4 CONSIDERATION OF ALTERNATIVES

4.1 INTRODUCTION

The purpose of this Section is to present a detailed description of project alternatives considered in the ESIA process. A detailed motivation for selecting specific alternatives, in line with the mitigation hierarchy of avoid, abate, mitigate and replace/compensate is presented. The assessment of alternatives is based on new information gathered during the present ESIA process, but also uses information gathered and used for assessing alternatives in the EIA process completed in 2000 (SRK Consulting).

4.2 MITIGATION HIERARCHY: AVOIDANCE, PREVENTION AND MINIMIZATION OF IMPACTS

The biodiversity sensitivity of the project area requires that the consideration of alternatives is closely aligned with the Mitigation Hierarchy (*Table 4.1* below). The priority in mitigation is to first avoid or reduce at source the magnitude of the impact from the associated Project activity through the design of the project ie avoid by siting or rerouting the activities away from sensitive areas. Once this is achieved, the resultant effect to the resource/receptor can be addressed via abatement at a site then the receptor level. Restoration or rehabilitation can then be undertaken and only once the above have been considered can compensatory measures or offsets be considered (ie to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude). In line with good practice, avoidance has been applied to help guide the location alternatives.

Table 4.1 Mitigation Hierarchy

• **Avoid at Source; Reduce at Source:** avoiding or reducing at source through the design of the Project (e.g., avoiding by siting or re-routing activity away from sensitive areas or reducing by restricting the working area or changing the time of the activity).
• **Abate on Site:** add something to the design to abate the impact (e.g., pollution control equipment, traffic controls, perimeter screening and landscaping).
• **Abate at Receptor:** if an impact cannot be abated on-site then control measures can be implemented off-site (e.g., noise barriers to reduce noise impact at a nearby residence or fencing to prevent animals straying onto the site).
• **Repair or Remedy***:* some impacts involve unavoidable damage to a resource (e.g. agricultural land and forestry due to creating access, work camps or materials storage areas) and these impacts can be addressed through repair, restoration or reinstatement measures.
• **Compensate in Kind; Compensate Through Other Means:** where other mitigation approaches are not possible or fully effective, then compensation for loss, damage and disturbance might be appropriate (e.g., planting to replace damaged vegetation, financial compensation for damaged crops or providing community facilities for loss of fisheries access, recreation and amenity space).

4.3 SUMMARY OF ALTERNATIVES FROM PREVIOUS EIA (SRK CONSULTING, 2000)

In 1999, Anglo American initiated an EIA process (undertaken by SRK Consulting) for the establishment of the Gamsberg mine and associated zinc refinery. An environmental authorisation was received in 2000, allowing Anglo American to proceed with the development. Due to a variety of factors (as outlined in Section 3), the project was placed on hold and the environmental authorisation expired.

During the 2000 EIA process, a suite of project alternatives were considered, including process alternatives, residue disposal alternatives from the refinery and a number of location alternatives for various major infrastructure components. The final list of alternatives that were considered is tabulated below. A tabulated summary of the various alternatives considered during the EIA process (SRK Consulting, 2000), together with the specialist preference, is presented in *Table 4.2* below.

Table 4.2 Summary of Pre-screened Project Alternatives Considered during Previous EIA Process (adapted from previous EIA Report: SRK Consulting, 2000)

Alternative type	Alternatives	Specialist motivation for preferred alternative
Location alternatives		
Contractors' camp	Site 1: Located between inselberg and southern border of the N14.	No particular preference was demonstrated.
	Site 2: Located along northern border of the N14.	No particular preference was demonstrated.
	Site 3: Located south of the N14 and west of the inselberg.	No particular preference was demonstrated.
Ore crusher	Site 1: South of pit, inside the inselberg.	Due to the presence of habitat of high ecological importance, this option was not considered viable. Furthermore, hauling costs to the waste rock dump and plant will be high.
	Site 2: Located along northern edge of open pit, along the rim of the inselberg.	Limited presence of habitat of high ecological importance, however, would likely be visible from the N14.
	Site 3: Located at the foot of the inselberg, north of the open pit.	Limited presence of habitat of high ecological importance, however, would result in greater haulage costs.
	Site 4: Located along the rim of the inselberg, adjacent to the proposed conveyor system.	Limited presence of habitat of high ecological importance and as this is located at a natural low point along the rim of the inselberg, the proposed crusher will not be visible from the N14. **This was identified to be the preferred choice.**
Waste rock dump	Dumped over the top of the inselberg and levelled to the same height as the inselberg (Site 1).	The location contains habitat of ecological importance. From the visual perspective, development of only the western dump would be desirable. Consolidation of disturbed areas as much as is possible is desirable. This is a financially viable option and is consistent with the technical design of the access road to the inselberg. **This was identified to be the preferred choice**.
	Within the pit (Site 2).	Ecologically preferable however handling costs excessive, in the order of R2.5 billion will influence the feasibility of the project.
	Inside the crater (site 3).	Ecologically least acceptable due to the presence of sensitive ecological habitat. Visually undesirable as the waste rock dump will be visible from all sides of the inselberg.
	Inside the crater (60%) and within pit (40%) (Site 2/3).	Ecologically least acceptable due to the presence of sensitive ecological habitat. Visually undesirable as the waste rock dump will be visible from all sides of the inselberg.
	North of the N14 national road (Site 4).	Ecologically preferable however excessive handling costs will influence the feasibility of the project. High

		visual impact.
Tailings dam	East of the plant – 1km to the east (Site 1).	The location contained some levels of sensitive ecological habitat. The location is preferred from a hydrogeological and visual perspective. Dust generation and dispersion maybe higher, when consolidated with dust from the waste rock dump.
	East of the plant – 3km to the east (Site 2).	Not recommend from the hydrogeological perspective because of the presence of a major fault.
	South-west of the inselberg (Site 3).	Ecologically least acceptable due to floral and faunal habitats. Not preferred from the hydrogeological perspective because of the presence of major fault. The footprint of the tailings dam is smaller because the dam is a natural valley. While this option has the lowest visual impact from the N14, it could have the highest impact post closure because it disturbs a visually attractive valley.
	South-west of the plant site – 2.5km south-west (Site 4).	Ecologically least acceptable and not preferred from the hydrogeological perspective because of the presence of a major fault.
	Inside of the pit, on top of the inselberg (Site 5).	Ecologically least acceptable and not recommended from the hydrogeological perspective.
	In the area of the waste rock dump so that it is ultimately covered by waste rock (Site 6).	Good from the hydrogeological perspective, but not a technically feasible option.
	Proposed at the workshop – north of the N14 national road (Site 7).	Ecologically desirable because away from sensitive habitats on and around Gamsberg. Further technical and economic studies required by the project engineers. Not desirable from the visual perspective because it will be a new area of disturbance. High winds could result in dust clouds blowing off the dump. The dust clouds could reduce visibility and this could be a traffic hazard on the N14. The dust clouds would also have a visual impact, depending on proximity to the N14. **This was identified to be the preferred choice**.
A non-hazardous solid waste disposal site	East of the plant (Site 1).	Smaller development footprint and located within same catchment as the Plant. **This was identified to be the preferred choice**.
	West of the plant (Site 2).	Greater operational costs and larger development footprint.
	Existing waste site at Aggeneys (Site 3).	Ecologically most acceptable, however, larger economic costs to upgrade the existing Aggeneys site.
Location of the EMV Workshop	On top of the inselberg, along the rim of the inselberg (Site 1).	The lighting could be visually disturbing and will impact sensitive ecological habitat. **This was identified to be the preferred choice**.
	Inside the inselberg (Site 2).	This is considered ecological least preferable. Operating costs will be large and technically unsuitable for the transfer of heavy vehicle in need of repair.

	On the plain, between the inselberg and N14 (Site 3).	Technically unfeasible to move heavy duty vehicles down steep slopes. In addition, operating costs will be greater than the other options.
Routes		
Access from the plains to the mountain top	Repair the existing road to the south-west of the inselberg (Option 1).	Ecologically least unacceptable. This is recognised by the project engineers as a no-go option from the ecological perspective.
	Construct new road up the front (northern) slope of the inselberg (Option 2).	Construction of this road will be prioritised. **This was identified to be the preferred choice**.
Relocation of the N14	No relocation (Option 1).	Status quo. **This was identified to be the preferred choice**.
	Relocation south of the Gamsberg (Option 2).	Ecologically unacceptable. Visual impact will be dispersed further from the inselberg.

4.4 *ANALYSIS OF OPEN PIT AND UNDERGROUND MINING TECHNIQUES*

BMM's base case for this project included the open pit mining option. However, it was broadly understood that open pit mining would result in a greater impact on the biodiversity resources that an Underground mining option. As a result, and to adhere to the mitigation hierarchy of firstly avoiding the impacts, BMM was requested to consider the potential to adopt an underground mining technique. BMM appointed AMEC Engineers to undertake a Technical Feasibility Study (TFS) (AMEC, 2013) to consider the technical and commercial viability of undertaking underground and open pit mining at the Gamsberg inselberg. As part of the technical and commercial analysis, the following criteria/ factors were considered:

- Geology and dimensions of the reserve: This included a detailed review of the depth, width and length of the reserve, the sequencing and composition of the geological formations and general topographical reviews.

- Geotechnical conditions: Based on previous investigations, the TFS reviewed the geotechnical suitability of the site and considered, *inter alia*, slope stability, groundwater conditions and potential slope failure.

- Net smelter return: The net smelter return considered the total cost of saleable product, after the removal of other minerals. This also included a review of the concentration of the zinc deposit itself, and manganese content within the reserve. Lastly, a predicted future costs for shipping, smelter charges, exchange rates and zinc prices were also incorporated into the commercial analysis.

- Processing costs: This included a review of the processing costs for both mining techniques, including aspects of labour, power and equipment, to name a few.

- Mining rate and operating costs: The mining rate for each mining technique will vary, due to technical differences in the construction and operation.

- Mine production schedule: Based on the dimensions and location of the reserve, the life of mine for both mining techniques were factored into the feasibility study.

- Physical and cash flow schedules: This considered the physical infrastructure and cash flow requirements for the different mining technique, in light of the proposed mining production schedule.

- Mine closure measures: Based on the different mining techniques, the mine closure costs were developed and factored into the study.

At this early stage, no environmental costs were considered in the Technical Feasibility Study for the underground options. It was, however, acknowledged upfront, that an open pit mine may result in greater impacts on biodiversity and that a biodiversity off-set was highly likely to be required. The associated off-set costs would need to be considered as part of the overall feasibility of the open pit option. However, the first step in the process was to establish if underground mining was feasible based on the existing site conditions.

4.4.1 Open Pit VS Underground Mining

The Gamsberg zinc deposit is confined to a steep-sided inselberg about 7 km east to west by 5 km north to south. During a site visit at Gamsberg from 15 to 17 October 2012, AMEC had the opportunity to inspect the underground workings of the existing underground mine. The ground can be described as competent with ground support in the 5 m wide by 4 m high cross-sections consists of occasional spot bolting with split-set bolts. The large open slopes with dimensions of 25 m by 20 m by 60 m height are not backfilled. Cavity monitoring surveys did not indicate any slope failures of concern. The geotechnical conditions are considered to be suitable for both mining techniques. However, a detailed geotechnical assessment will be undertaken, during the detailed design phase, to verify these preliminary findings.

The zinc deposit present within the Gamsberg inselberg is a defined ore body that is characterised with high content of sulphide and manganese, resulting in a low grade ore deposit of approximately 6% of zinc. Most smelters prefer the manganese grades in concentrates to be in the range 0.2 % to 0.8 % with preferred maximum levels of 0.4 % (AMEC, 2013). Importantly, the Gamsberg deposit has high in situ manganese concentrations and metallurgical testing in recent studies indicates that much of the manganese reports to the zinc concentrate, with the potential for manganese in concentrate to exceed 2.5 %. The low grade concentrate will impact the overall financial viability for both underground and open pit mining.

The feasibility study confirmed that both mining techniques will result in a life of mine of approximately 19 years. However, due to the shape and dimensions of the reserve, open pit mining would be able to produce 10 million tpa of concentrate per year, at full production capacity. The open pit mine will result in the production of approximately 190 million tons of concentrate, over the life of mine. However, underground mining has a slow mining rate (ie abstraction of ore) and will therefore only be able to produce 6.6 million tpa of concentrate, at full production capacity, therefore producing approximately 125.4 million tons of zinc concentrate in the same period.

The footprint of the waste rock dump and tailings facility will also vary with the different mining techniques. An open pit mining technique will generate 155 million tons of tailings, and 1.69 billion tons of waste rock, over the life of mine. Adopting an underground mining approach, the mine will generate 41 million tons of tailings and 7.2 million tons of waste rock [(1)]. The proposed waste generation for an open pit mine will be in an order of magnitude higher, than that of underground mining and therefore the footprint impacts of the mineral waste infrastructure will be greater.

(1) Note that is was assumed, for underground mining, that some waste rock will be backfilled into the underground shafts.

Open pit mining is expected to have an average work force of 504 people, whereas underground mining will require an average total workforce of 378. Based on approximate projections, the water and power requirements for open pit mining are 522 mega litres per annum and 22 Giga watts hourly per annum respectively. Underground mining would require 1 787 mega litres per annum of water and 73 Giga watts hourly per annum of power.

Due to the technical requirements for underground mining, approximately 58% of the reserve can be accessed, and therefore 42% of the reserve will be sterilised, at the end of life of mine. The method for open pit mining enables BMM to access up to 89% of the reserve, over the life of mine. The open pit mining technique will result in the sterilisation of 11% of the reserve. The construction costs (ie capex) for open pit and underground mining are estimated at R5.1 billion and R4.6 billion respectively.

In light of the technical constraints, financial return rates and sterilisation of the reserve, BMM considers underground mining not to be a viable options to pursue. Notwithstanding, due to the larger impacts anticipated with open pit mining, mitigation measures will be more stringent. Therefore the next step is to determine if open pit mining remains viable, once all mitigation measures (including biodiversity offsetting requirements) are determined and applied. BMM will incorporate the recommended mitigation measures of this ESIA Report into the Projects financial model to confirm if the proposed open pit mining option can retain viability.

Table 4.3 Summary of Comparison of Both Mining Techniques

Criteria/ Item	Open Pit	Underground
Mining rate	10 million tons per annum	6.6 million tons per annum
Life of mine	19 years	19 years
Percentage of reserve that is accessible	89%	58%
CAPEX	R5 122 million	R4 616 million
Operating costs (for 10mtpa and 6.6mtpa, respectively)	R50 753 million	R48 311 million
Employment	504	378
Volume of waste rock dump	155 million tons	41 million tons
Volume of Tailings Facility	1 690 million tons	7.2 million tons
Water requirements	502 mega litres per annum	1 787 mega litres per annum
Electrical power requirements	22 gig watts hourly per annum	73 gig watts hourly per annum
Revenue	R 97.4 Bn	R 65.6 Bn
Cash flow	R 41.6 Bn	R 12.7 Bn
C1 Costs	USD 0.94/lb	USD 1.10/lb

4.5 *ALTERNATIVES CONSIDERED FOR OPEN PIT TECHNIQUE*

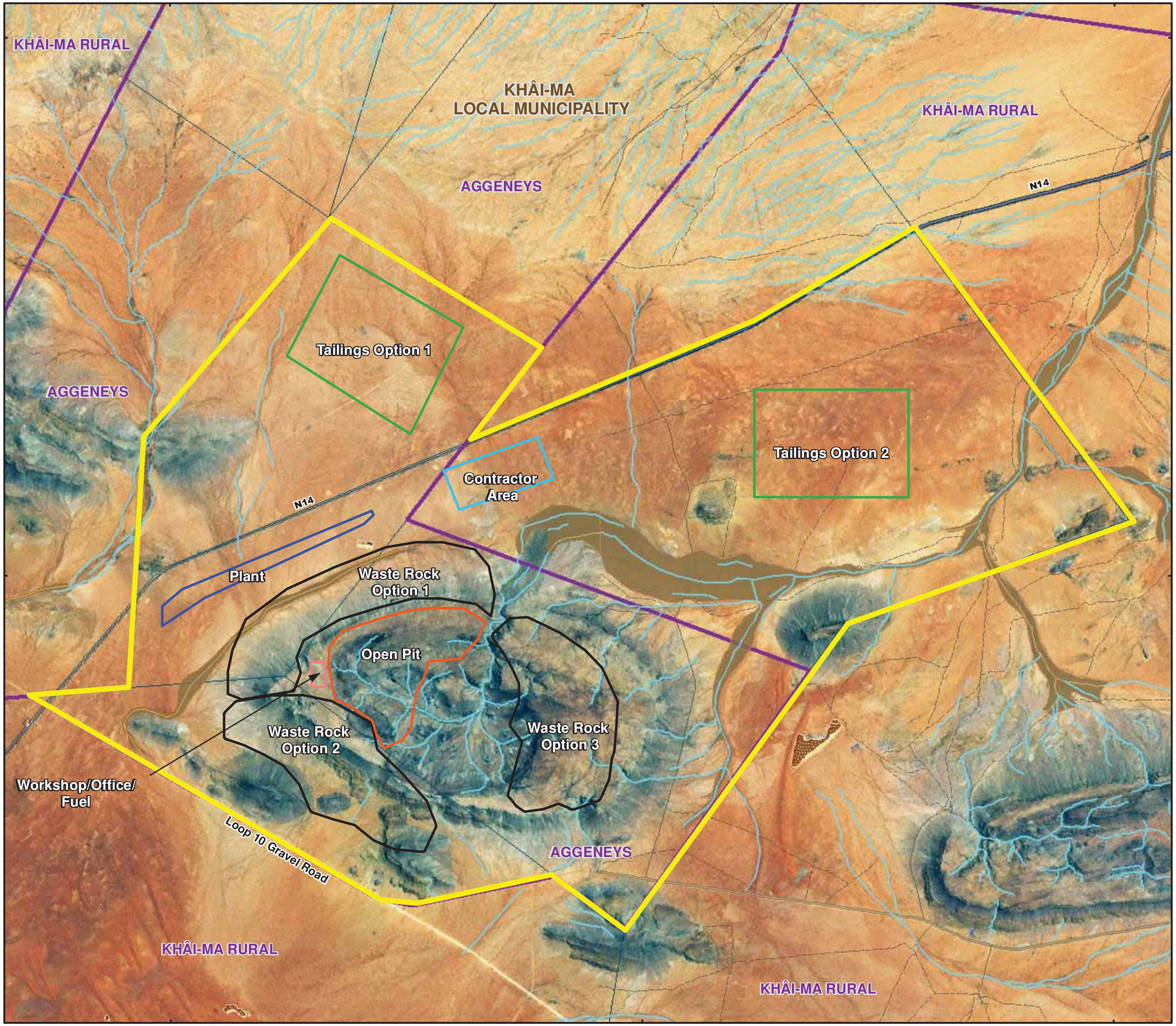
During the prefeasibility phase, an initial layout plan was developed. The initial layout plan was based on a high level feasibility analysis of the potential location alternatives of project infrastructure together with previous studies that were undertaken. The original layout plan is presented in *Figure 4.1*below.

The original layout plan identified the potential location or location alternatives for all major infrastructure required for the project. This included the following project components:

- Three waste rock dump options;
- Two tailings dam options;
- Open pit;
- Plant;
- Contractor area; and
- Access road alternatives.

Locations were identified for the open pit, plant and contractor area, based on discussions between the environmental and engineering teams. The locations were finalised primarily based on avoidance of sensitive habitats and previous assessment that were undertaken by SRK Consulting (2000). Discussions were initiated with the applicant's technical team regarding the potential relocation of these specific infrastructure components, based on the presence of sensitivities. It was agreed that the plant and contractor area could be shifted or inter-changed. However, due to the location and dimensions of the ore body, the location of the open pit could not be relocated, as it would result in the sterilisation of parts of the ore body.

In adopting a conservative approach, all estimations of footprints were based on worst case scenarios. It is understood that as detailed design is complete, the expected footprints of the development will be refined.



Legend

- Non-Perennial River
- Dry Water Course Centre Line
- Dry Water Course Floodplain
- Dam
- Dry Pan
- National Route
- Main Road
- Secondary Road
- Other Road
- Track/Footpath
- Town Boundary
- Open Pit
- Contractor Area
- Plant
- Workshop/Office/Fuel
- Tailings Dam Option 1
- Tailings Dam Option 2
- Waste Rock Dump Option 1
- Waste Rock Dump Option 2
- Waste Rock Dump Option 3
- Mineral Rights Area

SCALE: 0 1 2 3 4 Kilometres

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TITLE:

Figure 4.1: Original Layout Plan

CLIENT:

vedanta

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DATE: Apr 2012	CHECKED: MP	PROJECT: 0164903
DRAWN: AB	APPROVED: SHC	SCALE: 1 : 70 000

DRAWING: Original Layout Plan.mxd

REV: 0

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Projection: Transverse Mecator, CM19. Datum : WGS84
Source: Chief Directorate National Geo-Spatial Information.
McGregor Museum
Inset Map: Esri Data & Maps

SIZE: A3

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Upon receipt, the original layout plan was distributed to the specialist team for review and preparation for their respective site visits. Specialists were requested to base their field analyses on this original layout plan and upon their return, provide a sensitivity map in relation to the suggested layout options. The following sensitivity maps were presented to commence with the first mitigation hierarchy measure (ie ***Avoidance***):

1 Habitat Sensitivity Map.
2 Archaeological and Heritage Sensitivity Map.
3 Noise and Vibration Sensitivity Map.

Note that hydrological sensitivities were derived from satellite imagery, topographical surveys and previous hydrological analyses undertaken. In addition, the visual specialist provided preliminary feedback on the initial layout options, which are contained below.

Upon receipt of these specialist sensitivity maps and feedback on hydrological and visual sensitivities, the proposed location alternatives were reviewed in light of the specialist mapping and amended whenever feasible to avoid or prevent significant impacts/ conflict areas.

Although archaeological, visual, hydrological and noise sensitivities were considered and incorporated into the layout planning, the primary driver for *avoidance* was that of the habitat sensitivity map. A copy of the initial specialist sensitivity maps are presented below.

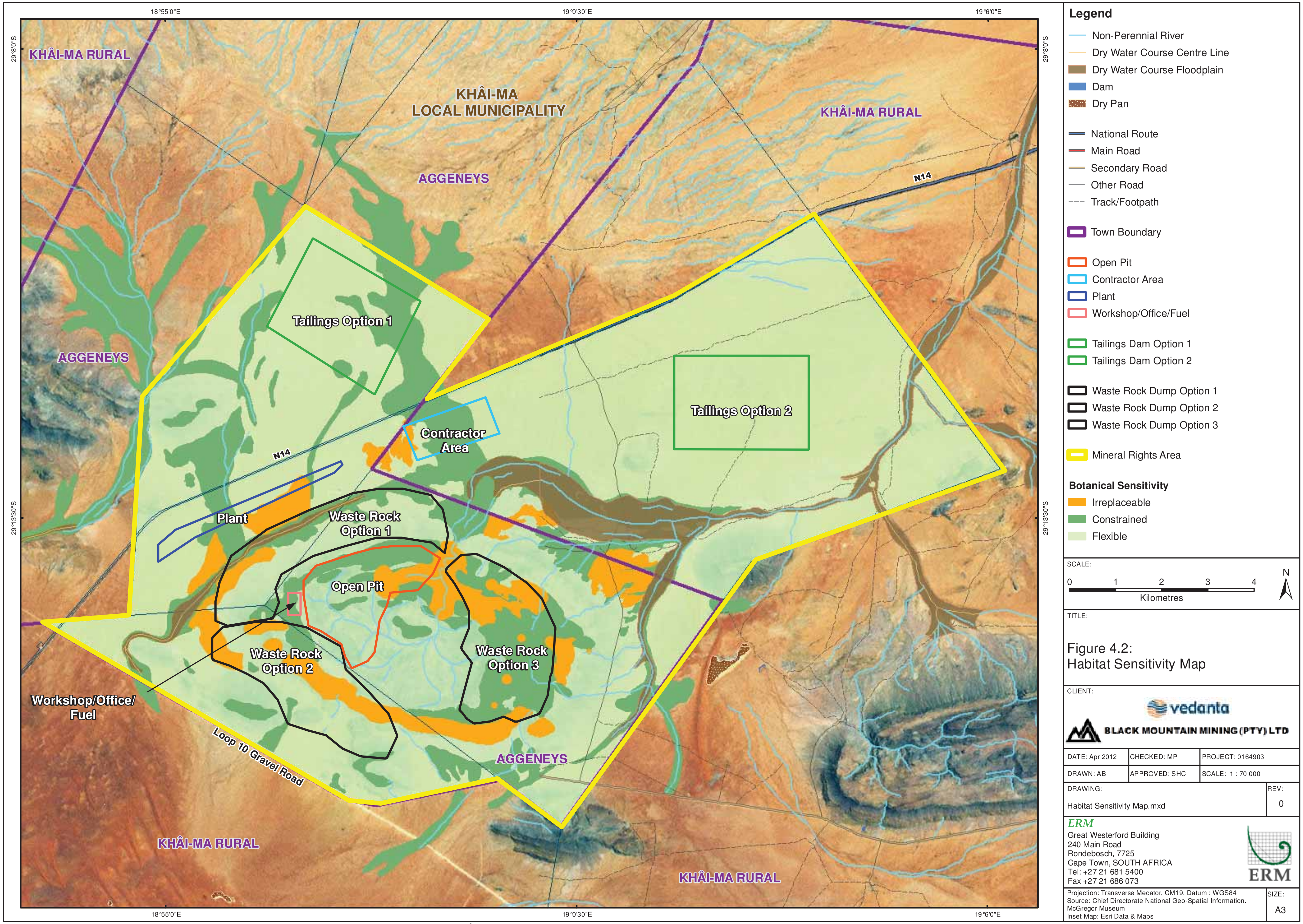
4.5.1 *Habitat Sensitivities*

In order to manage the impacts associated with the habitats and species of special concern, the botanical specialist has mapped areas of sensitivity, and provides a scale to rate the different sensitivities of each habitat. The habitat sensitivity map helped with delineating areas of conservation importance and thereby guided the location of Project related infrastructure. The scale to rate the different sensitivities of each habitat will be used as a guiding framework in distinguishing and prioritising areas of biodiversity importance.

Biodiversity "features of conservation concern" were identified based on quantifiable criteria such as their uniqueness to the site (ie local endemic); rarity; threatened status (ie risk of going extinct); cultural value; or, sensitivity to disturbance. Three categories of features of conservation can be defined, ie species, habitats and sites. In line with these categories of features, a flexibility map was developed to define constraints within the affected environment. A description of the flexibility is presented below:

Table 4.4 Habitat Sensitivity Scale

Level of Flexibility	Criteria	Offset Options
Flexible	Impact <5% of regional extent of feature (ie minimum 1:20 offset can be achieved).	Complete like-for-like offset possible.
Constrained	Impact 5-20% of regional extent impacted (ie Offset possible but at best a 1:5 offset can be achieved).	Offset likely to be possible.
Irreplaceable	Impact >20% of regional extent. Contains feature of conservation concern that are only know from 5 or less localities.	Potential fatal flaw with no offset possible.



TITLE:

Figure 4.2:
Habitat Sensitivity Map

CLIENT:

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DATE: Apr 2012	CHECKED: MP	PROJECT: 0164903
DRAWN: AB	APPROVED: SHC	SCALE: 1 : 70 000

DRAWING: Habitat Sensitivity Map.mxd

REV: 0

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Source: Chief Directorate National Geo-Spatial Information.
McGregor Museum
Inset Map: Esri Data & Maps

SIZE: A3

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4.5.2 *Archaeological/ Heritage Sensitivities*

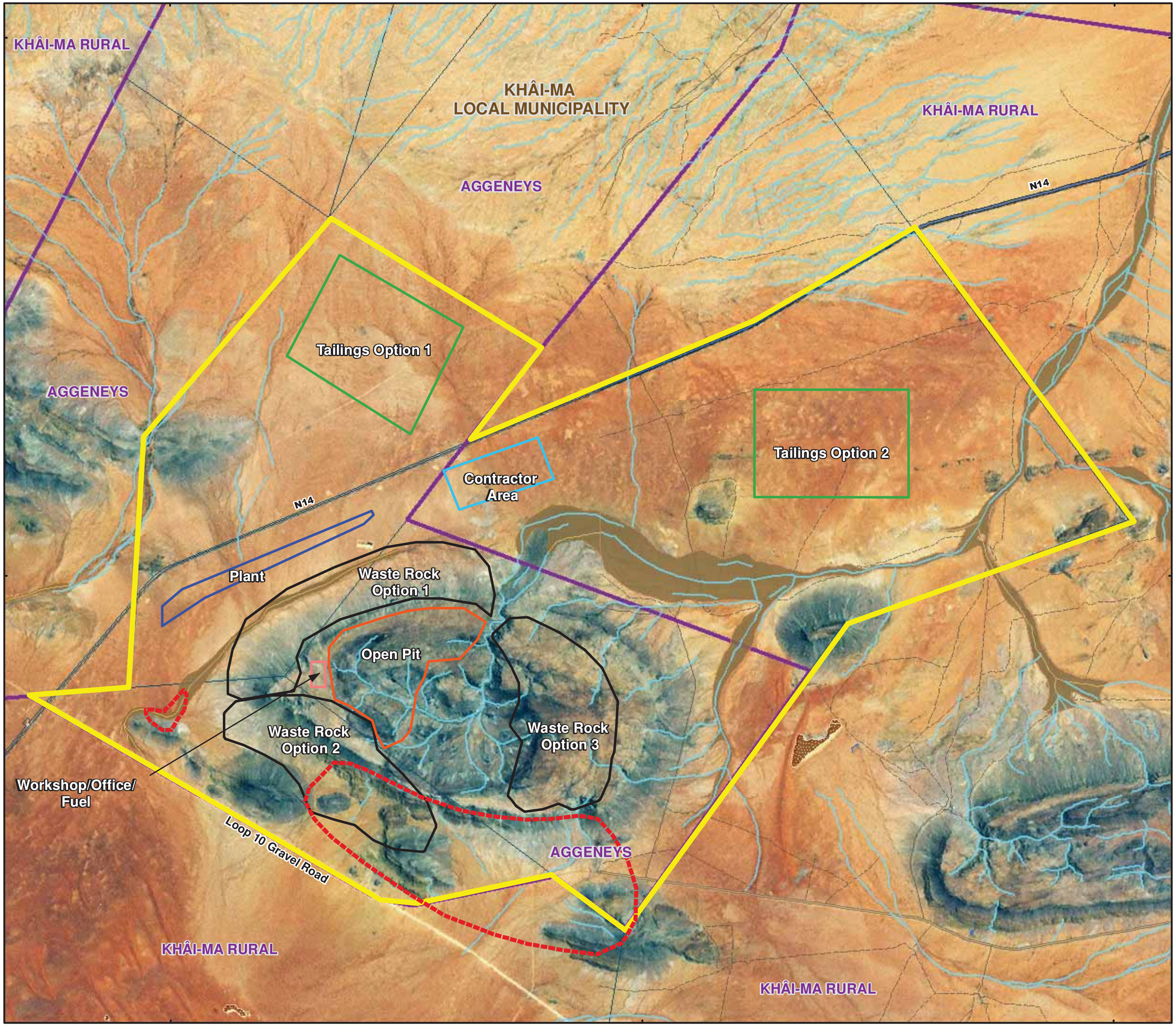
During the archaeological site visit, the Gamsberg inselberg contained limited archaeological artefacts, in the form of isolated stone flakes. A Middle Stone Age workshop site was identified along the northern rim of the inselberg. Two Acheulean workshop sites were also identified, and similar to the workshop site identified along the northern rim, indicates that the Gamsberg inselberg was favoured as a raw material source for historical communities. In addition, the stream courses found within the Gamsberg basin contains a mixture of low density Middle Stone Age and Acheulean material, which could be indicative of an area in which historical communities lived in (Morris, 2010). However, as the inselberg was previously and currently quarried, artefacts are therefore unlikely to be discovered below the surface, and thus represent limited sensitivity.

The archaeologist has noted that an area may pertain to the people who were subject to local genocide in the later nineteenth century (the south western corner of Gamsberg might have been one of the massacre sites), making this a rather sensitive landscape that may in future become increasingly a focus of genocide consciousness (refer to *Figure 4.3* below).

4.5.3 *Noise and Vibration Sensitivities*

The Gamsberg inselberg is located in an area that is sparsely populated, with limited sensitive noise receptors in the immediate area. Sensitive receptors in the area include the town of Aggeneys, adjacent land owners and road users (N14 and Loop 10 gravel road). The proposed Gamsberg mine will result in the generation of noise through the use of diesel equipment, crushing, concentrating and activity of mining such as blasting and drilling and hauling of rock and concentrate. Current noise generation activities include the Black Mountain Mine, road users of the N14 and residents within the town of Aggeneys.

During the site visit, the noise specialist has identified receptors located within close proximity to the mining license area (refer to *Figure 4.4* below).



Legend

- Non-Perennial River
- Dry Water Course Centre Line
- Dry Water Course Floodplain
- Dam
- Dry Pan
- National Route
- Main Road
- Secondary Road
- Other Road
- Track/Footpath
- Town Boundary
- Open Pit
- Contractor Area
- Plant
- Workshop/Office/Fuel
- Tailings Dam Option 1
- Tailings Dam Option 2
- Waste Rock Dump Option 1
- Waste Rock Dump Option 2
- Waste Rock Dump Option 3
- Mineral Rights Area
- Areas of Archaeological Sensitivity

SCALE: 0 1 2 3 4 Kilometres

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Figure 4.3:
Archaeological Sensitivity Map

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DRAWING: Archaeological Sensitivity Map.mxd

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Projection: Transverse Mecator, CM19. Datum : WGS84
Source: Chief Directorate National Geo-Spatial Information. McGregor Museum
Inset Map: Esri Data & Maps

SIZE: A3

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Legend

- Non-Perennial River
- Dry Water Course Centre Line
- Dry Water Course Floodplain
- Dam
- Dry Pan
- National Route
- Main Road
- Secondary Road
- Other Road
- Track/Footpath
- Town Boundary
- Open Pit
- Contractor Area
- Plant
- Workshop/Office/Fuel
- Tailings Dam Option 1
- Tailings Dam Option 2
- Waste Rock Dump Option 1
- Waste Rock Dump Option 2
- Waste Rock Dump Option 3
- Mineral Rights Area
- Potential Sensitive Receptors
- Open Pit (2000m Buffer)
- Plant (1000m Buffer)
- Tailings (500m Buffer)
- Waste Rock (500m Buffer)

SCALE:
0 1 2 3 4
Kilometres
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Figure 4.4:
Noise Sensitivity Map

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DDA Environmental Engineers
Inset Map: Esri Data & Maps

SIZE: A3

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4.5.4 *Hydrological Sensitivities*

As outlined above, the hydrological sensitivities identified were based on satellite imagery, topographical surveys and previous studies.

The mine is located at the watershed between two quaternary catchments, being D81G (northern catchment) and D82C (southern catchment). The latter (D82C) is an endoreic catchment, which means that it is an interior drainage basin that does not drain to the sea. Part of the Gamsberg inselberg is situated within quaternary catchment D81G, which drains in a northerly direction towards the Orange River some 35km away. In light of the two catchments, efforts were made to locate all project infrastructure within a single catchment, so as to avoid potential impacts to more than one catchment area. However, despite the efforts made, the open pit (the location of which is dictated by the location and dimensions of the ore body) is situated in catchment D81G. The remaining infrastructure is located within catchment D82C and will therefore not impact on the catchment leading to the Orange River. A detailed review of the two catchment areas (D81G and D82C) is presented in Chapter 5 below.

4.5.5 *Visual Sensitivities*

The visual specialist was requested to consider the initial design and provide feedback in terms of key sensitivities. The specialist was of the opinion that the Project will have a large visual impact regardless of where infrastructure is located. The relative scale and physical presence of project components, in essentially a 'green fields' location, make it difficult to mitigate. The specialist suggested that the location of facilities must try to be 'consolidated' into the smallest 'footprint' possible and preferably closer to the inselberg to maximise the visual absorption capacity of the impacted landscape.

4.6 *OUTCOMES OF AVOIDANCE*

As previously indicated, the habitat sensitivities were used as the primary driver to determine locations of project infrastructure. The aforementioned sensitivity maps were overlaid onto the original layout plan and subsequently used by the engineering team to shift infrastructure to avoid irreplaceable and sensitive vegetation.

4.6.1 *Waste Rock Dump Options*

Habitat

The habitat sensitivity map identified irreplaceable habitat within various sections of the inselberg and adjacent plains. Based on the original layout plan, waste rock dump *Options 2* and *3* (as reflected in *Figure 4.1* above) will impact on large sections of irreplaceable and sensitive vegetation habitats. Furthermore, Option 2 is located along the southern face of the inselberg, which is known to contain sensitive vegetation, indicative of the Succulent Karoo. Option 1, located along the northern slopes of the inselberg, is primarily limited to areas identified to possess a limited features of conservation concern. However, the north western section of Option 1 impacts irreplaceable vegetation. Therefore, a request was made to BMM to reconsider the location of Option 1and shift the expected footprint further north, so as to avoid the features of conservation concern.

Archaeological/ Heritage

The archaeologist has noted that an area (south and south west of the inselberg) may pertain to the people who were subject to local genocide in the later nineteenth century. Although this has not yet been confirmed and in adopting a risk adverse approach, Option 2 was identified to be unsuitable from an archaeological perspective and thus screened out. The archaeological sensitivity map identified Options 1 and 3 to be more suitable for the waste rock dump.

Noise

Despite adopting a conservative approach through the use of a 500 m buffer for the waste rock dump, no specific sensitivities were identified in this respect. Neither of the waste rock dump options was considered to impact sensitive noise receptors in the surrounding region. The noise specialist has not identified any preference with regard to the waste rock dump options.

Hydrology

The waste rock Options 2 and 3 are located within catchment D81G, which forms part of the larger catchment area that flows into the Orange River. Waste rock dump Option 1 is located within sub-catchment D82C, which is a closed catchment (ie does not flow into the sea). Due to the sensitive nature of the Kloof found within the inselberg and downstream users of the Orange River, an effort was made to avoid catchment D81G. The faunal and botanical specialists also identified this feature to be of concern from an ecological perspective. It was recommended that Option 1 be selected, so as to try and limit the mineral waste infrastructure facilities to a single sub-catchment.

Visual

Based on preliminary analysis, the visual specialist demonstrated preference to waste rock Option 2. Waste rock Option 2 would be the "easiest" to partially absorb the visual impact of this huge feature, as it would be 'enclosed' by the natural koppies to its south and the main Gamsberg to its north (assuming that the height of the dump is not higher than the Gamsberg). Option 2 would also ensure that major infrastructure is consolidated along the southern border of the N14, so as to limit the visual exposure of the project.

Based on habitat sensitivities identified around Option 2 (ie the catchment of the Kloof and botanical sensitivities associated with the southern slope of the inselberg), due consideration was given to both the visual and ecological sensitivities. In light of the larger Bushmanland Inselberg Region (BIR) and the nature of island geography applicable to the BIR, the ecological sensitivities were identified to have a greater regional importance.

Summary of Preferred Option

Based on the aforementioned inputs, waste rock dump *Option 1* was selected to be the preferred choice, with specific refinements required to avoid irreplaceable ecological habitat located to the south west.

4.6.2 Tailings Dam Options

Habitat

Based on the two tailings dam location alternatives identified, neither option was located in irreplaceable habitat. However, sensitive habitat was identified around sections of Tailings Option 1. Tailings Option 2 was located in an area that did not contain any features of special concern and was therefore identified to be marginally preferable, as it will not impact on sensitive habitat. It should be noted that subsequent to this, the size and location of Tailings option 1 was refined and confirmed to avoid any sensitive habitats. As the expected impacts to sensitive habitat is likely to be the similar for each option, there was not strong preference for a particular location option.

Archaeological/ Heritage

Based on the archaeological sensitivities identified, neither location alternative appeared to impact the areas of archaeological sensitivity identified and therefore no preference was demonstrated.

Noise

In defining the noise sensitivity, a 500 m buffer was established around both location alternatives of the Tailings facility. The noise specialist identified a single noise receptor located within this suggested buffer area for Tailings option 2. Based on the proximity of the noise receptors, Tailings Option 2 was identified to be the preferred choice.

Hydrology

From a hydrological perspective, it was request that all mineral and non-mineral waste infrastructures should be limited to a single catchment area. Furthermore, the Kloof catchment was identified to be a sensitive area and thus tailings Option 2 were identified to be less preferable. To ensure that only catchment D82C is impacted, Tailings Option 2 was identified to be the preferred option.

Visual

Based on preliminary analysis, the visual specialist demonstrated preference to tailings Option 2. Option 2 would also ensure that major infrastructure is consolidated along the southern border of the N14, so as to limit the visual exposure of the project.

Based on habitat sensitivities identified around Option 2 (ie the catchment of the Kloof and downstream users), due consideration was given to both the visual and hydrological sensitivities. Due to the potential extent of potential impacts to downstream users and the regional importance of the Kloof habitat, the hydrological sensitivities were identified to have a greater regional importance.

Summary of Preferred Option

In light of noise and hydrological sensitivities, and further refinements to the location of the Tailings facility to avoid habitat sensitivities, *Option 1* was identified to be the preferred choice.

4.6.3 Contractor Area and Plant

Although the original layout plan was based on the SRK Consulting (2000) layout plan, it did not identify alternative locations for the Plant and Contractor Area. For this reason, the option to refine the location of these pieces of infrastructure was considered. Subsequent to the initial sensitivity analysis, the locations of the Plant and Contractor Area was swopped, to achieve greater technical efficiency during the operational phase.

Habitat

Both the Plant and Contractor Area was originally located on habitat identified to contain areas of specialist concern (including irreplaceable habitat). Suggestions were made to shift the location so as to avoid the constrained and irreplaceable vegetation. In order to streamline the technical requirements for the transportation of ore to the Plant, the locations of the Contractor Area and Plant were inter-changed. Furthermore, based on the refinement of design, the footprints of these pieces of infrastructure were subsequently reduced and therefore avoided all botanical sensitivities.

Archaeological/Heritage

No areas of archaeological sensitivities were identified in the locations suggested for the Plant and Contractor Area. Furthermore, the subsequent changes to the location and footprints did not impact any areas of concern and therefore no particular preference was expressed from an archaeological perspective.

Noise

The noise sensitivity map identified a buffer are of 1000m for the Plant. Based on the original location, the Plant was likely to impact road users along the N14 (as the National road fell within the 1000m buffer area). Subsequent to inter-changing the locations of the Plant and Contractor Area, the noise buffer would still result in potential noise impacts to road users of the N14. Although the suggestion was made to shift the Plant closer to the Inselberg, the botanical constraints limited this option and therefore no preference was presented from a noise perspective.

Hydrology

The locations for the Plant and Contractor Area are limited to catchment D82C, and are therefore consolidated into a single catchment together with the proposed water rock dump and tailings dam. Therefore, no specific preference was identified. However, due to the presence of various drainage lines in the immediate area, a suite of mitigation measures would be required to limit impacts to all watercourses. This is detailed further in the Impact Assessment below.

Visual

Due to the proximity of the Plant and Contractor Area to the N14, the visual specialist confirmed that the suggested locations would result in a large visual impact. From a visual perspective, the specialist requested for all infrastructure to be consolidated closer to the inselberg, thereby reducing road user visibility along the N14.

Based on habitat sensitivities, as were with the tailings dam and waste rock location, the relocation of the Plant and Contractor area was not considered viable from an ecological perspective.

Summary of Preferred Option

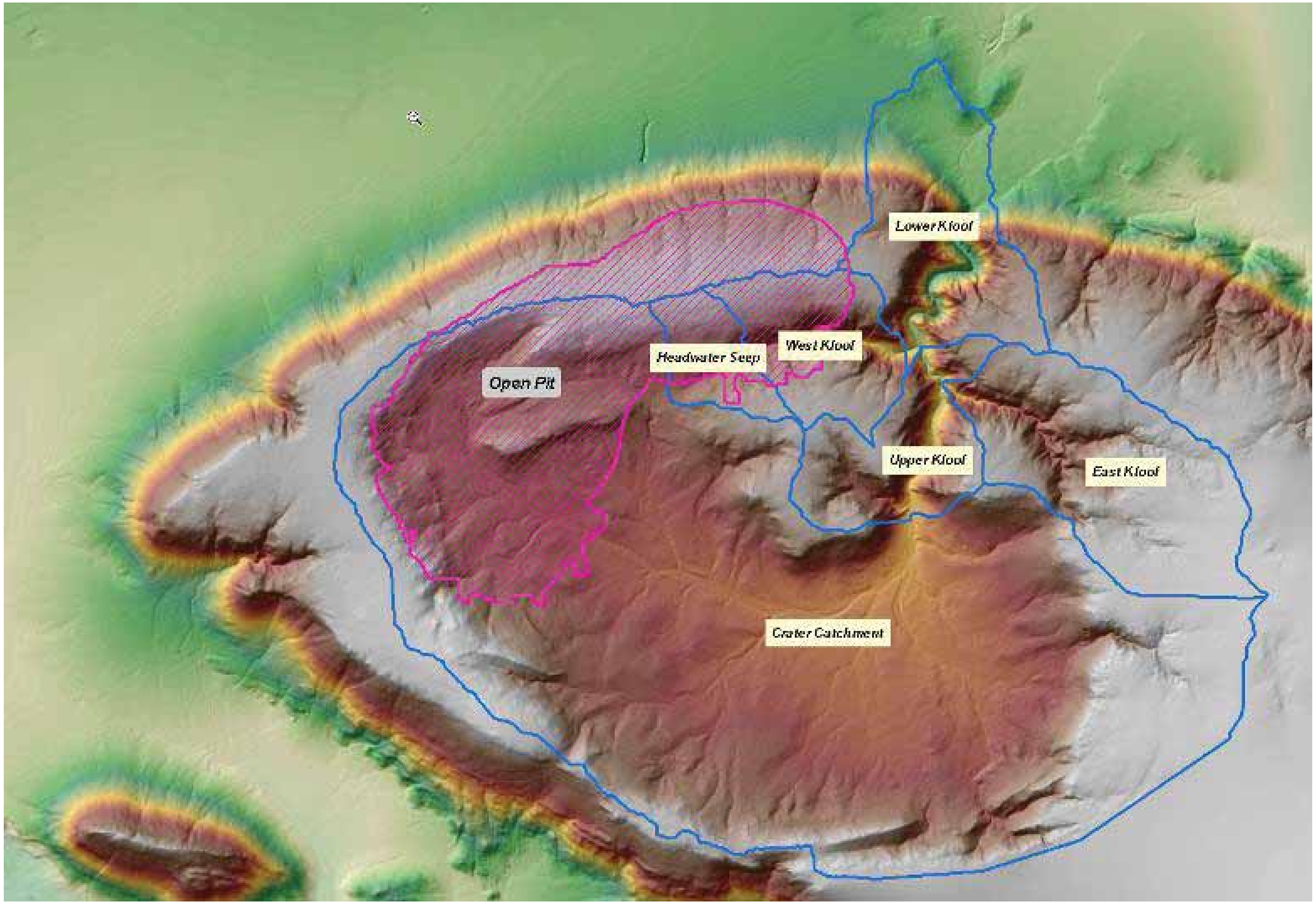
The proposed locations for the Plant and Contractor Area, as per the original layout plan, was subsequently swopped and was taken forward for detailed impact assessment.

4.6.4 Open Pit

Habitat

The original sensitivity mapping identified patches of irreplaceable vegetation and headwater seepland within the expected footprint of the open pit. Furthermore, the proposed open pit would also infringe on the surface catchment area of the Kloof. The expected footprint of the open pit is based on the dimensions of the ore body as well as technical requirements to access the reserve. Due to the technical limitations of the proposed open the Botanist requested due consideration for the shifting of the open pit in a southerly direction, so as to avoid the physical catchment of the open pit area, and possible the headwater seepland wetland (refer to *Figure 4.5* below).

Figure 4.5 Consideration of Setback Lines for Open Pit (Desmet, 2013)



Based on the location of the headwater seep, creating a setback line to avoid the wetland boundaries would limit the ability to access the reserve and thus result in the sterilisation of parts of the ore body. This technical limitation would reduce the financial viability of the Project and was therefore screened out. However, the design engineers have explored the potential to limit the extent of the proposed open pit so as to avoid the catchment area of the Kloof, as far as reasonable possible.

As the Kloof serves as the only permanent water source in that immediate region, protection of its integrity remains an important aspect for supporting on-going ecological processes. The design engineers have confirmed that, due to technical reasons for accessing the ore body, part of the western surface catchment area of the Kloof will be impacted. The remaining parts of the surface catchment area for the Kloof will not be impacted (refer to Final Layout *Figure 4.6* below).

Archaeological/Heritage

The archaeological specialist has not identified any specific areas of concern with regard to the location of the proposed open pit. Apart from various artefacts identified, there were not heritage or archaeological limitations identified.

Noise

A 2000m noise buffer was identified for the proposed open pit area. Based on the initial identification of sensitive receptors, the open pit is unlikely to impact adjacent receptors. The noise specialist has therefore not expressed any objections to the initial layout.

Hydrology

Further to the discussion in the ecological section above, the proposed open pit is expected to infringe on the catchment area of the Kloof. From a hydrological perspective, the proposed open pit would partly fall within catchment D81G (ie feeding into the Orange River), and thus could potentially impact on downstream users. Furthermore, the Project would impact on the two catchment areas that divide the inselberg. Based on the technical and financial feasibility analysis to avoid the Kloof catchment, it was confirmed that part of the western surface catchment area of the Kloof will be impacted.

Visual

The proposed open pit would be located within the inselberg and would therefore not be visible from the N14 or adjacent properties. However, the visual specialist has requested that the open pit must not result in the breaking of the inselberg walls. The specialist also requested that the open pit operations do not exceed the height of the rim of the inselberg, so as to reduce visibility from the N14. These requirements were incorporated into the design and therefore taken forward.

Summary of Preferred Options

In light of the aforementioned comments, together with the technical limitations to the dimensions of the open pit, the location of the pit will not be moved. However, to avoid the catchment area of the Kloof, the proposed setback lines for the Kloof catchment can be partly met (ie impact limited to western catchment area only), while maintaining a technically safe slope angle.

4.7 ADDITIONAL INFRASTRUCTURE LOCATION ALTERNATIVES

Upon completion of the initial screening exercise, additional site location alternatives were identified for further analysis. The following project components were also overlaid onto the specialist sensitivity maps to identify potential conflicts and suggest suitable alternatives:

- Main access road onto the inselberg.
- Location of primary ore crusher.
- Location of engineering workshop.

4.7.1 *Access Roads*

BMM originally proposed that the existing access road along the southern slopes of the inselberg will be used for the construction and operational phases. In order to accommodate the size of the vehicles to be used, the existing access road will need to be widened.

Due to the habitat sensitivities identified along the southern slopes of the inselberg, together with the potential site of a historic genocide (archaeological sensitivity), the applicant was requested to consider alternative route options up the northern slopes of the inselberg. The expansion of the existing access road and the associated dust impacts will result in impacts to the biodiversity along the southern end of the inselberg. Based on the sensitivities identified, BMM agreed to construct a new access road up the northern slopes of the inselberg at the operational phase. However, for ease of technical requirements, BMM will utilise the existing access road along the southern slopes of the inselberg for construction only. Due to the size of construction vehicles and slope angle, the existing access road on the southern face of the inselberg would need to be expanded by approximately 12 m.

In summary, it was agreed that during the construction phase, the existing southern access road will be widened and used until a new access road along the northern face of the inselberg is constructed and utilised for the life of mine.

4.7.2 *Location of Primary Crusher*

During initial planning, the potential location of the primary crusher was reviewed in light of specialist sensitivities. The initial location identified was along the southern rim of the inselberg, consistent with the use of the existing access road on the southern slopes of the inselberg. However, this option was screened out, once a decision was made to relocate the access road to the northern slopes of the inselberg (ie was not technically consistent with the newly proposed access road).

Despite the consideration of various alternatives, a location north of the proposed open pit was identified. This location was situated outside of any areas of biodiversity sensitivity.

Based on the potential visibility of the crusher, the visual specialist requested that the proposed primary crusher be situated so as not to be visible from the N14 (ie not higher than the rim of the inselberg). BMM has therefore been requested to ensure that the crusher be located in a low point, thereby reducing visibility from the N14 and adjacent properties. Lastly, the technical requirement for locating the crusher along the northern section of the inselberg was consistent with the proposed access road along the northern face of the inselberg.

4.7.3 Location of Engineering Workshop

Originally, the engineering workshop was identified on the top of the inselberg, due to ease of access for mining equipment (including haul trucks). The potential locations for the engineering workshop were limited to around the open pit area, along its boundaries. Due to biodiversity sensitivities identified, the proposed location on the inselberg was not considered to be ecologically acceptable and BMM was therefore asked to reconsider the location.

The proposed engineering workshop was relocated to the adjacent plains, between the Plant and inselberg. Due to changes in technical requirements resulting from the newly proposed access road along the northern face of the inselberg, the new location was consistent with the technical requirements. Furthermore, the location of the workshop avoids all sensitive habitats, identified by the botanist.

No hydrological and archaeological issues were identified. Although located closer to the N14, the proposed engineering workshop will likely be screened by the Plant and therefore not significantly increase the visual impacts of the entire project.

4.8 SUMMARY OF ALTERNATIVES CONSIDERED

Based on the review of site sensitivities and proposed infrastructure, the following table provides a summary of all alternatives considered and the preferred options taken forward for detailed impact assessment refer to Final Layout Plan included in Chapter 3 as *Figure 3.1*.

Table 4.5 Summary of Alternatives for Detailed Impact Assessment

Alternatives	Preferred Choice	Specialist Comment

1	***Underground VS Open Pit Mining***		
	Underground Mining		• Achieve a mining rate of 6.6 million tons per annum. • Life of mine of 19 years. • Recover 58% of resources and sterilise 42% of resources. • Employ approx. 378 people. • Require 1787 Ml of water per annum. • Require 77 Gigawatts hourly per annum. • Produce 41.8 million tons of tailings. • Produce 7.2 million tons of waste rock. • CAPEX of R4 616 million. • Operational costs of R48 311 million.
	Open Pit Mining	**Preferred Option**	• Achieve mining rate of 10 million tons per annum. • Life of mine of 19 years. • Recover 89% of resources and sterilise 11% of resources. • Employ approx. 504 people. • Require 502 Ml of water per annum. • Require 22 Gigawatts hourly per annum. • Produce 155 million tons of tailings. • Produce 1 690 million tons of waste rock. • CAPEX of R5 122 million. • Operational costs of R50 753 million.
2	***Tailings Dam***		
	Option 1: 1km North East of Inselberg, along southern border of N14		• Result in a high visual impact. • Greater impacts to hydrological sensitivities, (ie stream related to the Kloof) Presence of visual receptors. • Limited botanical and faunal sensitivities. • Larger operational costs due to distance from open pit. • Located in close proximity to adjacent landowners (ie receptors). • This option would not need to cross the N14.
	Option 2: North of inselberg, along northern border of N14	**Preferred Option**	• Result in a large visual impact (Infrastructure would need to cross the N14). • No impacts to the hydrological sensitivities (ie Kloof stream). • Reduced operational costs due to shorter travel distance. • Avoid irreplaceable vegetation and faunal sensitivities. • Reduced number of noise receptors. • No areas of archaeological concern.
3	***Waste Rock Dump***		

	Site 1: Northern face of [(1)](#)	**Preferred Option**	• Avoid irreplaceable vegetation. • Impact faunal habitat along slopes of inselberg. • Lower handling costs (reduced haulage). • Consistent with design of ramp and pit access via northern face of inselberg. • Large visual impact. • No areas of archaeological concern.
	Site 2: South western face of inselberg		• Impact areas of archaeological concern. • Impact sensitive faunal habitats. • Impact irreplaceable vegetation. • Reduced visual impact as infrastructure is consolidated to the south western part of the inselberg. • Limited noise receptors. • Greater operational costs as access road is located along northern slope of inselberg.
	Site 3: Inside the Crater		• Result in sterilisation of mineral resources. • Impact sensitive faunal habitats. • Impact irreplaceable vegetation. • Reduced visual impact (would not be visible from N14). • Limited noise receptors. • Low handling costs (closer proximity). • Technically unsuitable due to proximity to open pit operation.
4	***Contractors Camp***		
	Site 1: North of inselberg, along southern border of N14.		• Large visual impact from N14. • Greater impacts to the hydrological sensitivities (ie kloof stream). • Impacts irreplaceable vegetation. • No faunal sensitivities present. • Reduced number of noise receptors. • No areas of archaeological concern. • Technically not suitable to link the open pit with the Concentrator Plant.
	Site 2: North West of inselberg, along the southern border of N14	**Preferred Option**	• Located outside of catchment of Kloof stream. • Avoids irreplaceable vegetation. • Limited faunal habitat sensitivities identified. • No areas of archaeological concern. • Technically suitable to link the open pit with the Concentrator Plant. • Reduced number of noise receptors. • Large visual impact from N14
5	***Ore Crusher***		
	Site 1: On top of inselberg, north of pit	**Preferred Option**	• Reduced haulage distance to pit and concentrator. • Consistent with future pit and ramp design. • Located within area of proposed open pit (ie no additional loss of sensitive vegetation & faunal habitat). • Larger visual impact (visible from N14).

(1) In order to accommodate the proposed conveyor system to extend from the open pit to the plant, the waste rock dump is presented as two items on the layout plan below.

	Site 2: On the adjacent plains, north west of inselberg		• Increased handling costs. • High visual impact (visible from N14). • Located within sensitive flora and faunal habitats. • No areas of archaeological concern. • Technically not suitable for proposed pit and ramp design.
6	***Engineering Workshop***		
	Site 1: Top of inselberg, west of open pit		• Not consistent with northern access road. • Operational costs are greater. • Impact the Kloof catchment . • Reduced visibility from N14 (due to distance). • Limited noise receptors. • No archaeological sensitivities.
	Site 2: North of inselberg along the adjacent plains, between the waste rock dump and Plant.	**Preferred Option**	• Large visual impact (visible from N14). • Consistent with the access road to open pit. • Avoids Kloof catchment. • Avoid irreplaceable vegetation. • Limited sensitive faunal habitat. • Limited noise receptors. • No archaeological sensitivity.
7	***Access Road to Inselberg (operational phase only)***		
	Option 1: Repair existing road along the southern slope of the inselberg		• Reduced operational costs (ie more direct route). • Impact sensitive faunal habitats. • Impact irreplaceable vegetation. • Impact areas of archaeological concern. • Reduced visibility from N14. • Reduced footprint as expanding an existing road.
	Option 2: New road along northern slope of inselberg	**Preferred Option**	• Avoids irreplaceable vegetation. • Limited faunal sensitivities. • No areas of archaeological concern. • Higher operational costs. • Greater visibility from N14. • Increase in footprint.
8	***Concentrator Plant***		
	Site Option 1: North of inselberg, along southern border of N14	**Preferred Option**	• Reduced haulage costs. • Consistent with conveyor design. • Large visual impact (due to proximity to N14). • Avoids irreplaceable vegetation. • Limited sensitive faunal habitats.
	Site Option 2: North west of inselberg, along southern border of N14		• Greater haulage costs due to greater distance. • Not consistent with conveyor design. • Large visual impact. • Impact irreplaceable vegetation and sensitive faunal habitats. • Infrastructure limited to southern border of N14.

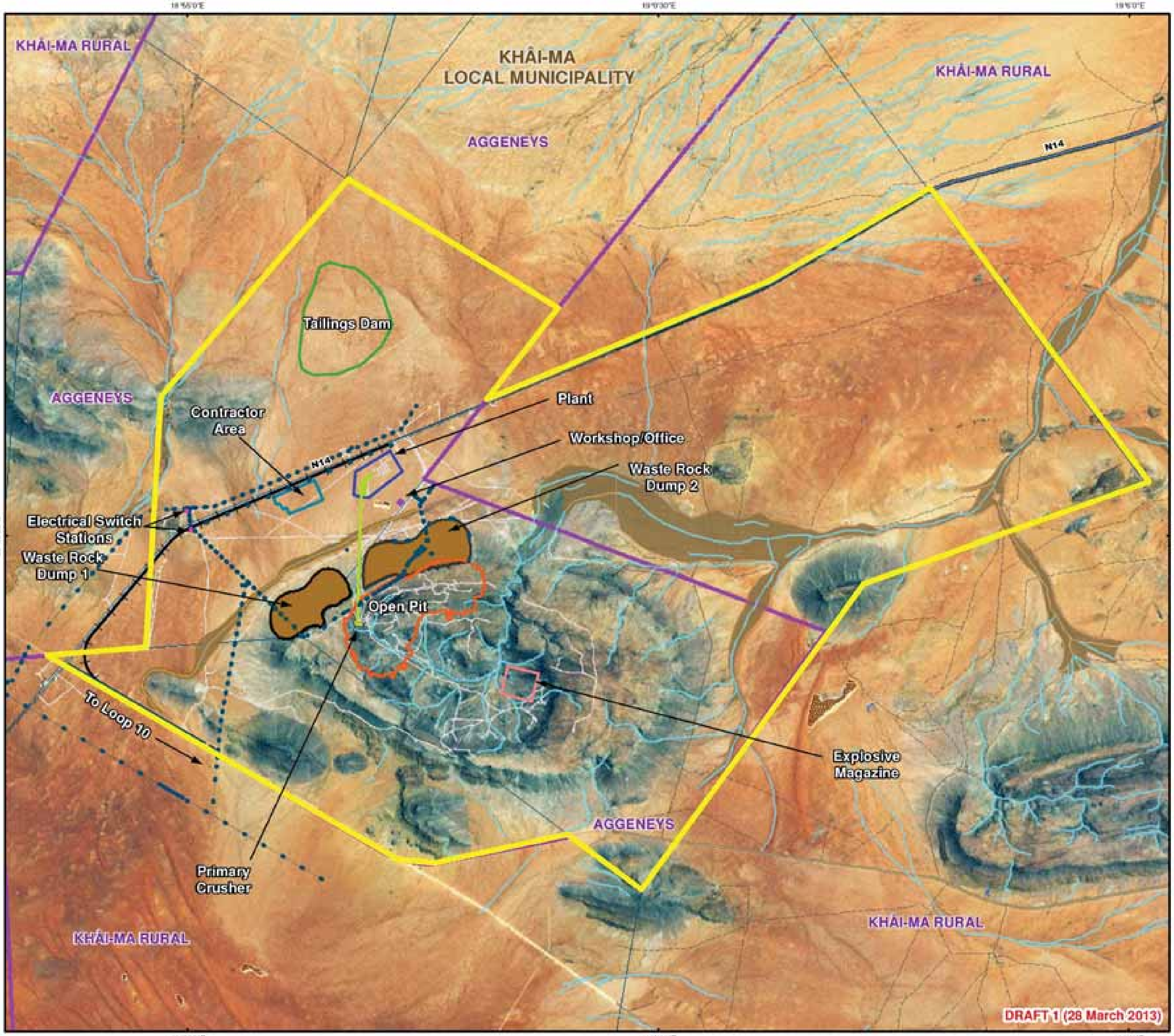
4.8.1 *Refinement of Project Design*

Based on the aforementioned screening process, a project layout was developed and distributed to the specialist team. The specialists undertook their impact assessments based on the initial layout plan (refer to *Figure 4.6* below). Based on the initial findings of the specialist studies, the following changes were recommended by the specialist team, which were subsequently made:

- Relocation of the explosives magazine area from the top of the inselberg to an area located between the N14 and inselberg. Due to the impacts to three watercourses on the inselberg, the explosives magazine area was relocated.
- Increase in size of the waste rock dump from to 270 hectares to 490 hectares. In order to reduce the slope angle of the waste rock dump (i.e. from 45^0 – 35^0 degree slope angle), the footprint of the waste rock dump has subsequently increased.

Note that each specialist has been requested to confirm the aforementioned refinements to the project design, in relation to their specialist impact assessment. Each specialist report contains a section outlining the implications of the above mentioned layout. It was confirmed that all specialist findings and impact ratings were not going to change, as compared to the impacts assessed against the initial layout plan.

The final layout plan, which reflects the relocation of the explosives magazine area and increase in footprint of the waste rock dump was compiled, in which this ESIA Report is based on is included as *Figure 3.1* in Chapter 3 above.



Legend

- Dry Water Course Centre Line
- Non-Perennial Centre Line
- Dry Water Course Extent
- Dam
- Dry Pan

- National Route
- Main Road
- Secondary Road
- Other Road
- Track/Footpath

- Conveyors
- Railway
- Electrical cables
- Haul Roads

- Town Boundary
- Cadastral_Boundaries

- Waste Rock Dump 1 (116.1 Hectares)
- Waste Rock Dump 2 (144.08 Hectares)
- Tailings Dam (273.44 Hectares)
- Plant (45.62 Hectares)
- Contractor Area (31.78 Hectares)
- Open Pit (303.94 Hectares)
- Truck Workshop / Office (0.78 Hectares)
- Explosive Magazine (32.33 Hectares)
- Primary Crusher
- Electrical Switching Yard

- Mineral Rights Area

SCALE: 0 1 2 3 4 Kilometres

N

TITLE:

Figure 4.6: Initial Layout Plan

CLIENT:

vedanta

BLACK MOUNTAIN MINING (PTY) LTD

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

DRAWING: General Layout Plan.mxd

REV: 0

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

Projection: Transverse Mercator, CM19, Datum : WGS84
Source: Chief Directorate National Geo-Spatial Information, Ground Truth Report
Inset Map: Esri Data & Maps

SIZE: A3

T:\Gis Projects\0164903_Gamsberg\Mapping\MXD\Report\Mar2013\General Layout Plan.mxd

4.8.2 *Comparative Analysis of Alternatives from the Previous and Current ESIA Process*

Based on a review of the alternatives considered during the previous and current EIA process, the proposed location of the following infrastructure is consistent with both EIA processes:

- Open pit;
- Waste rock dump;
- Tailings dam;
- Primary crusher; and
- Access road along the northern slopes of the inselberg.

It should be noted that, based on original design, the location of the engineering workshop was similar. However, in light of the request for the construction of a new access road along the northern slopes, the location of the engineering workshop has shifted to the plains, between the plant and waste rock dump. The biodiversity sensitivities (irreplaceable habitat) have been taken into consideration, when siting the workshop. The new location of the workshop is consistent with the technical requirement of the proposed access road along the northern slope of the inselberg.

Lastly, the initial location for the plant and contractor camp for the current ESIA process was similar to the previous layout plan. However, the location of the plant and contractor camp has now been inter-changed for technical requirements. Locating the plant north of the contractor area facilitates the transportation of the ore from the crusher, via the proposed conveyor, to the Plant.