substances to humans. In addition, people exposed to dioxins and furans have experienced changes in hormone levels. High doses of dioxin have caused chloracne. Animal studies show that animals exposed to dioxins and furans experienced changes in their hormone systems, changes in the development of the foetus, decreased ability to reproduce and suppressed immune system (ATSDR 2008 Toxicological Profile for Chlorinated Dibenzo-p-dioxins).

The toxic equivalency (TEQ) has been developed in order to assess the impacts associated with dioxin exposure. The TEQ is used as a standard internationally to assess impacts associated with dioxin exposure. International toxicity equivalency factors (ITEFs) are applied to 17 dioxin and furan isomers of concern to convert them into 2,3,7,8- TCDD (tetrachlorodibenzo-p-dioxin) toxicity equivalents (Ontario Canada, 2001). The conversion involves multiplying the concentration of the isomer by the appropriate I-TEF to yield the TEQ for this isomer. Summing the individual TEQ values for each of the isomers of concern provides the total toxicity equivalent level for the sample mixture (Ontario Canada, 2001).

5.2.4 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

Three dispersion modelling scenarios were developed for the respective primary pollutants, as follows:

1. All relevant background emission sources (including existing BRMO operations, Kalagadi Manganese sinter plant and Delta EMD operations);
2. Emission sources associated with the proposed project alone; and
3. Cumulative contributions to ambient air quality resultant from a combination of scenarios 1 and 2 above ('worst case').

Scenario 3 has been used as the premise (i.e. worst case scenario) for modelling the proposed project's impact on ambient air quality for the respective primary pollutants of concern. Scenario 3 dispersion modelling has assumed that the Kalagadi and Assmang sinter plants will meet the applicable stack emission limits stipulated in GN 248:2010. It must be noted that these limits serve as a set of minimum requirements and that the Atmospheric Emissions Licence of the plant will give final determination for the emission limits and conditions to be met.

5.2.4.1 NOx Dispersion Modelling Results:

The cumulative impact of NO_x emissions on ambient air quality (Scenario 3 – worst case) appears to be potentially significant (Figure 5-2), however, it must be noted that the predicted (modelled) impact is a highly conservative, over-estimate, in view of 100% of NO_x emissions having being assumed to be in the form of NO_2, whereas literature shows that NO_x emission are typically only 5% NO_2, and 95% NO. The rate of conversion of NO to NO_2 is dictated by the kinetics of reaction in the atmosphere, and while the ratio of NO_2:NO increases downwind the total concentrations will decrease with dispersion. Even so, the modelled exceedances (i.e. assuming all NO_x is NO_2) are well within the legal limit of 88 permissible hourly exceedances per year.

The cumulative ambient air quality impact (scenario 3- worst case) of all other modelled pollutants (i.e. for the respective averaging periods) are well within their applicable limits, as can be seen in Figure 5-3 to Figure 5-8 that follow.

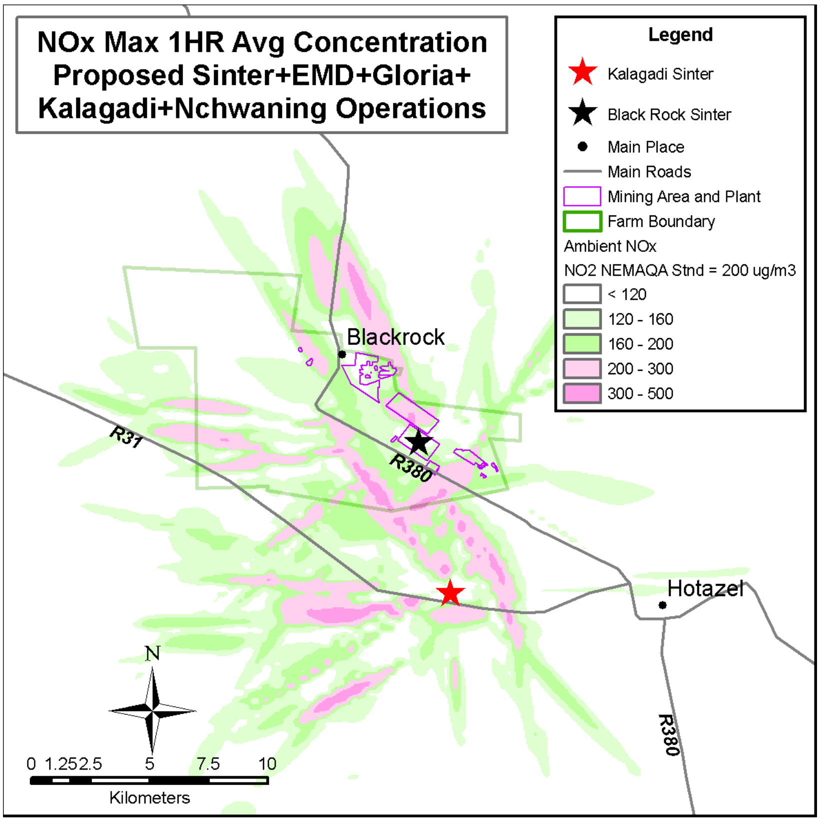


Figure 5-2: Maximum modelled 1 hour average ambient concentration for NO_x (cumulative)

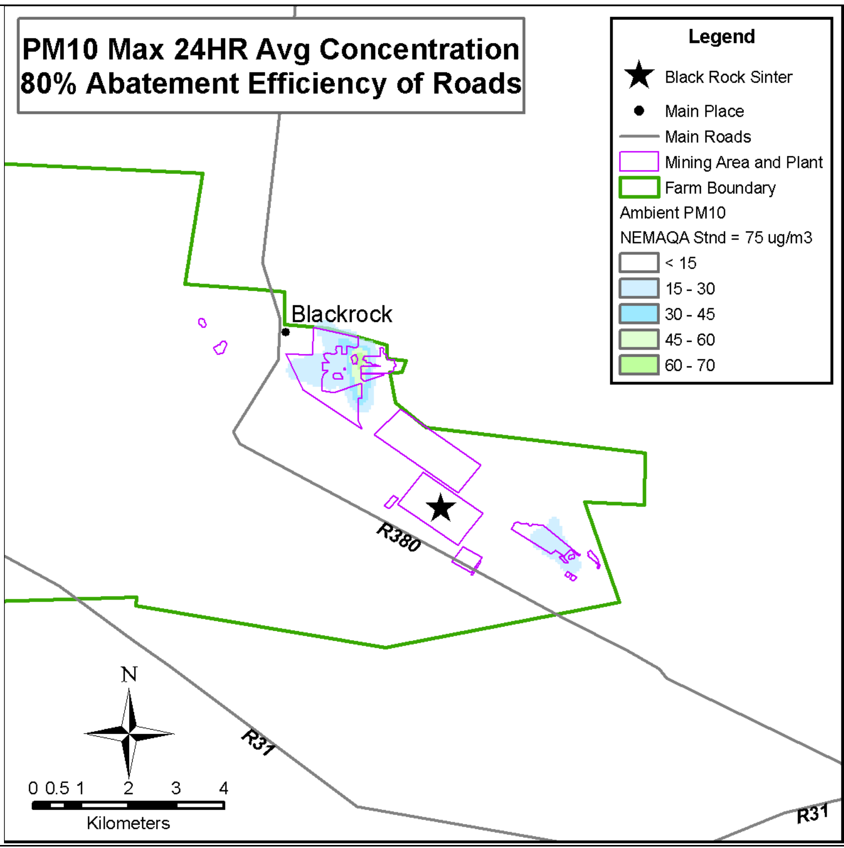


Figure 5-3: Maximum modelled 24 hour average ambient concentration for PM_{10} (cumulative)

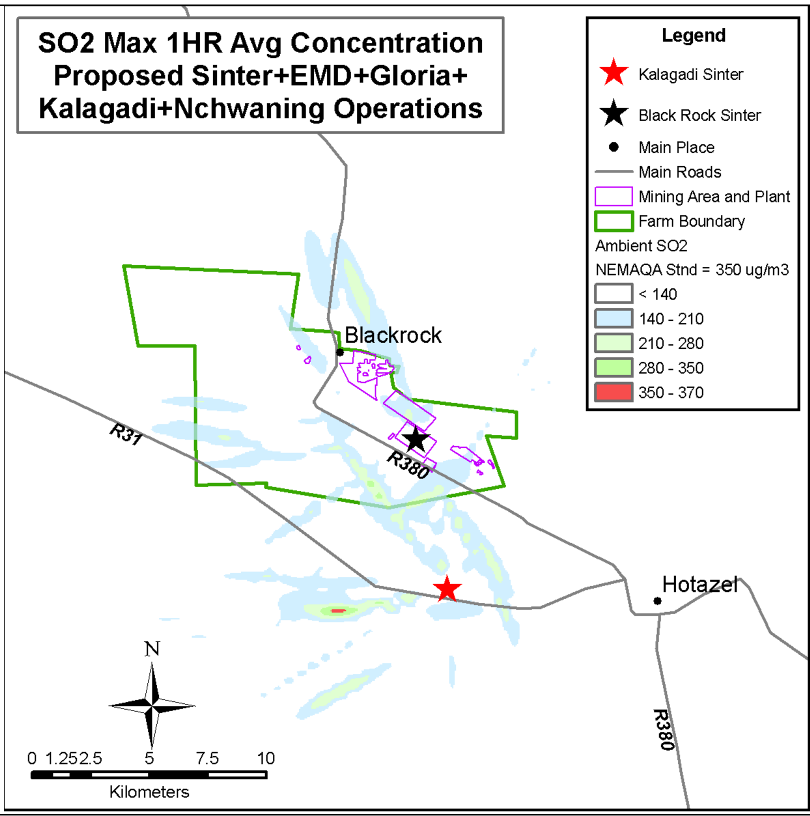


Figure 5-4: Maximum modelled 1 hour average ambient concentration for SO_2 (cumulative)

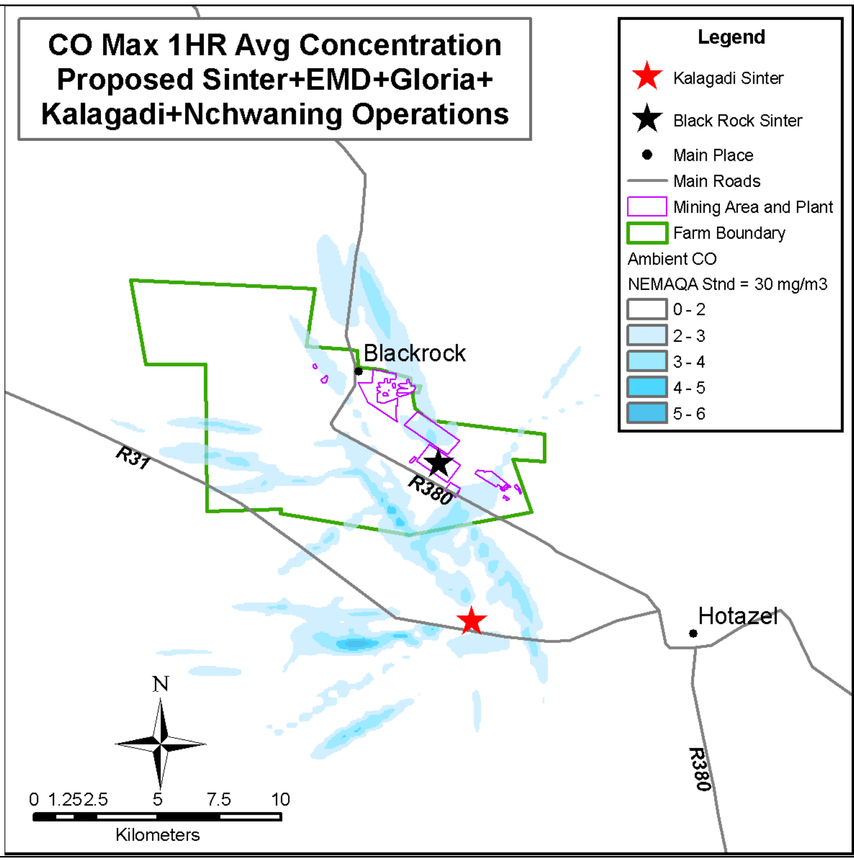


Figure 5-5: Maximum modelled 1hour average ambient concentration CO (cumulative – scenario 3)

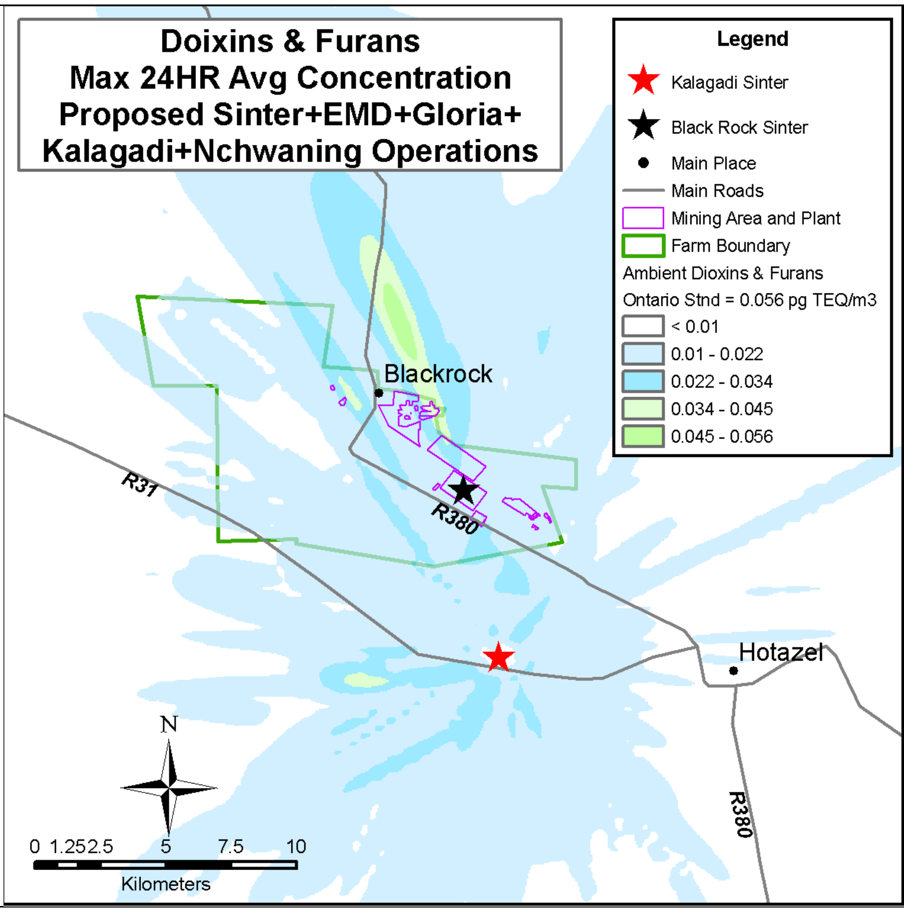


Figure 5-6: Maximum modelled 24 hour average ambient concentration for dioxins and furans (cumulative – scenario 3)

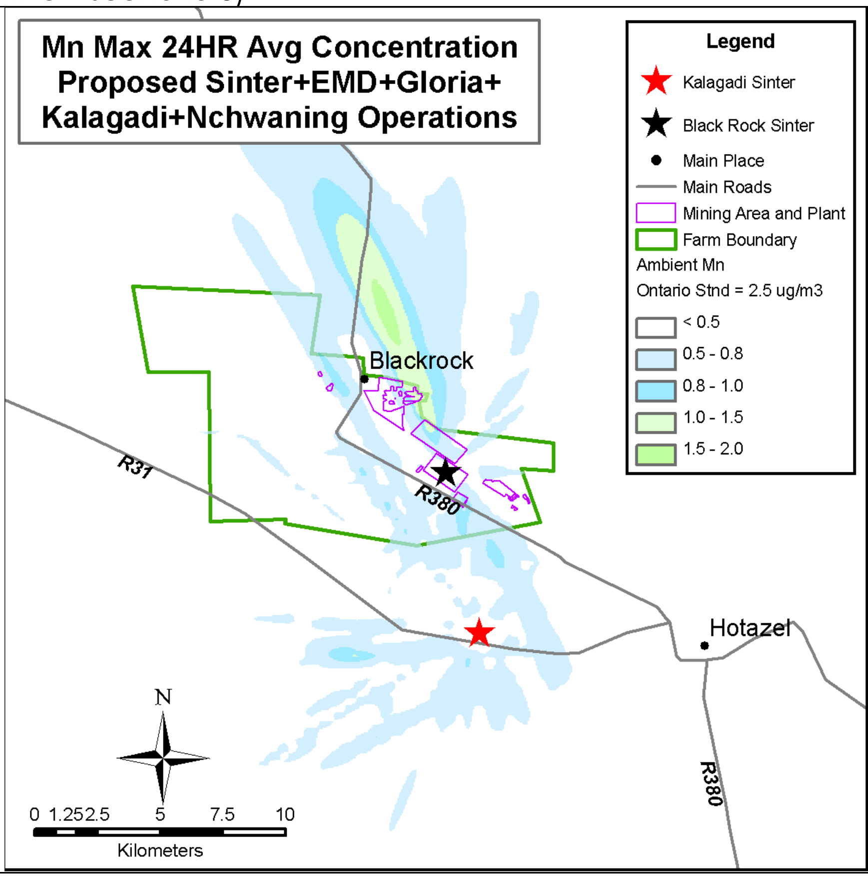


Figure 5-7: Maximum modelled 24 hour average ambient concentration for manganese -

Mn (cumulative – scenario 3)

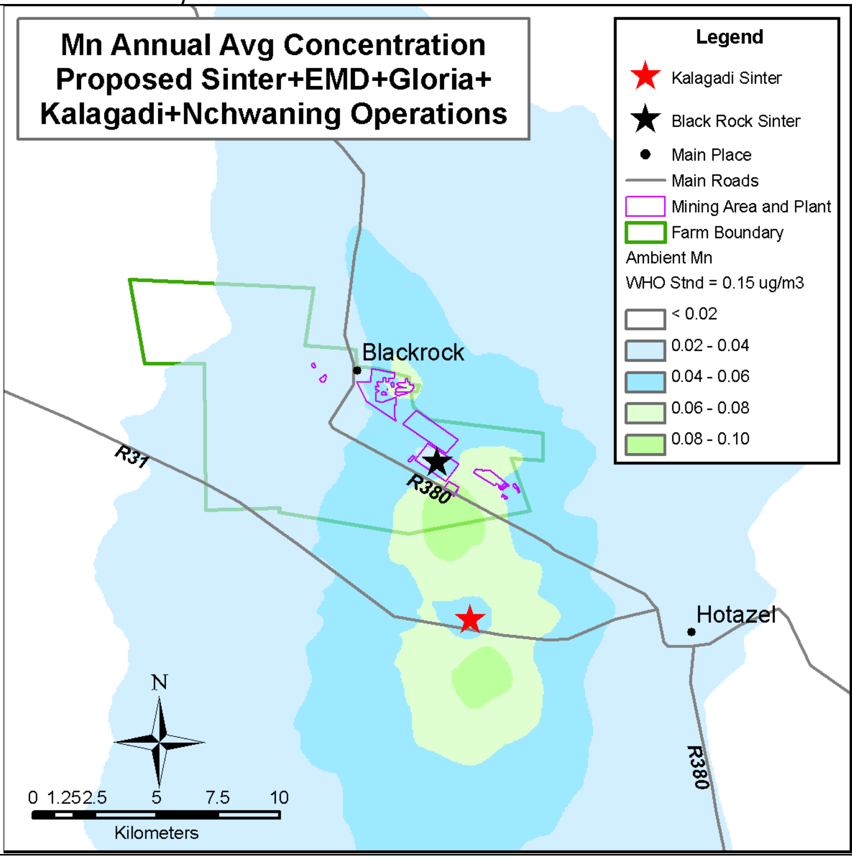


Figure 5-8: Maximum modelled annual average ambient concentration of manganese – Mn (cumulative – scenario 3)

Table 5-1: Impact on Air Quality – Significance Rating		
Nature (N)	Negative: Negative impacts on ambient air quality.	1
Extent (E)	Locally: Within the vicinity of the site.	2
Duration (D)	Very long-term: Impact will persist for the operational lifespan of the mine, which is estimated to be approximately 30 years	5
Intensity (I)	Major: Major when one considers the hazardous nature and potential extent (volume & dispersion) of the emissions that will be generated by the proposed activity (i.e. PM_{10}, NO_x, SO_2, CO, Mn, dioxins and furans).	4
Probability (P)	Definite: The proposed activities (i.e. more specifically the proposed sinter plant) will definitely result in emissions to atmosphere.	4
Mitigation (M)	Well mitigated: The impact can be mostly mitigated and the residual impact is negligible or minor (i.e. residual impacts on ambient air quality do not result in exceedances of human health-based ambient air quality limits, as regulated by law).	4
Enhancement (H)	N/A	-
Reversibility (R)	Irreversible: Once emissions are emitted to the atmosphere, no amount of time or money will allow	1

Table 5-1: Impact on Air Quality – Significance Rating			
	the proponent to 're-capture' such.		
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	44.8
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Severe**	112
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H)		-

5.2.5 MANAGEMENT ACTIONS

The primary mitigation measures required to abate the emission of pollutants to the atmosphere centre around:

- The installation of emission abatement technology at the sinter plant, such that stack emissions will indeed be maintained within regulated legal limits for all criteria pollutants. To this end, the proponent proposes the establishment of an ESP and bag-house plant, as well as flue-gas desulphurisation technology; and
- The application of a dust palliative on all major haul roads at the mine, with at least an 80% dust emission reduction efficiency. The EMPR is not prescriptive in terms of the exact palliative to be applied, but the source reduction of 80% must be achieved.

5.3 SURFACE- AND GROUNDWATER

5.3.1 INTRODUCTION

Considering the geology and hydro-geological characteristics of the site (i.e. the calcrete aquifer used by the surrounding farming communities, as well as boreholes visited during the hydrocensus and used for general farming), it should be regarded as a "Major aquifer system" based on the following:

- Public supply and other purposes: The aquifer plays a major role in the livelihood of the farming community surrounding BRMO; and
- Water quality: The water quality is good.

A specialist geo-hydrological assessment was undertaken for the EIA. The aim of which was to assess the potential impact that the proposed project will have on the geo-hydrological environment of the site and surrounds. A risk based approach was followed by the relevant specialist; where the emphasis of the investigation was to quantify the risk associated with the proposed project on:

- the soil and groundwater pathways and receptors;
- groundwater levels; and
- groundwater quality.

The two potential ground- and surface water impacts relevant to the EIA thus relate to:

- The potential pollution of ground- and surface water resources, such that the health and well-being of either humans, or agricultural livestock, ingesting such water may potentially be negatively affected; and
- The potential for mine dewatering to affect ground water levels in the area, such that adjacent farmers' access to water may be negatively impacted upon.

The largest potential sources of groundwater pollution during the operational phase of the project are deemed to be the bulk storage of oil/fuel, potentially contaminated run-off from 'dirty' mine works areas, underground sanitary arrangements, as well as the proposed TSF and FGD disposal facility. The specialist groundwater assessment report identifies the proposed tailings dams (i.e. TSF) in particular as posing a major threat to groundwater pollution at BRMO. This being due to the high infiltration of the Kalahari sands across the BRMO. The construction of the tailings dams, in the opinion of the groundwater specialist should be done to prevent leachate from entering the sub-surface. The same holds true for the FGD residue disposal site, irrespective of the extent thereof, which was not specifically assessed as part of the groundwater study due to limitations in available information regarding generation volumes and chemical composition.

5.3.2 TAILINGS RECOVERY VS. TSF LINER

BRMO propose to sequentially recovery tailings/fines from the proposed TSF cells in two year cycles as the material therein dries sufficiently (Section 3.5.3). In order to achieve this, it is the proponent's view that it is not economically viable to install a liner system beneath the TSF, as every time the material therein is mechanically recovered (i.e. by heavy duty excavator/vehicle) the liner would become damaged and need replacing at significant cost. The advantages of the proponent's proposal to recover the tailings waste from the TSF thus needs to be weighed up against the groundwater pollution threat actually posed by the tailings.

The advantages of recovering the tailings through the proposed sinter plant are as follows:

- BRMO is able to recover residual volumes of manganese, with economic value, from the waste tailings through the sintering process; and
- The recovery of the tailings would eliminate the presence of a tailings residue waste dump at the end of life of the mine; where ordinarily such a dump could hypothetically remain in position into perpetuity.

The disadvantage of the proponent's proposal to recover the waste tailings is the fact that it is only practical/economically viable if no pollution containment barrier/liner is installed beneath the TSF. One thus needs to carefully establish whether the pollution potential of the tailings is such that not lining the TSF presents a fatal flaw to the proposed recovery of the tailings.

The following points need to be noted in regard to the above:

- Although certain metallic pollutants are present in the tailings in elevated total concentrations [e.g. manganese (Mn) and selenium (Se)], they are present in a mineralogical form that appears to be relatively unavailable to the groundwater pathway (i.e. relatively immobile through leaching), as can be seen by the measured leachable values for the constituent pollutants;
- According to the groundwater specialist, "*the water quality from the boreholes sampled in the hydrocensus is generally good*" (Appendix 14); where it must, however, be acknowledged that the sampled boreholes cannot be construed as being a comprehensive groundwater monitoring network. None the less, the occurrence of 'good' quality groundwater in the proximity of the existing site must also be viewed from the perspective that the Gloria mine has been operational for approximately 35 years, with 'un-lined' tailings dams dating back the same approximate period;

- The site is located in a water scarce area; where rainwater ingress into the TSF is not likely to contribute to the generation of significant leachate over time (i.e. the site has a negative water balance; where evaporation exceeds precipitation). The exception to this is the tailings deposition phase; where tailings are added with significant moisture content to the TSF. The proponent proposes at least 'secondary thickening' technology implementation in this regard, to recapture some water from the tailings, with the result that less water is added to the TSF; and
- The source of inorganic pollutants in the waste tailings is the *in situ* parent material (geology) from which the ore is mined, and then subsequently washed, crushed and screened. The possible exception to this is 'nitrates', which may be derived from nitrate-based explosives used in underground blasting activities. No chemical additives are used in the processing of the mined ore. The processing of the mined ore does, however, change the physical form thereof (i.e. as relates to the tailings/fines, which may influence its pollution generating potential relative to the parent material, from a leach perspective).

Despite the aforementioned, the EAP believes there to be sufficient risk to groundwater associated with the tailings to still warrant the installation of at least a 'class C' landfill liner beneath the TSF. The risk is nominal, but a precautionary approach is advocated none the less.

5.3.3 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

Subject to the currently available information discussed in the preceding sections of this report, and with reference to the stated scope of work, the following was concluded by the groundwater specialist assessment:

- The Sedibeng Vaal-Gamagara Pipeline is the main source of water for all the mining areas. There is limited surface run-off in the Kalahari area, due to high infiltration during rain events combined with relatively high evapotranspiration potentials;
- The topography ranges from 1100 mamsl in the south west from where it dips to 990 mamsl to the Gamagara river in the north east. The Gamagara is non-perennial stream/river to the west of the study area;
- BRMO is within the Kalahari Manganese Field, which in turn lies within a large structural basin that extends approximately 40 km south to north and 5 km to 15 km east to west, dipping gently northwest. At Black Rock, near the northern end of the basin, the Transvaal System rocks lie about 300 m from the surface, beneath Kalahari Formation sands and calcretes, Dwyka tillites and Waterberg System shales and quartzites;
- A total of 23 boreholes were visited during the hydrocensus of February 2011 (Appendix 14). The minimum water level measured was 18.8 m. The maximum was 110 m at an arithmetic average of 69.6 m below surface. The reason for the variation of depth of the water levels below surface is due to the secondary alterations such as weathering and fracturing in the calcrete giving rise to different water levels across the area. The water level close to the Gamagara is much shallower than further west from it;
- In general the groundwater mimics the topography where it dips from the south-west to the north-east except in boreholes where there is extensive pumping activity such as in BRMO-7 and BRMO-20 (Appendix 14). These boreholes are used for domestic use and stock farming;
- The only elevated constituents compared to the maximum allowable drinking water standard (SANS 241) were found in boreholes BRMO-1 and BRMO-9

(Appendix 14). The elevated constituent was NO_3 as N. The source of the elevated nitrates may be due to livestock, such as horses and cattle, contaminating the water in the vicinity of these boreholes;

- These elevated values of NO_3 rendered the water quality of BRMO-1 and BRMO-9 (channel) as potentially negative to human health. All other anions/cations analysed for by means of ICP-OES were either below the detection limit of the analytical method, or at levels acceptable to drinking water standards. This indicates that the groundwater in general is of good quality;
- The site is underlain by the Kalahari formation which consists of a top layer of aeolian sands followed by calcrete of tertiary age. If weathered, the calcareous sands have the favourable characteristics of porosity and permeability. The calcrete deposit acts like a "sponge";
- The potential of groundwater occurrence in the calcrete depends on the presence of secondary alteration and fracturing in the calcrete. Weathering and fracturing may increase the aquifer potential, thus zones of weathering and fracturing within the calcrete will act as targets for potential groundwater exploration. The maximum depth of the Kalahari formation is ±125 m. The arithmetic average depth of the static water levels in the boreholes found during the hydrocensus at BRMO was 69.6 m, with a maximum depth of 110 m below the surface. If the depth of the Kalahari formation is considered with the water levels found in the hydrocensus it can be concluded that the farmers tap their water from this weathered/fractured calcrete aquifer. The average recharge values assigned to calcrete is ±10% (Vegter, 2005) of the mean annual precipitations (MAP). The water quality from the boreholes sampled is generally good; and
- Considering the geology and hydrogeology characteristics of the site, the calcrete aquifer used by the farming community for general farming should be regarded as a major aquifer system.

Based on the limited boreholes visited during the hydrocensus, the specialist deems there currently to be a low risk for the users found in the hydrocensus to be impacted by either dewatering, or contaminated groundwater originating from the proposed project. This was based on:

- the lack of groundwater encountered at BRMO; and
- current water levels and water quality data, and the vicinity of water users encountered at BRMO during the hydrocensus.

The relevant specialist deems that caution should, however, be exercised as no historical data from boreholes were available and, therefore, trends regarding water levels and quality could not be established in the said study. The establishment of a comprehensive operational phase groundwater monitoring network in this regard is deemed essential.

The specialist groundwater assessment did not include the specific assessment of the proposed FGD disposal facility, as there are still substantial information gaps in this regard with respect to the chemical composition and volumes of the FGD residue to be generated. As such, a 'class A', or H:H equivalent containment barrier is deemed a minimum ('worst case') requirement for any such disposal facility or temporary storage areas established on site. In addition, geo-physics data obtained for the site must be used in combination with specialist geo-hydrologist inputs to inform the environmentally sound placement of such facilities. Detailed engineering designs and supporting geo-physics data (in relation to the environmentally sound positioning of the facility) must be submitted to the DWA and DEA for consideration and approval prior to construction and operation of the facility.

A subsequent geo-physics survey of the affected project area, however, yielded the following conclusions pertaining to the potential underlying occurrence of preferential groundwater flow pathways/geological structures that may act to transport groundwater pollution from the site (GPT, 2011):

- Based on the interpretation of the results, recommendations could be made regarding the design of an optimal groundwater monitoring network for gathering information on the depth of the water table and the groundwater chemistry; and
- Due to the thickness of the Kalahari sands, which overlies fractured calcrete and Dwyka sediments of the Karoo Formation, no definite secondary structures in the floor sediments could be mapped. Note that the regional groundwater table is in excess of 75 mbgl, rendering the unsaturated zone as a buffer zone regarding the vertical infiltration of contaminants. The location is therefore suitable for the construction of the slimes dam.

The following was recommended by the relevant specialist, based on the geophysical data:

- Taking into account the lay-out of the operation (future mine dumps, plant, etc.). Three boreholes (GPT8, 9 and 10) can be drilled for plume monitoring purposes as they are situated very close the proposed slimes dam location; and
- It is further recommended that all boreholes be drilled in the presence of a competent hydro-geologist who should advice with matters regarding borehole construction such as depth and installation of casing.

Table 5-2: Impacts on groundwater		
Nature (N)	Negative: Negative impact on the groundwater environment.	1
Extent (E)	Locally: Within the general vicinity of the site	2
Duration (D)	Very long term: For example, groundwater pollution, even if treated, will persist for a very long time – if not permanently	5
Intensity (I)	Major: The disturbance to the environment is enough to disrupt existing functions or processes (i.e. agricultural practices and human health due to borehole water ingestion), resulting in reduced diversity; the system could be damaged to the extent that it is no longer what it used to be, but there are still remaining functions; the system will probably decline further without positive intervention.	4
Probability (P)	Likely: There is a possibility (however low, by virtue of low measured pollutant mobility) that an un-lined TSF could impact negatively on groundwater quality.	2
Mitigation (M)	Unmitigated: No mitigation is planned by the proponent (at least with respect to not lining the TSF).	1
Enhancement (H)	N/A	-
Reversibility (R)	Slightly reversible: The pollution of groundwater is by no means easy to reverse and will require much effort, taken immediately after the impact, and even then, the final quality will not match the original environment prior to the impact.	2

Table 5-2: Impacts on groundwater			
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	37.3
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**High**	56
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

5.3.4 MANAGEMENT ACTIONS

The following mitigation and monitoring is deemed essential to the project's successful implementation:

- The development of a comprehensive groundwater monitoring network for the BRMO and according to the specialist recommendations documented in the EMPR (i.e. with respect to modelling parameters, frequencies, etc.);
- Geo-physics need to be carried out to delineate geological structures such as faults which can act as preferential groundwater flow paths;
- The monitoring network should be implemented as soon as possible to get background data before the project commences, such that operational impact trending can be undertaken and further recommendations can be made after the implementation of the monitoring network; and
- Temporal and spatial trend analysis of the groundwater quality should be conducted bi-annually to determine whether the priority areas are being managed as well as to identify new areas of concern. The monitoring system should then be adapted accordingly.

The project EMPR addendum, furthermore, provides for extensive management actions pertaining to:

- The separation and management of 'clean' and 'dirty' storm water management;
- The management of bulk fuel and oil storage facilities, such the potential leaks and spills are prevented from entering into the groundwater environment (e.g. bunding, emergency response procedures, etc.); and
- The management of underground sanitary practices.

5.4 NOISE

5.4.1 INTRODUCTION

The specialist noise impact assessment referred to in section 8.1.10 of the EIA included an assessment of the potential noise related impacts for the proposed project during the operational phase thereof. The noise specialist refers to 'noise' as, "*part of our daily exposure to different sources which are either a) part of daily life, or b) intrusive sources, such as traffic, that both form part of the ambient noise and which people get accustomed to without noticing the higher sound levels*". Any person in the workplace and at home is exposed to the following noise levels as given in Table **5**-**3**; where the table is aimed at providing a frame of reference to IAPS and the regulator alike for the anticipated cumulative noise levels as a result of the project.

Table 5-3: Table Showing Noise Levels for Typical Household Noises

	Activity	dBA
Communication	Whisper	30
Communication	Normal Conversation	55-65
Communication	Shouted Conversation	90
Communication	Baby Crying	110
Communication	Computer	37-45
Home/Office	Refrigerator	40-43
Home/Office	Radio Playing in Background	45-50
Home/Office	Background Music	50
Home/Office	Washing Machine	50-75
Home/Office	Microwave	55-59
Home/Office	Clothes Dryer	56-58
Home/Office	Alarm Clock	60-80
Home/Office	Vacuum Cleaner	70
Home/Office	TV Audio	70
Home/Office	Flush Toilet	75-85
Home/Office	Ringing Telephone	80
Home/Office	Hairdryer	80-95
Home/Office	Maximum Output of Stereo	100-110

The aforementioned study considered the potential cumulative impacts of the following proposed operational, noise generating, activities in relation to current ambient noise levels:

- Increased traffic volumes;
- Processing plant;
- Sinter plant;
- Nchwaning II – sinter plant conveyer;
- RoM conveyer (i.e. Gloria shaft complex – sinter plant complex); and
- Gloria surface shaft complex mechanical ventilation fan.

The effects of time of day, as well as wind direction, were taken into account by the noise assessment specialist in undertaking the aforementioned study.

5.4.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

Using calculations of the anticipated line-of-sight noise level attenuations (i.e. the extent to which noise will reduce with cumulative distance from the source thereof) for similar existing infrastructure at BRMO, the noise specialist was able to model the potential cumulative impacts of the applicable, 'noisy', project aspects on ambient noise levels (dBA) at various potentially sensitive noise receptors at BRMO (Figure 5-9). Figure 5-9 and Figure 5-10 provide a graphic representation of the anticipated ambient noise levels (dBA) following project implementation.

In terms of noise increases, people exposed to an increase of 2 dBA or less would not notice the difference. Some people exposed to increases of 3-4 dBA will notice the increase in noise level, although the increase would not be considered serious. Noise increases of 5 dBA and above are very noticeable, and, if these are frequent incidents, or continuous in nature, could represent a significant disturbance.

From Table 5-4 it can be seen that no increase/intrusion in ambient noise levels (i.e. that could be considered as 'disturbing') is anticipated from the operational phase of the proposed project. The only area where potentially significant noise level increases are modelled is along the R380, opposite the proposed Gloria surface shaft complex. No sensitive noise receptors are present at this position that would make the modelled ambient noise level intrusion/increase significant.

Table 5-4: Potential Operational Phase Noise Intrusion Levels

Receptor	**Prevailing noise level (Daytime) - dBA**	**Prevailing noise level (Night time) - dBA**	**Calculated noise level - dBA**	**Noise impact (Daytime)- dBA**	**Noise impact (Night time)- dBA**
Along the R380	62.7	54.0	58.2	No intrusion	4.2
Acacia guesthouse	46.6	47.1	42.9	No intrusion	No intrusion
Schoonspruit village	47.9	40.7	41.6	No intrusion	0.9
Farmhouse east of Gloria mine	42.8	42.6	40.7	No intrusion	No intrusion
Measuring point 22 which is opposite the proposed sinter plant	62.7	54.0	53.1	No intrusion	No intrusion
Opposite the Crusher plant along the R380	62.7	54.0	54.5	No intrusion	0.5
Opposite the Surface plant complex along the R380	62.7	54.0	61.1	No intrusion	7.1

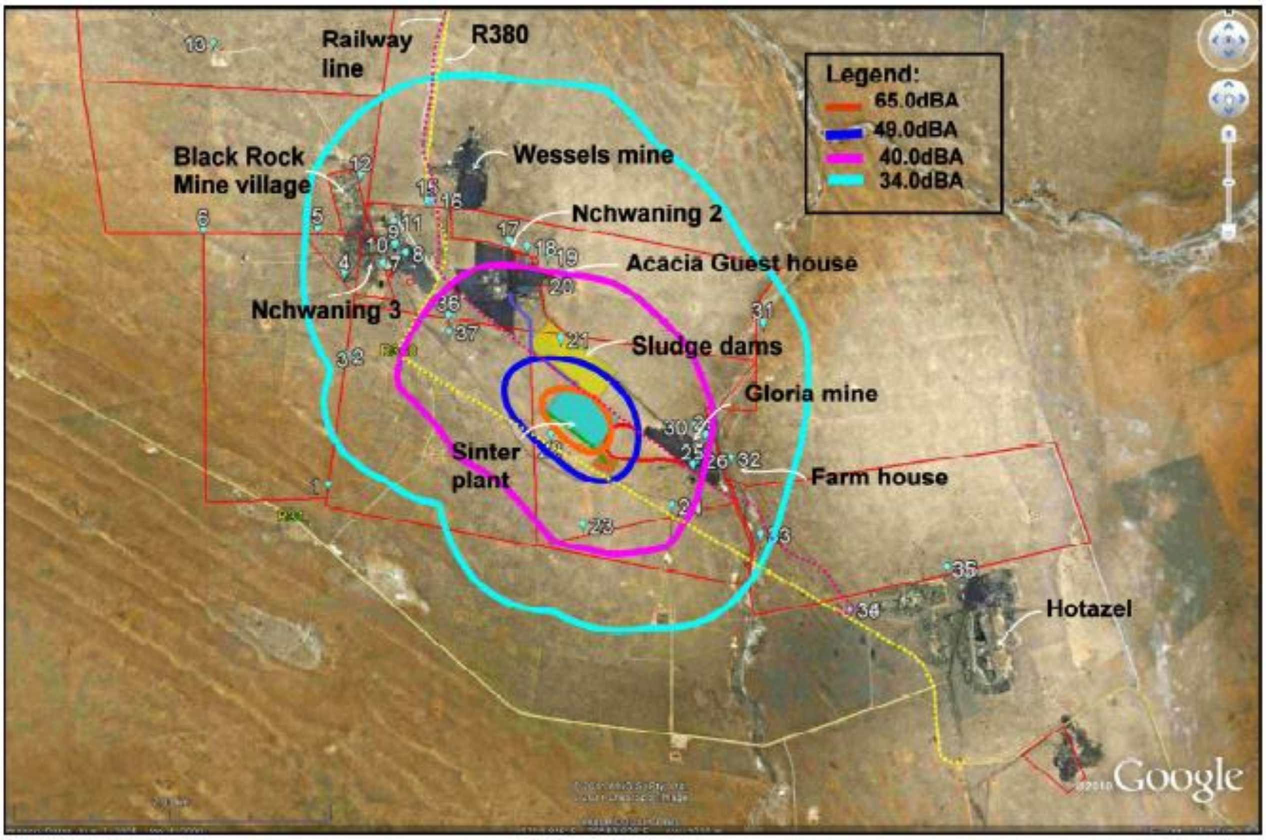


Figure 5-9: Modelled noise contours for the proposed project (south-easterly wind)

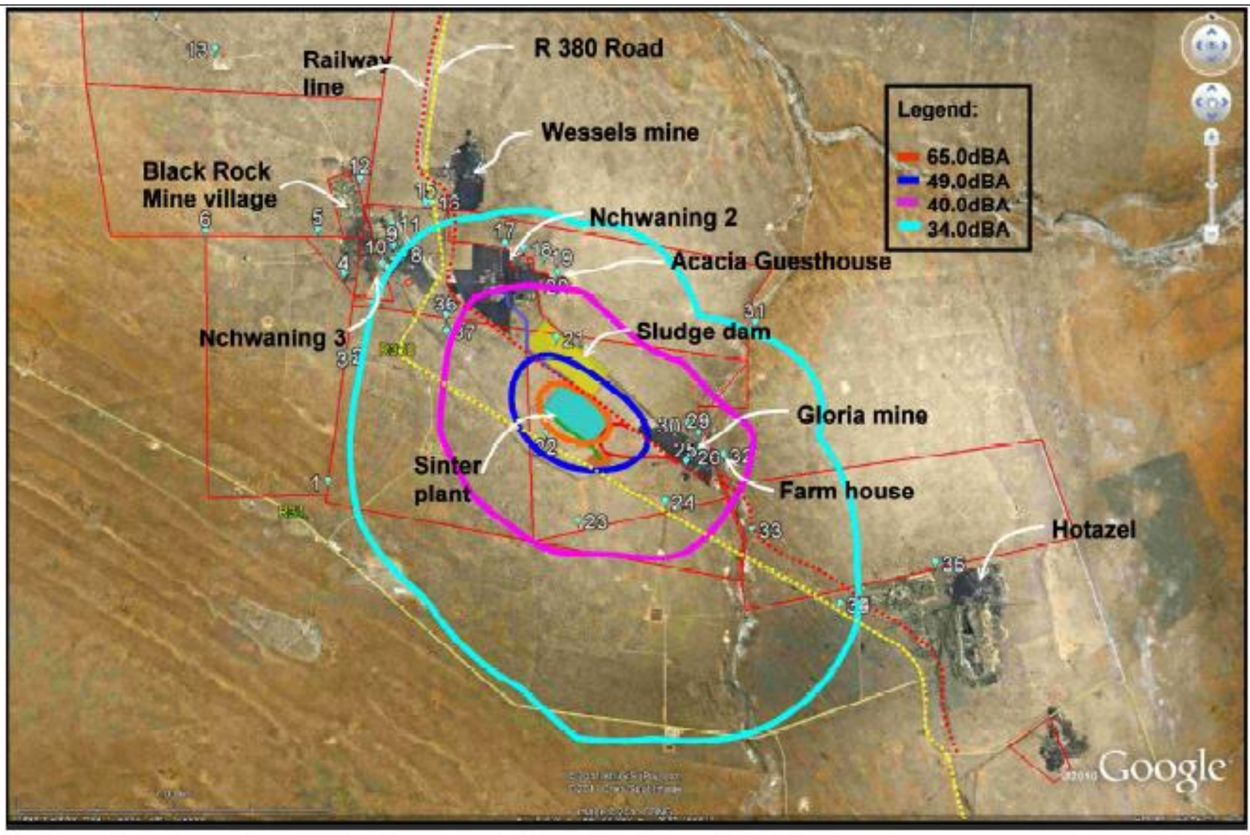


Figure 5-10: Modelled noise contours for the proposed project (north-westerly wind)

Table 5-5: Operational phase noise impacts			
Nature (N)	Negative: Potential increases to current ambient noise levels		1
Extent (E)	Locally: Within the vicinity of the site		2
Duration (D)	Very long term: Noise impact for the operational extent of the mining operations		5
Intensity (I)	Moderate: The anticipated, noise impacts will not result in the discontinuation of environmental function and processes. The anticipated impact will, however, add additional stress to the bio-physical environment, but this is not expected to be significant.		3
Probability (P)	Likely: There is a possibility that noise impacts will occur, to the extent that provisions may need to be made to negate such.		3
Mitigation (M)	Slightly mitigated: A small reduction in noise level generation is possible through appropriate mitigatory actions.		2
Enhancement (H)	N/A		-
Reversibility (R)	Mostly reversible: Reversible at any stage of the operational lifetime of the mine, as well as at closure; where all noise generating infrastructure will be decommissioned.		4
Significance Rating with Mitigation -	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	21

Table 5-5: Operational phase noise impacts			
Negative Impact (S)			
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	31.5
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

5.4.3 MANAGEMENT ACTIONS

The following three primary variables should be considered by the proponent when designing acoustic screening measures for the control of sound and/or noise:

- The source - reduction of noise at the source;
- The transmission path - reduction of noise between the source and the receiver;
- The receiver - reduction of the noise at the receiver.

The last option is not deemed applicable, as it is far better to control the noise levels at the source.

Should there be complaints noise disturbance, or should noise measurements indicate noise nuisance, then the source of the noise must be investigated. Reduction of noise at the source must be implemented, the following activities may be considered:

- Acoustic screening to take place at rotating parts, blowers and fans which will include the use of acoustic absorbent material to be used at the inside of acoustic screens in order to ensure an equivalent noise level of no more than 86.0 dBA at 5 m away from the source;
- Any duct outlet at the ventilation shafts to face away from noise sensitive areas; and
- Haul roads within the plant area to be maintained and all potholes to be removed on a daily basis.

The following measures must be considered prior to the acquisition of earthmoving equipment by the proponent and/or contractors:

- Enclosure of engine bays;
- Modification of radiator fan design and materials;
- Installation of louvers on radiator and hydraulic cooling fans; and
- Re-engineering of exhaust systems.

5.5 VISUAL AND AESTHETIC IMPACTS

5.5.1 INTRODUCTION

The specialist Visual Impact Assessment (VIA) undertaken for the project took cognisance of the following principles and concepts underpinning Visual Input, according to guidelines for involving visual and aesthetic specialists in EIA processes:

- An awareness that 'visual' implies the full range of visual, aesthetic, cultural and spiritual aspects of the environment that contribute to the areas sense of place;
- The consideration of both the natural and the cultural landscape, and their inter-relationships;
- The identification of all scenic resources, protected areas and sites of special interest, together with their importance in the region;

- The nature and location of any cultural heritage sites, and areas of special or historical interest;
- An understanding of the landscape processes, including geological, vegetation and settlement patterns, which give the landscape its particular character or scenic attributes;
- The need to include both quantitative criteria, such as 'visibility', and qualitative criteria, such as landscape or townscape 'character';
- The need to include visual input as an integral part of the project planning and design process, so that the findings and recommended mitigation measures can inform the final design, and hopefully quality of the project.

Importantly, background research in respect of informing the legislative context of the area with respect to visual impact was undertaken and revealed that:

- No listed or proclaimed sites, such as nature reserves, biosphere reserves, proclaimed scenic routes, National parks or proclaimed view-shed protection areas were identified in proximity to the proposed development terrain; and
- No scenic routes, special areas or proclaimed heritage sites are within proximity of proposed development terrain.

5.5.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The proposed development area was deemed by the relevant specialist to be of low scenic value, predominantly due to:

- An absence of interesting landscape features;
- The lack of contrasting vegetation types in the area;
- An absence of water in the area;
- A lack of enhancement in visual quality contributed by adjacent scenery;
- The relatively widespread distribution of the particular vegetation types making up the development terrain; and
- Existing environmental modifications (i.e. mining activity in the area) add variety, but are discordant and promote strong disharmony.

An assessment of 'visual sensitivity' will vary with varying user types/receptors. Recreational sightseers, for example, may be highly sensitive to changes in visual quality. Residents in the immediate environment would welcome the augmentation for the purposes of job creation and a few eco-tourist facilities in proximity to the proposed development might view it as a negative augmentation. It is, however, inferred that occasional sightseers will be outnumbered by individuals who frequent the R380 road specifically for the purpose of engaging in mining-related activities in the area. The towns of Black Rock and Hotazel were appropriated for the very purpose of supplying accommodation to people engaged in mining-related activities.

The VIA identified two sensitive visual receptors for the project, as follows:

- Vantage point 1 – The Acacia Guesthouse to the east of the Nchwaning II Mine (a recreational facility that provides overnight facilities, mainly to mine visitor, or temporary employees of the mine itself); where it is assumed that the predominant type of viewers at this vantage point will perceive visual changes to the landscape as neutral or positive; and
- Vantage point 2 – Along the R380 road to the south west of the proposed development terrain, adjacent to the proposed entrance to the new Gloria surface shaft complex; where it is accepted that from this vantage point, the development will be highly visible to a substantial number of viewers (i.e. road

users). It was also inferred that the kind of viewers exposed to the change in scenic quality will have a neutral to positive attitude toward it.

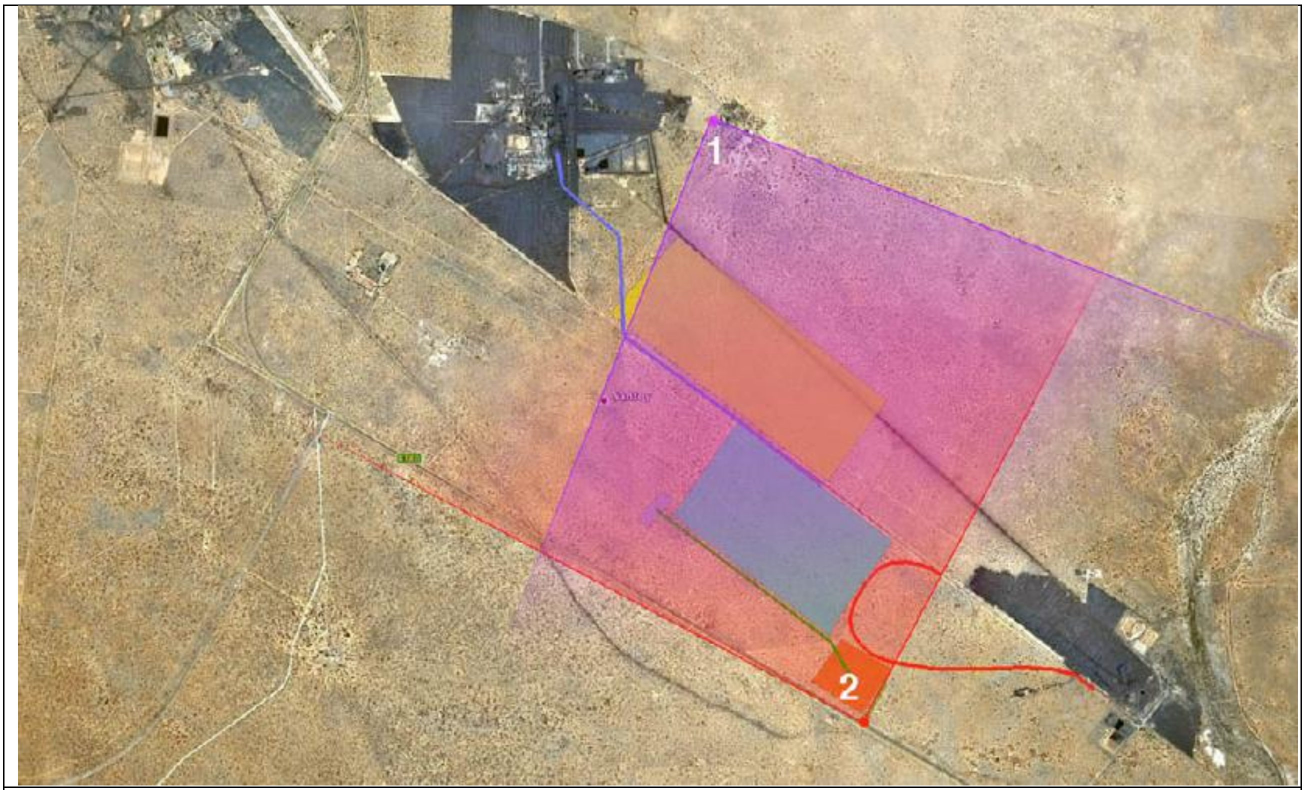


Figure 5-11: Identified Sensitive Visual Receptors

Figure 5-12 to Figure 5-15 provide view simulations for day- and night time visual quality changes anticipated from each of the aforementioned visual receptors as a result of the development. The figures provide one with an idea of what the proposed project would look like from a ground level perspective if implemented.
The specialist VIA undertaken for the project concluded the following:

- *"The existing scenic quality of the area indicates low scenic quality;*
- *The existing cultural modifications and adjacent industrial activity surrounding the propose development will constitute a potential low contrast ratio with the environment;*
- *Due to the distance from vantage point 1, it is considered to be marginally visible;*
- *Due to the proximity to vantage point 2, it is considered to be highly visible;*
- *The proposed development poses a low visual change rating*; and
- *The proposed development poses a moderate visual impact rating*".

Table 5-6: Visual and Aesthetic Impact Significance Rating		
Nature (N)	Negative impact on visual character of the area	1
Extent (E)	Locally: Within the vicinity of the site and immediate surrounds	2
Duration (D)	Life of Mine: Approximately 30 years	5
Intensity (I)	Low: Visual and scenic resources are not affected	2
Probability (P)	Definite: Distinct possibility that the impact will occur	4
Mitigation (M)	Unmitigated: No practical mitigation possible	1
Enhancement (H)	N/A	-

Reversibility (R)	Entirely reversible at Mine Closure and Decommissioning		4
Significance Rating with Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	22.4
Significance Rating without Mitigation - Negative Impact (S)	N x (E+D) x I x P ÷ ½(M+R)	**Moderate**	22.4
Significance Rating -Positive Impact (S)	N x (E+D) x I x P x (H).		-

5.5.3 MANAGEMENT ACTIONS

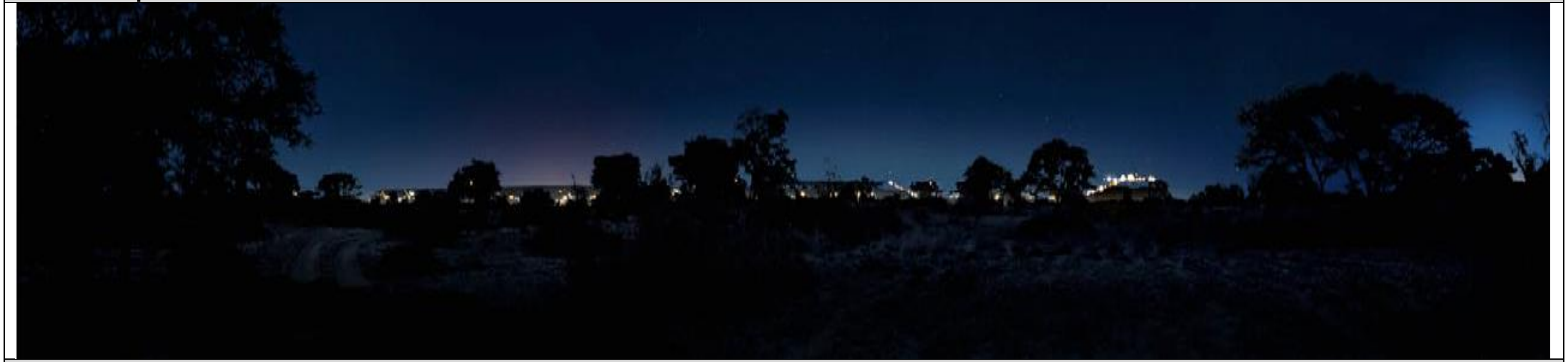
Due to the development's size, as well as its distance from identified sensitive receptors, no implementable or manageable management actions can be suggested that would be effective, other than the painting of structural surfaces in neutral colours, similar to the surrounding vegetation; where even this potential mitigation measure is not deemed practical due to the nature and scale of the proposed development.

Pre Development View

Post Development View Simulation

Figure 5-12: Daytime Pre- and Post-Development View Simulations (Vantage Point 1 Acacia Guesthouse)

Pre Development View



Post Development View Simulation

Figure 5-13: Night time Pre- and Post-Development View Simulations (Vantage Point 1 Acacia Guesthouse)

Pre Development View

Post Development View Simulation

Figure 5-14: Daytime Pre- and Post-Development View Simulations (Vantage Point 2 – Road R380)

Pre Development View

Post Development View Simulation

Figure 5-15: Night time Pre- and Post-Development View Simulations (Vantage Point 2 – Road R380)

5.6 TRAFFIC

To accommodate the proposed mine expansion and proposed sinter plant development, the staff compliment at the mine would increase by approximately 1 000 people by 2017, bringing about potentially significant additional light duty- and bus traffic increases between the mine and Kuruman/Kathu; where the bulk of additional employees will be sourced and housed.

In addition, the proposed doubling of mine output/capacity from 3 mtpa to 6.3 mtpa will bring about potentially significant increases in the number of heavy duty haul trucks using the R380 road to and from the BRMO. The proponent anticipates an approximate 50:50 split between the transport of mine product/s by road and rail respectively.

The potential impacts of increased traffic volumes on road users and R380 road condition respectively, will be similar for the operational phase as they will for the construction phase described previously (Section 8.1.11). This is particularly true with respect to the requirements for the implementation of a strategic R380 upgrade strategy, as described in detail in Section 8.1.11. This is probably more pertinent to the operational phase of the project.

No detailed impact assessment is provided for operational phase traffic impacts, as the potential impacts and required mitigation are already well described and assessed in Section 8.1.11 of the EIA Report.

5.7 SOCIO-ECONOMICS

5.7.1 INTRODUCTION

A specialist SEIA was commissioned in support of the EIA process for the proposed project. The evaluation of the net impact of the proposed project during its operational phase is presented in the following section. The information under analysis is the average impact that can be expected on an annual basis during the operational life of the facility at its full operational capacity. Due to the longevity of the project, the impacts related to this phase are considered sustainable.

5.7.2 IMPACT DISCUSSION & SIGNIFICANCE ASSESSMENT

The operations of the facility will ramp up over a period of five years, starting from the second year of the construction period. Once full capacity is achieved, the operations of the mine and the sinter plant complex would earn the economy between R2.9 billion and R4.7 billion on an annual basis through exports of manganese ore. The operating expenditure of R1 055 million (2011 prices) per annum will create and thereafter support for 25 years the production in the country to the value of R2 757.7 million, which translates into R875.3 million of value added. Slightly more than three quarters of the value added to be generated by operations are expected to be created in the Northern Cape. This could increase the provincial economy by 1.1%. Given that direct effects on value added will be accounted in the district economy, the effect on the JT Gaetsewe DM could be the growth of its economy 1.9% and its mining sector by 2.9%.

Jobs to be created as a result of operating expenditure will be sustainable and will be retained for at least 25 years – until the closure of the mine. It is estimated that on an annual basis, 3 517 FTE (Full Time Equivalent) jobs will be supported. Of these, 846 FTE jobs will be created on site itself and the rest will be created through indirect and induced effects. The owner is planning to establish a learning development centre to support skills development initiatives, as well as provide for learnership opportunities within the mine and the sinter plant.

The creation of new employment opportunities will have a positive effect on earnings of benefiting households. Overall, R464 million (2011) in salaries and wages will be paid out annually to the households, increasing their living standards. The only prominent negative socio-economic impact that could be associated with the operations of the proposed development relate to the household and service delivery situation. Most likely some of the positions created at the mine and the sinter plant will need to be filled by skilled workers from outside the district. This means that these workers and their household will be creating a demand for accommodation, both rental and permanent. As a result, the housing situation and service delivery situation in the district could be aggravated.

The SEIA provides the specialist's detailed impact assessment on numerous operational related socio-economic aspects. Table 5-7 that follows, as well as the preceding paragraphs, aim to provide readers with a concise summary of the anticipated significance of socio-economic impacts (positive and negative) to potentially result from the operational phase of the project.

Table 5-7: Summary of socio-economic impacts evaluation

Impact	Status		Direct		Indirect		Induced	
Impact during operations								
Impact on balance of payment	Negative	BM	Moderate	-22.5	-	-	-	-
		AM	Moderate	-22.5	-	-	-	-
Net impact on production	Positive	BM	Moderate	-30	Moderate	-33.8	Moderate	-22.5
		AM	Moderate	-30	Moderate	-33.8	Moderate	-22.5
Net impact on GDP-R	Positive	BM	Moderate	-30	Moderate	-33.8	Moderate	-22.5
		AM	Moderate	-30	Moderate	-33.8	Moderate	-22.5
Net impact on employment	Positive	BM	High	-60	Moderate	-33.8	Moderate	-22.5
		AM	High	-60	Moderate	-33.8	Moderate	-22.5
Net impact on income	Positive	BM	High	-60	Moderate	-33.8	Moderate	-22.5
		AM	High	-60	Moderate	-33.8	Moderate	-22.5
Impact on skills development	Positive	BM	Moderate	-48	-	-	-	-
		AM	High	-72	-	-	-	-
Impact on housing and basic service delivery	Negative	BM	Low	10.5	-	-	-	-
		AM	Negligible	7	-	-	-	-

During a full operational capacity, the project will further stimulate the development of national, provincial and most importantly local economies. During a full operational capacity, the expanded mine will stimulate the net production in the economy to the value of R2 757.3 million per annum and increase the national GDP-R by R875.2 million per annum. On an annual basis, 3 615 new employment opportunities will be supported and R463.9 of net income will be paid out to households. The socio-economic impact on the local economy will be particularly noticeable, as its size is expected to increase by 1.9% and the employment situation notably improve.

In summary, from a socio-economic point of view, the proposed project offers far greater societal and economic benefits than the current activity, which represents a "no go" option. Thus, it represents the preferred option amongst the two considered (i.e. the "no go" option and the proposed development option).

5.7.3 MANAGEMENT ACTIONS

The facility should be encouraged to procure materials, goods, services and products required for the operation of their businesses from local suppliers to increase the impact on local and regional economies, without jeopardising its own efficiency and competitiveness. Furthermore, where possible, the local labour should be considered for employment to increase the positive impact on the district economy (i.e. JG Gaetsewe DM).

In order to increase the income retention in the local economy, local Environmental Specialists should be employed to provide selected services, such as cleaning, security, transportation, etc. Skills development initiatives, including learnerships and on-job training, should continue to be pursued. A learner development centre planned by Assmang should also provide opportunities for developing skills and gaining knowledge in a wider field to allow local communities to increase their employability in sectors supporting mining activities and beyond.

Given the situation with housing in the local area, consideration should be given to the provision of housing to the workers. Information regarding the project and the potential requirements with respect to water and electricity will also need to be provided to the local municipality and other authorities to allow for adequate planning and timely provision of services. Assistance with housing in the local area could reduce the significance of this impact to negligible.