Report on the ecological and wetland assessment for the proposed alluvial diamond mining operations on a portion of the Remainder of the Farm Pniel 218 including a portion of the Vaal River near the town of Delportshoop, Northern Cape Province.

January 2019

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DECLARATION OF INDEPENDENCE

DPR Ecologists and Environmental Services is an independent company and has no financial, personal or other interest in the proposed project, apart from fair remuneration for work performed in the delivery of ecological services. There are no circumstances that compromise the objectivity of the study.

Report Version	**Final 1.0**		
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Executive Summary

The site proposed for mining operations has been rated as being acceptable for the development. However, this is subject to the Vaal River being excluded as far as possible from mining activities and that comprehensive rehabilitation is implemented.

The study area is situated adjacent to the Gong Gong rural settlement. The study area proposed for alluvial diamond mining is located on the southern banks of the Vaal River and has an approximate extent of 110 hectares (Map 1). The study area also includes a portion of the Vaal River including the main channel, banks and floodplain. The banks of the river in this portion is considered to still be largely natural. However, the terrestrial portion of the site, i.e. interior, has been heavily affected by previous and recent mining operations without any adequate rehabilitation having been done and consequently this area is in a relatively poor condition largely altered from the natural condition.

The previous mining operations must be regarded as the most significant impact on the terrestrial portion of the study area (Map 1). Impacts associated with this include the initial removal of the natural vegetation layer. Associated with this was also the removal of the topsoil layer, which was evidently not adequately replaced and consequently prevented the establishment of natural vegetation in many areas. This will also have implications for rehabilitation should the proposed mining operations take place. The topography has been altered to a large degree through the excavation of a large amount of material which was not replaced adequately in the post mining environment. Large areas consist of tailings of rounded gravel rocks and boulders and in these areas vegetation is unable to establish due to the absence of soil. The inadequate rehabilitation resulting from previous mining clearly indicate the high impact this has and the need for post mining rehabilitation and adequate management of topsoil.

In conclusion, from the survey of the terrestrial portion of the study area it is clear that previous mining operations has transformed and removed the natural vegetation and has also altered the topography and soil profile to a large degree (Map 1). Vegetation has become re-established in many areas but is still in an early stage of succession and dominated by pioneer species with a low species diversity. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. However, the poorly rehabilitated study area should clearly illustrate the importance of comprehensive rehabilitation, re-instatement of the natural topography as far as possible as well as the correct management of topsoil. It is also evident that through adequate rehabilitation it is possible to re-instate a natural vegetation layer similar to that of the surrounding natural areas.

The Vaal River forms part of the northern and eastern border of the proposed mining area (Map 1). Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section forming part of the study area (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system. The largest impact on the site itself is considered historical alluvial diamond mining which has had a high impact on the site. Consequently almost the entire site has been transformed from the natural vegetation type and is currently dominated by pioneer species. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant impacts as well as historical alluvial diamond mining within the study area. The unique braided morphology of the river does increase the condition to some degree.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Although a comprehensive rehabilitation and monitoring regime may decrease this risk it is still unlikely to ensure the re-establishment of current natural functioning. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Mining within close proximity to the Vaal River and associated wetland areas is anticipated to have a moderate risk and will likely still have significant impacts though unlikely to be permanent and will mostly influence sediment load and runoff values. Furthermore, through adequate mitigation these can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of this system will result.

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Mining along the banks of the Vaal River is recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Furthermore, should mining take place along the banks of the river this should be confined to the upper and lower zones and the marginal zone and main channel excluded in order to provide some buffer. In addition, should any mining of the bed or banks occur the extent should be kept to a minimum. The survey has indicated that the portion of the river along the northern part of the site consists of a more unique habitat and consequently should mining of the river banks be desired this should concentrate on the eastern, less unique, portion of the river with the mining of the northern

portion being the last resort (Map 1). Where mining within the river is desired the only mitigation can be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS.

Mining in close proximity to the Vaal River will clear vegetation, disturb the soil surface and mobilise soils. This may cause high levels of sedimentation within the river. It is therefore recommended that measures be implemented to prevent sediment from entering the river. Due to the removal of vegetation and disturbance of the soil surface the mining areas will be highly susceptible to the establishment of invasive weeds. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area.

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Ecological and wetland assessment.

1. INTRODUCTION

1.1 Background

Natural vegetation is an important component of ecosystems. Some of the vegetation units in a region can be more sensitive than others, usually as a result of a variety of environmental factors and species composition. These units are often associated with water bodies, water transferring bodies or moisture sinks. These systems are always connected to each other through a complex pattern. Degradation of a link in this larger system, e.g. tributary, pan, wetland, usually leads to the degradation of the larger system. Therefore, degradation of such a water related system should be prevented.

Though vegetation may seem to be uniform and low in diversity it may still contain species that are rare and endangered. The occurrence of such a species may render the development unviable. Should such a species be encountered the development should be moved to another location or cease altogether.

South Africa has a large amount of endemic species and in terms of plant diversity ranks third in the world. This has the result that many of the species are rare, highly localised and consequently endangered. It is our duty to protect our diverse natural resources.

South Africa's water resources have become a major concern in recent times. As a water scarce country, we need to manage our water resources sustainably in order to maintain a viable resource for the community as well as to preserve the biodiversity of the system. Thus, it should be clear that we need to protect our water resources so that we may be able to utilise this renewable resource sustainably. Areas that are regarded as crucial to maintain healthy water resources include wetlands, streams as well as the overall catchment of a river system.

In order to better manage our water resources several guidelines and research sources have been developed. Amongst these are the National Freshwater Ecosystem Priority Areas for South Africa 2011 (NFEPA).

It is well known that diamond mining operations, especially pertaining to alluvial mining, has several detrimental impacts on the environment. These impacts are numerous but the most pronounced impacts are associated with the excavation of large amounts of earth materials, the storage and disposal thereof and the sedimentation associated with it. This usually causes degradation of waterways due to sedimentation as well as the transformation of the vegetation and ecosystem on the site.

The study area is situated adjacent to the Gong Gong rural settlement which is located approximately 11 km to the south east of the small town of Delportshoop and 13 km to the north west of the small town of Barkly West. The study area proposed for alluvial diamond mining is located on the southern banks of the Vaal River and has an approximate extent of 110 hectares (Map 1). The study area also includes a portion of the Vaal River including the main channel, banks and floodplain. The banks of the river in this portion is considered to still be largely natural. However, the terrestrial portion of the site, i.e. interior, has been heavily affected by previous and recent mining operations without any adequate rehabilitation having

been done and consequently this area is in a relatively poor condition largely altered from the natural condition.

A site visit was conducted on 9 to 10 January 2019. The entire footprint of the proposed mining area, including terrestrial and riparian areas, was surveyed over the period of two days. The site survey was conducted during summer, and plant identification along the river could be easily done. However, the current severe drought makes species identification in the terrestrial portion difficult.

For the above reasons it is necessary to conduct an ecological and wetland assessment of an area proposed for development.

The report together with its recommendations and mitigation measures should be used to minimise the impact of the proposed mining development.

1.2 The value of biodiversity

The diversity of life forms and their interaction with each other and the environment has made Earth a uniquely habitable place for humans. Biodiversity sustains human livelihoods and life itself. Although our dependence on biodiversity has become less tangible and apparent, it remains critically important.

The balancing of atmospheric gases through photosynthesis and carbon sequestration is reliant on biodiversity, while an estimated 40% of the global economy is based on biological products and processes.

Biodiversity is the basis of innumerable environmental services that keep us and the natural environment alive. These services range from the provision of clean water and watershed services to the recycling of nutrients and pollution. These ecosystem services include:

- Soil formation and maintenance of soil fertility.
- Primary production through photosynthesis as the supportive foundation for all life.
- Provision of food, fuel and fibre.
- Provision of shelter and building materials.
- Regulation of water flows and the maintenance of water quality.
- Regulation and purification of atmospheric gases.
- Moderation of climate and weather.
- Detoxification and decomposition of wastes.
- Pollination of plants, including many crops.
- Control of pests and diseases.
- Maintenance of genetic resources.

2. SCOPE AND LIMITATIONS

- To evaluate the present state of the vegetation and ecological functioning of the area proposed for the mining development.
- To identify possible negative impacts that could be caused by the proposed clearing of vegetation and establishment of mining operations.
- Identify and delineate wetland and riparian areas associated with the Vaal River along the northern and eastern border of the site.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the Vaal River in the study area.
- Conduct a risk assessment and determine the likelihood that watercourses and wetlands will be adversely affected by the mining operations.

2.1 Vegetation

Aspects of the vegetation that will be assessed include:

- The vegetation types of the region with their relevance to the proposed site.
- The overall status of the vegetation on site.
- Species composition with the emphasis on dominant-, rare- and endangered species.

The amount of disturbance present on the site assessed according to:

- The amount of grazing impacts.
- Disturbance caused by human impacts.
- Other disturbances.

2.2 Fauna

Aspects of the fauna that will be assessed include:

- A basic survey of the fauna occurring in the region using visual observations of species as well as evidence of their occurrence in the region (burrows, excavations, animal tracks, etc.).
- The overall condition of the habitat.

2.3 Wetlands and watercourses

Aspects of the wetlands that will be assessed include:

- Identification and delineation of watercourses including rivers, streams, pans and wetlands.
- Describe condition and status of watercourses and importance relative to the larger system.
- Conduct habitat integrity assessment of perennial systems to inform the condition and status of watercourses.

2.4 Limitations

Due to the season of the survey several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to their seasonal or deciduous nature.
The current severe drought in the area makes species identification difficult since many plants would remain in a dormant state.
Although a comprehensive survey of the site was done it is still likely that several species were overlooked.
Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
Due to previous mining activities this may have altered soil layers and the morphology of the river banks which would complicate the delineation of wetland and riparian areas.
Due to a rocky substrate soil sampling was not possible along all areas of the river bank.
Some animal species may not have been observed as a result of their nocturnal and/or shy habits.

3. METHODOLOGY

3.1 Several literature works were used for additional information.

Vegetation:
Red Data List (Raymondo *et al.* 2009)
Vegetation types (Mucina & Rutherford 2006)
Field guides used for species identification (Adams 1976, Bromilow 1995, 2010, Coates-Palgrave 2002, Gerber *et al* 2004, Gibbs-Russell *et al* 1990, Manning 2009, Roberts & Fourie 1975, Shearing & Van Heerden 2008, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Rooyen 2001, Van Wyk & Malan 1998, Van Wyk & Van Wyk 1997).

Terrestrial fauna:
Field guides for species identification (Smithers 1986a).

Wetland methodology, delineation and identification:
Department of Water Affairs and Forestry 2004, 2005, 2008, Collins 2006, Duthie 1999, Gerber *et al* 2004, Kleynhans 2000, Marnewecke & Kotze 1999, Macfarlane *at el* 2014, Nel *et al* 2011, SANBI 2009, Van Ginkel *et al* 2011.

3.2 Survey

The site was assessed by means of transects and sample plots.

Noted species include rare and dominant species.
The broad vegetation types present on the site were determined.
The state of the environment was assessed in terms of condition, grazing impacts, disturbance by humans, erosion and presence of invader and exotic species.

Animal species were also noted as well as the probability of other species occurring on or near the site according to their distribution areas and habitat requirements.
The state of the habitat was also assessed.

All rivers, streams, pans and wetlands were identified and surveyed where it occurred in the study area.

These systems were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix B & C).
The following guidelines and frameworks were used to determine and delineate the rivers, streams, pans and wetlands in the study area:

- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.
- Marnewecke & Kotze 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

The following guidelines and frameworks were used to determine the sensitivity or importance of these identified watercourses in the study area:

- Nel *et al.* (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

- Government of South Africa. 2008. National Protected Area Expansion Strategy for South Africa 2008: Priorities for expanding the protected area network for ecological sustainability and climate change adaptation. Government of South Africa, Pretoria.

- Duthie, A. 1999. Appendix W5: IER (floodplain and wetlands) determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

These guidelines provide the characteristics which can be utilised to determine if a wetland or watercourse is present and also aids in determining the boundary of these systems.

A Risk Assessment will be conducted for the mining operations in the study area in accordance with the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use.

3.3 Criteria used to assess sites

Several criteria were used to assess the site and determine the overall status of the environment.

Vegetation characteristics
Characteristics of the vegetation in its current state. The diversity of species, sensitivity of habitats and importance of the ecology as a whole.

Habitat diversity and species richness: normally a function of locality, habitat diversity and climatic conditions.
Scoring: Wide variety of species occupying a variety of niches – 1, Variety of species occupying a single nich – 2, Single species dominance over a large area containing a low diversity of species – 3.

Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species on a proposed site plays a large role on the feasibility of a development. Depending on the status and provincial conservation policy, presence of a Red Data species can potentially be a fatal flaw.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely – 3.

Ecological function: All plant communities play a role in the ecosystem. The ecological importance of all areas though, can vary significantly e.g. wetlands, drainage lines, ecotones, etc.
Scoring: Ecological function critical for greater system – 1, Ecological function of medium importance – 2, No special ecological function (system will not fail if absent) – 3.

Degree of rarity/conservation value:
Scoring: Very rare and/or in pristine condition – 1, Fair to good condition and/or relatively rare – 2, Not rare, degraded and/or poorly conserved – 3.

Vegetation condition
The sites are compared to a benchmark site in a good to excellent condition. Vegetation management practises (e.g. grazing regime, fire, management, etc.) can have a marked impact on the condition of the vegetation.

Percentage ground cover: Ground cover is under normal and natural conditions a function of climate and biophysical characteristics. Under poor grazing management, ground cover is one of the first signs of vegetation degradation.
Scoring: Good to excellent – 1, Fair – 2, Poor – 3.

Vegetation structure: This is the ratio between tree, shrub, sub-shrubs and grass layers. The ratio could be affected by grazing and browsing by animals.
Scoring: All layers still intact and showing specimens of all age classes – 1, Sub-shrubs and/or grass layers highly grazed while tree layer still fairly intact (bush partly opened up) – 2, Mono-layered structure often dominated by a few unpalatable species (presence of barren patches notable) – 3.

Infestation with exotic weeds and invader plants or encroachers:
Scoring: No or very slight infestation levels by weeds and invaders – 1, Medium infestation by one or more species – 2, Several weed and invader species present and high occurrence of one or more species – 3.

Degree of grazing/browsing impact:
Scoring: No or very slight notable signs of browsing and/or grazing – 1, Some browse lines evident, shrubs shows signs of browsing, grass layer grazed though still intact – 2, Clear browse line on trees, shrubs heavily pruned and grass layer almost absent – 3.

Signs of erosion: The formation of erosion scars can often give an indication of the severity and/or duration of vegetation degradation.
Scoring: No or very little signs of soil erosion – 1, Small erosion gullies present and/or evidence of slight sheet erosion – 2, Gully erosion well developed (medium to large dongas) and/or sheet erosion removed the topsoil over large areas – 3.

Faunal characteristics
Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species on a proposed site plays a large role on the feasibility of a development. Depending on the status and provincial conservation policy, presence of a Red Data species or very unique and sensitive habitats can potentially be a fatal flaw.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely.

3.4 Biodiversity sensitivity rating (BSR)

The total scores for the criteria above were used to determine the biodiversity sensitivity ranking for the sites. On a scale of 0 – 30, six different classes are described to assess the suitability of the sites to be developed. The different classes are described in the table below:

Table 1: Biodiversity sensitivity ranking

BSR	BSR general floral description	Floral score equating to BSR class
Ideal (5)	Vegetation is totally transformed or in a highly degraded state, generally has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area has lost its inherent ecological function. The area has no conservation value and potential for successful rehabilitation is very low. The site is ideal for the proposed development.	29 – 30
Preferred (4)	Vegetation is in an advanced state of degradation, has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area's ecological function is seriously hampered, has a very low conservation value and the potential for successful rehabilitation is low. The area is preferred for the proposed development.	26 – 28
Acceptable (3)	Vegetation is notably degraded, has a medium level of species diversity although no species of concern are present. Invasive plants are present but are still controllable. The area's ecological function is still intact but may be hampered by the current levels of degradation. Successful rehabilitation of the area is possible. The conservation value is regarded as low. The area is acceptable for the proposed development.	21 – 25
Not preferred (2)	The area is in a good condition although signs of disturbance are present. Species diversity is high and species of concern may be present. The ecological function is intact and very little rehabilitation is needed. The area is of medium conservation importance. The area is not preferred for the proposed development.	11 – 20
Sensitive (1)	The vegetation is in a pristine or near pristine condition. Very little signs of disturbance other than those needed for successful management are present. The species diversity is very high with several species of concern known to be present. Ecological functioning is intact and the conservation importance is high. The area is regarded as sensitive and not suitable for the proposed development.	0 - 10

4. ECOLOGICAL OVERVIEW OF THE SITE

4.1 Overview of ecology and vegetation types (Mucina & Ruterford 2006)

Refer to the list of species encountered on the site in Appendix B.

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures.

The study area is situated adjacent to the Gong Gong rural settlement which is located approximately 11 km to the south east of the small town of Delportshoop and 13 km to the north west of the small town of Barkly West. The study area proposed for alluvial diamond mining is located on the southern banks of the Vaal River and has an approximate extent of 110 hectares (Map 1). The study area also includes a portion of the Vaal River including the main channel, banks and floodplain. The banks of the river in this portion is considered to still be largely natural. However, the terrestrial portion of the site, i.e. interior, has been heavily affected by previous and recent mining operations without any adequate rehabilitation having been done and consequently this area is in a relatively poor condition largely altered from the natural condition. Where vegetation has been to re-establish in the post mining area it is mostly represented by a savannah structure consisting of an open to closed shrub and tree layer with a very sparse grass understorey.

The entire terrestrial portion of the study area has been transformed by previous mining operations (Map 1). The riparian zone associated with the Vaal River seems to be largely intact but will be discussed in detail in the following sections. Rehabilitation of the post mining environment was overall poorly done and consequently the re-establishment of natural vegetation is also poor with some areas unable to establish any kind of vegetation. Portions of the study area has however been able to establish a pioneer but largely indigenous vegetation layer. Whatever the case may be, the vegetation on the site, although indigenous, must be considered to be of secondary establishment. Vegetation may either be of primary establishment, i.e. it is the natural occurring vegetation type which has never been altered by anthropogenic activities. Or it may be of secondary establishment, i.e. the naturally occurring vegetation has at some stage been cleared by human activity and a natural, though not necessarily representative of the natural vegetation type, vegetation layer has re-established.

The previous mining operations must be regarded as the most significant impact on the terrestrial portion of the study area. Impacts associated with this include the initial removal of the natural vegetation layer. Associated with this was also the removal of the topsoil layer, which was evidently not adequately replaced and consequently prevented the establishment of natural vegetation in many areas. This will also have implications for rehabilitation should the proposed mining operations take place, but will be discussed further in later sections. The topography has been altered to a large degree through the excavation of a large amount of material which was not replaced adequately in the post mining environment. Large areas consist of tailings of rounded gravel rocks and boulders and in these areas vegetation is unable to establish due to the absence of soil. The inadequate rehabilitation resulting from previous mining clearly indicate the high impact this has and the need for post mining rehabilitation and

adequate management of topsoil. Other smaller but still significant impacts include numerous dirt tracks and gravel roads as well as high levels of overgrazing by domestic stock.

Figure 1: A pioneer vegetation layer has become re-established in many post mining areas though mining scars are evident almost everywhere.

Figure 2: Gravel roads and dirt tracks are common in the study area and mine tailings such as visible in the background are common.

Figure 3: Areas where rehabilitation has been undertaken with mine tailings but without topsoil is unable to re-establish vegetation.

Figure 4: A close-up of the area in Fig. 3 indicating the absence of any vegetation.

Figure 5: Large areas of the study area is affected by extensive mining scars where it is evident that little or rehabilitation was undertaken.

As already mentioned the topography of the study area has been altered to a large degree. This is a result of previous mining operations and inadequate rehabilitation being undertaken. Deep excavations and a variety of small and large tailing dumps litter the study area. The general topography, anticipated to have been present prior to mining, is considered to largely consist of a uniform plain which has a gradual slope toward the Vaal River, i.e. to the north and east, but which may increase significantly in the slope gradient in the portion adjacent to the river. The topography of the banks of the Vaal River is considered still intact to a large degree although mining has evidently affected the upper zone in many areas. The interior of the study area is devoid of any watercourses or wetlands with these being confined to the Vaal River. Available mapping sources indicate that the study area is devoid of any other watercourses with one or two small drainage lines occurring in the surrounding area.

The immediate region have an approximate mean annual rainfall of 400 mm (Bezuidenhout 1994). This is considered a relatively low rainfall and causes the area to form part of the more arid parts of South Africa. The occurrence of wetlands are therefore not common, however, due to the proximity to the Vaal River the area does contain several wetlands associated with the floodplain of the Vaal River. Temperature is less erratic than rainfall with cold winters as low as -4˚C while the summer temperatures may be as high as 44˚C.

Geology of the study area is underlain by the following: Outcrops of andesitic lavas of the Ventersdorp Supergroup overlain by calcrete occur as low hills. Outcrops of tillite of the Dwyka Formation and shale of the Prince Albert Formation occur in the north west of the area. The

majority of the study area is underlain by aeolian sands and alluvial gravels of Tertiary to Recent age covering Dwyka tillite. Surface limestone also occurs sporadically. Three land types, the AH, Ae and Dc land types occur in the area (Bezuidenhout 1994).

The study area is situated adjacent to the deproclamated Vaalbos conservation area where a comprehensive study of the vegetation was undertaken (Bezuidenhout 1994). This was also utilised to provide an indication of the natural vegetation which was present in the area prior to mining operations. This study had identified 11 plant communities in the area. These communities are:

- *Schmidtia pappophoroides - Themeda triandra* Grassland
- *Grewia flava - Acacia erioloba* Woodland of deep red sandy soil
- *Lycium hirsutum - Acacia erioloba* Woodland of deep yellow sandy soil
- *Rhus ciliata - Tarchonanthus camphoratus* Shrubland distributed within large areas
- *Acacia erioloba - Acacia tortilis* Woodland of ancient gravel filled water courses.
- *Boscia albitrunca - Acacia mellifera* Shrubland of rocky isolated rocky hills.
- *Acacia tortillis - Acacia mellifera* Shrubland near the Vaal River.
- *Enneapogon cenchroides - Acacia tortillis* Woodland of recently deposited Vaal River gravel
- *Pentzia incana - Acacia melifera* Shrubland
- *Eragrostis sp. - Chloris virgata* Grassland restricted to the floodplain along the Vaal River.

Take note that the following changes to taxonomy has been made since this study:

A. erioloba - Vachellia erioloba
R. ciliata - Searsia ciliata
A. torilis - Vachellia tortilis
A. mellifera - Senegalia mellifera

As mentioned previously the dominant vegetation structure on the site consists of savannah with an open to relatively dense shrub/tree layer and very sparse grass understorey. The tree/shrub layer is dominated largely by a single species, *Vachellia tortilis*. This is a pioneer tree species being the first to establish in disturbed areas. The size of these trees vary from small shrubs to quite large trees over the study area and can be used to indicate the relative time lapsed since the cessation of the previous mining operations. A few other species of tree and shrubs are also present but are rare and most consisting of single specimens. These include *Senegalia melifera* subsp. *detinens*, which is normally quite abundant in this area, *Grewia flava, Diospyros lycioides* and *Searsia lancea*. An exotic tree species*, Schinus molle*, is also present as scattered specimens. The tree layer in the study are is indicative of a transformed natural vegetation layer. It is dominated by a single, pioneer species with other trees common in this vegetation type being rare or absent from the study area. The grass layer is also dominated by only a few pioneer species and is quite sparse with a very low percentage vegetation cover. Although the area is in an arid region, currently experiencing a severe drought this is still quite low when compared to surrounding natural areas and also indicates the difficulty of grasses to establish in the post mining area. Dominant grass species are *Aristida congesta* and *Eragrotsis lehmanniana* with other common species including *Enneapogon cenchroides, Cynodon dactylon, Eragrostis obtusa* and *Aristida adscensionis*. A low shrub which is also prominent, *Laggera decurrens*, is a pioneer species which often proliferates in disturbed areas. The study area has a low diversity of species with only a few

herbaceous species being present. These include *Senna italica, Lycium horridum, Nolletia ciliaris, Tribulus terrestris, Cucumis africanus, Sesamum triphyllum, Gomphocarpus tomentosus, Peliostomum leucorrhizum* and *Jamesbrittenia atropurpurea*. Several exotic weeds and invaders has also become established due to the disturbed condition. These may be abundant but do not yet dominate the vegetation. They include *Bidens bipinnata, Boerhavia cordobensis, Opuntia ficus-indica* and *Nicotiana glauca*.

Along the western border of the study area a very small portion of natural vegetation remains. It is very small being approximately only 1 hectare in size. It is therefore not of high conservation value but does give some indication of the natural vegetation. Tree and shrubs are dominated by *Vachellia tortilis, Senegalia melifera* subsp. *detinens, Ehretia rigida, Ziziphus mucronata* and *Diospyros lycioides*. A higher species diversity not being dominated by a single species is clearly evident. Grasses are dominated by *Ennepogon cenchroides, Heteropogon contortus, Eragrostis lehmanniana* and *Aristida congesta*. Note that this is similar to the surrounding area. Other herbaceous species include *Aptosimum marlothii, Eriocephalus ericoides* and *Cadaba aphylla*. Two invasive succulent species, *Opuntia microsadys* and *Echnopsis schickendantzii*, are also present and can become abundant around historical rock walls.

The previous study of the adjacent area (Bezuidenhout 1994) indicates that the natural vegetation community of the study area is most likely the *Enneapogon cenchroides - Acacia tortillis* Woodland. A description of this community as taken from this study follows:

"The woodland…is strongly associated with the relatively recently deposited Vaal River gravel. Because of the debris of the old diamond diggings the soil is very disturbed and soil depth varies from shallow to deep (>0.3m) and two soil forms Mispah and Hutton are present… The soil is also well drained and more than 30% well rounded rocks or stones were noted on the soil surface. The woodland is situated in the Ae land type.

The *Enneapogon cenchroides - Acacia tortillis* Woodland is characterised by the diagnostic shrub *Rhigozum trichotomum* and the diagnostic forbs *Hermannia quartiniana, Corbichonia decumbens* and *Cleome maculata*. The tree stratum is 4m tall with a canopy cover of 5% while the dominant shrub stratum is well-developed with a canopy cover of 30% and a height of 1.5 m. The woody component is dominated by the tree/shrub *Acacia tortilis* (*Vachellia tortilis*) while the tree *Ziziphus mucronata*, the shrubs *Acacia melifera* (*Senegalia melifera*), *Diospyros lycioides* and a *Lycium* species are also present. The herbaceous layer is 0.7 m tall and has a canopy cover of 68%. The prominent grasses are *Digitaria eriantha, Cenchrus ciliaris, Enneapogon cenchroides, Aristida adscensionis, A. congesta* subsp. *barbicollis, Eragrostis obtusa, E. lehmanniana* and *Cynodon dactylon*. Prominent forbs in this community are *Pentzia incana, Phyllanthus maderaspatensis, Pupalia lappacea, Pollichia capestris* and *Lippia javanica*."

The above description clearly shows affinities with the vegetation currently in the study area but also clearly illustrates that the study area is currently dominated by only a few species and mostly pioneers. Note also that the above study already mentioned that the area was disturbed by mining operations which also indicates that the natural vegetation may be also different from the vegetation composition identified by them. However, this also indicates that if adequate rehabilitation is implemented that a vegetation community somewhat resembling the natural condition can be re-instated.

When comparing the results from the above quoted study as well as the small portion of remaining natural vegetation on the site with the vegetation currently dominating the study area the following conclusion can be made; It should be clear that it is heavily degraded but that a vegetation layer is in the process of re-establishing and that it already has some affinities with the surrounding natural or semi-natural vegetation. Given time it may be possible that the vegetation will advance to a condition which is somewhat similar to that of the surroundings.

From available aerial imagery (Google Earth 2006 – 2017) it is clear that previous mining activities has taken place for quite some time and it is also clear how vegetation has become re-established in many areas (Fig. 6 & 7).

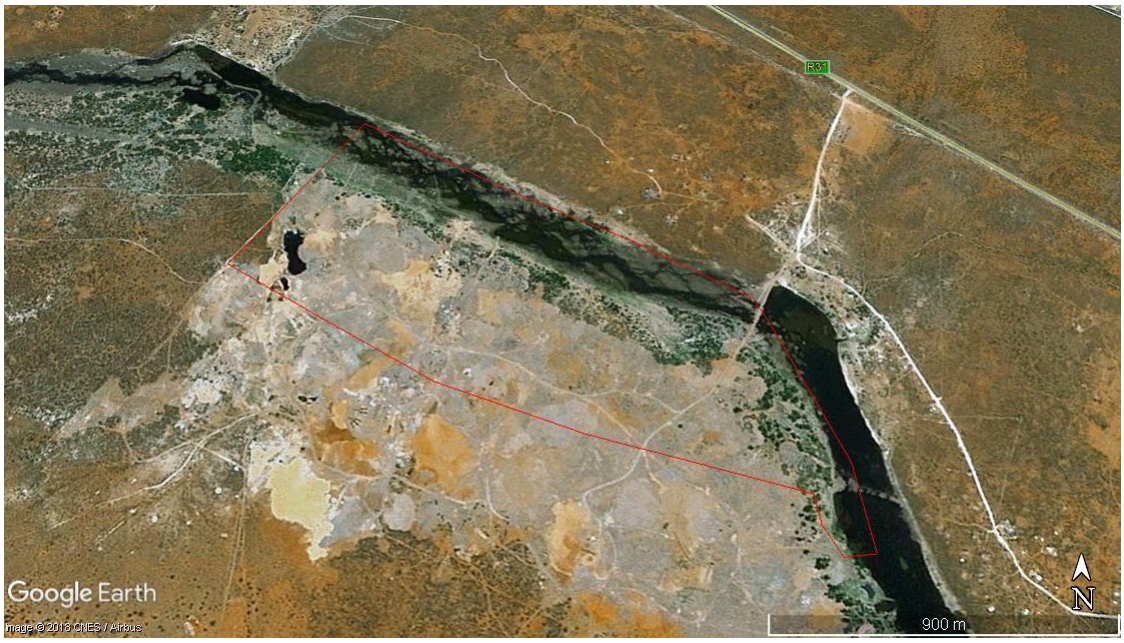

Figure 6: Aerial view of the proposed site (Google Earth 2006). Note that extensive mining operations are already in process.

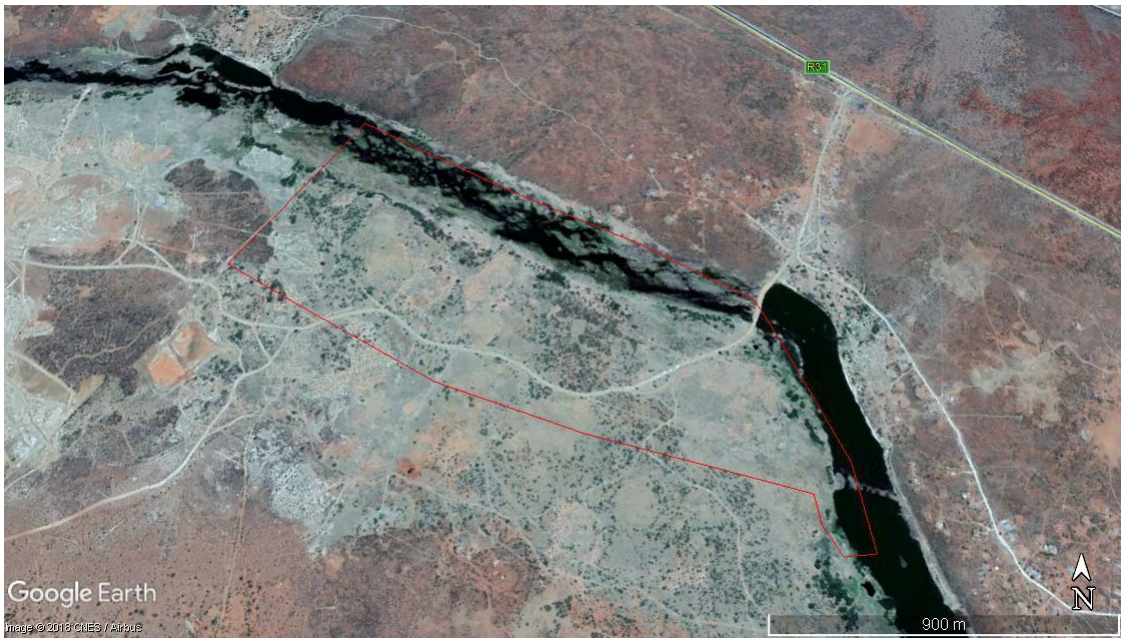

Figure 7: Aerial view of the proposed site (Google Earth 2017). Mining operations has ceased and the re-establishment of vegetation is visible in some areas.

In conclusion, from the survey of the terrestrial portion of the study area it is clear that previous mining operations has transformed and removed the natural vegetation and has also altered the topography and soil profile to a large degree (Map 1). Vegetation has become re-established in many areas but is still in an early stage of succession and dominated by pioneer species with a low species diversity. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. However, the poorly rehabilitated study area should clearly illustrate the importance of comprehensive rehabilitation, re-instatement of the natural topography as far as possible as well as the correct management of topsoil. It is also evident that through adequate rehabilitation it is possible to re-instate a natural vegetation layer similar to that of the surrounding natural areas. The Vaal River, also forming part of the northern and eastern portions of the study area, is however highly sensitive and will be affected by the proposed mining operations. It will be discussed in the following sections.

4.2 Overview of terrestrial fauna (actual & possible)

It was noticeable that almost no tracks and signs of mammals were present on the site. Burrows were also conspicuously absent, also likely as a result of the rocky, gravel substrate. The modification of the study area due to mining has most likely altered the habitat to such a degree that it is not suitable for most mammals occurring in this area. Furthermore, as has been previously discussed many areas does not contain any established vegetation and where vegetation has managed to re-establish this is very sparse. Consequently the resources available to mammals is also very low and not able to sustain a viable mammal population. Communal grazing by domestic stock is also relatively high and will further provide competition for natural mammals.

The Vaal River will contain a much more substantial mammal population and with a more natural species assemblage. Surrounding vegetation transformation by previous mining will influence the mammal population along the river to some extent. Nonetheless, watercourses are able to sustain a higher bio-load which in turn supports a larger mammal population and it is likely that the mammal population along the river will be substantial. Should mining take place along the banks or main channel of the river the impact on mammals will be significant.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. However, as discussed, the available habitat is already transformed and mammal population would be much diminished from the natural condition. Where the banks and main channel of the Vaal River is affected this is anticipated to still have a significant impact on the mammal population. It will be possible to significantly mitigate this by amongst others to limit mining to set areas and not mine several areas at the same time, limit the extent of each such mining area and comprehensive and successful rehabilitation of mined areas.

It is also considered likely that several mammal species were overlooked during the survey but owing to the transformed condition of the site due to previous mining it is considered unlikely

that any rare or endangered species would occur on the site. The likelihood that such species may still occur along the Vaal River cannot be discounted and remains possible.

Mining operations itself may also affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed. The hunting, capturing or harming in any way of mammals on the site should not be allowed. Voids and excavations may also act as pitfall traps to fauna and these should continuously be monitored and any trapped fauna removed and released in adjacent natural areas.

Table 2: Red Listed mammals occurring or likely to occur in the study area (Child *et al* 2016).

Common name	**Scientific name**	**Status**
SA hedgehog	*Erinaceus frontalis*	Near Threatened
Pangolin	*Smutsia temminnki*	Vulnerable
Small spotted cat	*Felis nigripes*	Vulnerable
Brown hyena	*Parahyyaena brunnea*	Near Threatened
Leopard	*Panthera pardus*	Vulnerable

Table 3: Likely mammal species in the region.

Order	**Family**	**Common name**	**Scientific name**
Phylum Vertebrata; Class Mammalia			
Macroscelidea	Macroscelididae	Round-eared Sengi	Macroscelides proboscideus
		Rock Elephant Shrew	*Elephantulus myurus*
Eulipotyphla	Erinaceidae	Southern African Hedgehog	*Atelerix frontalis*
	Soricidae	Lesser Red Musk Shrew	*Crocidura hirta*
Chiroptera	Vespertilionidae	Cape Serotine Bat	*Neoromica capensis*
	Molossidae	Egyptian Free-tailed Bat	*Tadarida aegyotiaca*
	Rhinolophidae	Geoffrey's Horseshoe Bat	*Rhinolophus clivosus*
Primates	Cercopithecidae	Vervet Monkey	*Cercopithecus aethiops*
		Chacma Baboon	*Papio ursinus*
Pholidota	Manidae	Ground Pangolin	*Smutsia temminckii*
Lagomorpha	Leporidae	Cape Hare	*Lepus capensis*
		Scrub Hare	*Lepus saxatilis*
		Smith's Red Rock Rabbit	*Pronolagus campestris*
Rodentia	Sciuridae	Southern African Ground Squirrel	*Xerus inauris*
	Pedetidae	Southern African Springhare	*Pedetes capensis*
	Bathyergidae	Common Mole-rat	*Cryptomys hottentotus*
	Hystricidae	Cape Porcupine	*Hystrix africaeaustralis*
	Muridae	Woosnam's Desert	*Zelotomys woosnami*

		Mouse	
		Pygmy Mouse	*Mus minutoides*
		Pouched Mouse	*Saccostumus campestris*
		Grey Climbing Mouse	*Dendromus melanotis*
		Large-eared Mouse	*Malacothrix typica*
		Cape Short-tailed Gerbil	*Desmodillus auricularis*
		Pygmy Hairy-footed Gerbil	*Gerbillurus paeba*
		Bushveld Gerbil	*Gerbilliscus leucogaster*
		Highveld Gerbil	*Gerbilliscus brantsii*
		Namaqua Rock Mouse	*Micaelamys namaquensis*
		Red Veld Rat	*Aethomys chrysophilus*
		Four-striped Grass Mouse	*Rhabdomys* spp
		Black-tailed Tree Rat	*Thallomys nigricauda*
		Southern Multimammate Mouse	*Mastomys Coucha*
		Brant's Whistling Rat	*Parotomys brantsii*
Carnivora	Canidae	Cape Fox	*Vulpes chama*
		Bat-eared Fox	*Otocyon megalotis*
		Black-backed Jackal	*Canis mesomelas*
	Mustelidae	Honey Badger	*Mellivora capensis*
		African Striped Weasel	*Poecilogale albinucha*
		Striped Polecat	*Ictonyx striatus*
		Cape Clawless Otter	*Aonyx capensis*
	Herpestidae	Slender Mongoose	*Galerella sanguinea*
		Yellow Mongoose	*Cynictis penicillata*
		Suricate	*Suricata suricatta*
		Water Mongoose	*Atilax pludinosus*
	Viverridae	Small-spotted Genet	*Genetta genetta*
	Hyaenidae	Brown Hyaena	*Parahyaena brunnea*
		Aardwolf	*Proteles cristatus*
	Felidae	African Wild Cat	*Felis silvestris*
		Small Spotted Cat	*Felis nigripes*
		Caracal	*Caracal caracal*
		Leopard	*Panthera pardus*
Tubulidentata	Orycteropodidae	Aardvark	*Orycteropus afer*
Hyracoidea	Procaviidae	Rock Hyrax	*Procavia capensis*
Artiodactyla	Bovidae	Mountain Rheedbuck	*Redunca fulvorufula*
		Greater Kudu	*Tragelaphus strepsiceros*
		Springbok	*Antidorcas*

			marsupialis
		Steenbok	*Raphicerus campestris*
		Common Duiker	*Sylvicapra grimmia*

4.3 Wetland Assessment

The Vaal River forms part of the northern and eastern border of the proposed mining area and will be discussed below (Map 1).

The term watercourse refers to a river, stream, wetland or pan. The National Water Act (NWA, 1998) includes rivers, streams, pans and wetlands in the definition of the term watercourse. This definition follows:

Watercourse means:

- A river or spring.
- A natural channel in which water flows regularly or intermittently.
- A wetland, lake or dam into which water flows.
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The classification of stream orders from 1 to 3 can be illustrated by means of the Strahler 1952 classification:

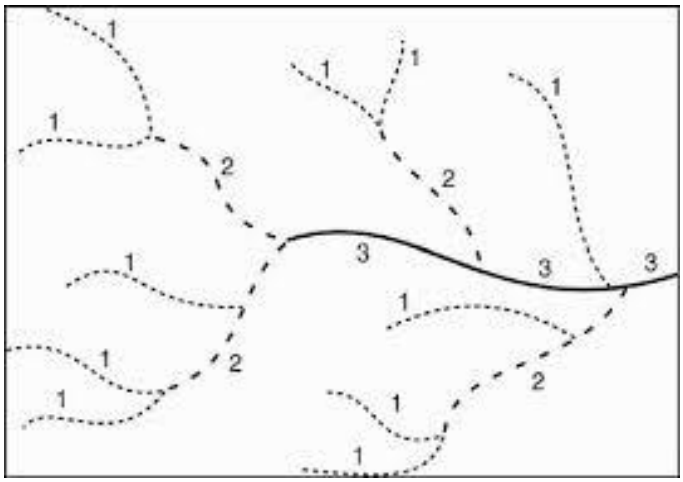

Figure 8: The classification of stream orders from 1 to 3 (Strahler 1952)

Riparian habitat is an accepted indicator of watercourses used to delineate the extent of wetlands, rivers, streams and pans (Department of Water Affairs and Forestry 2005).

The Vaal River and its associated wetland conditions were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix C). The following guidelines and frameworks were used to determine and delineate the watercourses and wetlands in the study area:

- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.
- Marnewecke & Kotze 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

The upper zone contains a minimal grey matrix, no mottles and is not considered as being a wetland area. However, the marginal and lower zone of the Vaal River contains distinctive wetland soil indicators. The banks (Lower Zone) shows indications of a seasonal zone of wetness whilst the Marginal Zone shows soil characters of a permanent zone of wetness. The Vaal River and its banks are clearly defined and easily identifiable. The boundary of the floodplain is not easily identified due to previous transformation by mining operations although the riparian zone is still clearly defined (Map 1).

4.3.1 Classification of wetland systems

The wetland conditions identified along the Vaal River can be classified into a specific wetland type.

The wetland conditions associated with the Vaal River can be characterised as a channel wetland system (SANBI 2009):

"An open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterises the hydrodynamic nature of these units. Note that, for purposes of the classification system, channels generally refer to rivers or streams (including those that have been canalised) that are subject to concentrated flow on a continuous basis or periodically during flooding, as opposed to being characterised by diffuse flow (see unchannelled valley-bottom wetland). As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks. An active channel is a channel that is inundated at sufficiently regular intervals to maintain channel form and keep the channel free of established terrestrial vegetation. These channels are typically filled to capacity during bankfull discharge (i.e. during the annual flood, except for intermittent rivers that do not flood annually)."

This accurately describes the wetland conditions along the Vaal River (Map 1). Here the wetland conditions are most prominent along the main channel and decrease in distance from the channel.

4.3.2 Description of the Vaal River

The Vaal River was surveyed by three separate locations along the section adjacent to the site. The length of river included in the study area is relatively long, approximately 2km (Map 1). The Vaal River, though well known to be degraded and modified, still performs several vital ecosystem services as well as services rendered to downstream users. The river in the study area is quite variable in terms of geomorphology though vegetation structure and species composition remains relatively similar.

Obligate wetland vegetation was also used to determine the presence of wetland conditions. Obligate wetland species are confined to wetlands and are only able to occur in wetlands. They are therefore reliable indicators of wetland conditions. Field observations over time as well as the following sources were used to determine FW and OW species:

- Marnewecke, G. & Kotze, D. 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

- DWAF. 2008. Updated manual for the identification and delineation of wetlands and riparian areas, prepared by M.Rountree, A.L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

River systems can be divided into different riparian zones within the lateral section of the system. These zones are as follows:

The marginal zone is the lowest zone and is always present in river systems while the other two zones may not always be present. The zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 16 & 17). The marginal zone of the river is considered to be largely intact though has been modified to some degree. A small low water gravel bridge occurs in the river and which was constructed a long time ago. This acts as flow barrier and altered the flow velocity and influences the river morphology in terms of deposition and scouring. The main channel and marginal zone contains a highly braided condition which may also have been influenced by the small bridge but is likely of natural origin (Map 1). This causes an extensive marginal zone in many areas and also forms extensive wetland areas. It is likely that the wetland functioning in these areas have several important functions including unique wetland habitats and water purification properties. It is possible that some historical mining operations occurred but no evident mining scars are visible and the geomorphology of the river seems to be natural. Vegetation in the marginal zone is dominated by a variety of obligate wetland plants including aquatic and semi-aquatic species. These include sedges *Cyperus marginatus, C. longus, C. eragrostis, C. textilis,* rushes *Juncus exertus, J. rigidus,* Bulrush *Typha capensis*, reeds *Phragmites australis,* hygrophilous grasses *Agrostis lachnantha, Paspalum distichum* and a variety of aquatic and semi-aquatic herbs *Ornithogalum flexuosum, Persicariaa lapathifolia, Samolus valerandi, Berula erecta, Gomphostigma virgatum, Ludwigia octovalis*. The riparian

tree, *Salix mucronata*, is also scattered along the marginal zone. Exotic species are rare although the floating aquatic, *Myriophyllum spicatum*, does occur where low flows are present. This also serves to indicate that the marginal zone is in a relatively good condition. The diversity of species and habitat is considered significant and those areas forming extensive braiding in the main channel is considered a unique habitat which is uncommon along the course of the Vaal River and in totality such habitats cover a low percentage of the river course. This braided portion of the river is unique and forms extensive wetland areas (Map 1). This habitat is most prominent downstream of the low water bridge. This habitat is considered to have a natural origin but may also have been altered by the flow retardation caused by the low water bridge.

Figure 9: View of the marginal zone (red) in the northern section of the Vaal River in the study area. Note the extensive braiding visible in the background.

Figure 10: View of the marginal zone (red) in the northern section of the Vaal River in the study area. Again note the extensive marginal zone and braided nature of the main channel.

Figure 11: View of the marginal zone (red) in the eastern portion of the study area. Here the zone is clearly much narrower without braiding in the main channel.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. This area may be accompanied by a change in species distribution patterns. The lower zone consists of geomorphic features that are activated on a seasonal basis (Figure 16 & 17). The lower zone is also extensive and covers large areas of the river bank, especially along the northern portion of the study area. It is less clearly distinguished due to the varied topography and size of the wetland area. The border of the lower and upper zones may be difficult to discern where mining has taken place in the upper zone. The lower zone is considered largely natural. Though it is possible that historical mining could have taken place there is no longer any remaining evidence of this and the lower zone seems to still be natural without significant modification. The lower zone is inundated infrequently and only during larger flooding events. It is dominated by riparian grasses and rushes. Riparian grasses include *Cynodon dactylon, Panicum coloratum, Setaria icrassata* and rushes include *Juncus rigidus*. Herbaceous species are also abundant with several adapted to a higher moisture and include *Phyla nodiflora, Pseudognaphalium luteo-album* and *Arctotis arctotoides*. Smaller specimens of riparian trees are scattered in the lower zone and include *Diospyros lycioides* and *Vachellia karroo*. A few exotic weeds are present but are still scattered and not abundant on the site. These include *Xanthium spinosum, Calibrachoa parviflora, Sphaeralcea bonariensis* and *Cirsium vulgare*.

Figure 12: The lower zone (red) can be quite extensive in the northern portion of the study area and can be clearly differentiated from the marginal and upper zones.

Figure 13: The lower zone (red) does however decrease in width toward the east of the study area.

Figure 14: The lower zone (red) along the eastern portion of the study area.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 16 & 17). The upper zone is relatively narrow and well defined along the banks of the river (Map 2). The area is dominated by riparian thicket. The topography which drastically decreases over a short distance also clearly indicates the upper zone. Portions of the upper zone has been mined recently and here the border between upper and lower zones are less prominent. These areas has also caused significant transformation of the upper zone. Furthermore, the upper zone borders on the previously mined areas discussed in previous sections and this also contributes to impacts on the zone as a result of the edge-effect. The upper zone is only flooded during exceptionally large floods and this occurs on an ephemeral basis. The zone is relatively natural but is adversely affected by mining adjacent to the river banks. The vegetation consisting of riparian tree species clearly indicates that this portion forms part of the floodplain of the river. The tree species are able to attain height and age due to the deep root systems still able to access the higher moisture levels and as flood disturbance in the upper zone is much less the trees are allowed to grow old without being removed by flood damage. The riparian tree species within the upper zone is dominated by *Searsia lancea, Vachellia karroo, V. tortilis, Ziziphus mucronata, Diospyros lycioides* and *Lycium hirsutum*. Several of these are considered riparian species in this region. The understorey is dominated by grasses and herbaceous species and includes grasses such as *Eragrostis obtusa* and *Cynodon dactylon* and herbaceous species such as *Phyla nodiflora* and *Atriplex semibaccatta*. The terrestrial, pioneer herb, *Laggera decurrens*, is also common and indicative of disturbance and the transition into the surrounding terrestrial environment. Exotic weeds are also abundant and indicative of disturbance caused by previous mining and these include *Sphaeralcea bonariensis, Schinus molle, Bidens bipinnata, Xanthium spinosum* and *Boerhavia cordobensis*.

Figure 15: The upper zone (red) is clearly visible as an increase in slope and riparian woodland.

Habitat and species diversity is considered significant and diverse, especially along the northern portion of the Vaal River. The site contains numerous habitats with the braided river section considered relatively unique (Map 1). As a result of these varied and rather unique habitats the diversity of species is relatively high. The area is capable of sustaining a large biomass and consequently contributes to species diversity. In comparison with the river section in this region this habitat type is uncommon and takes up a small percentage of the river habitats. The braided network and marginal zone is considered especially sensitive and unique. This must be seen in context that all watercourse systems must be regarded as sensitive systems although some habitats can be regarded as more unique than others.

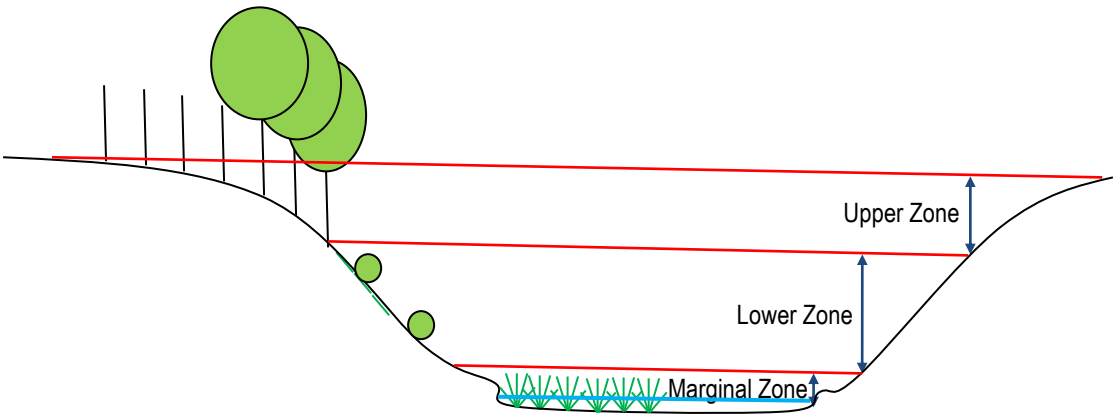

Figure 16: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation which is largely confined to the eastern portion of the river.

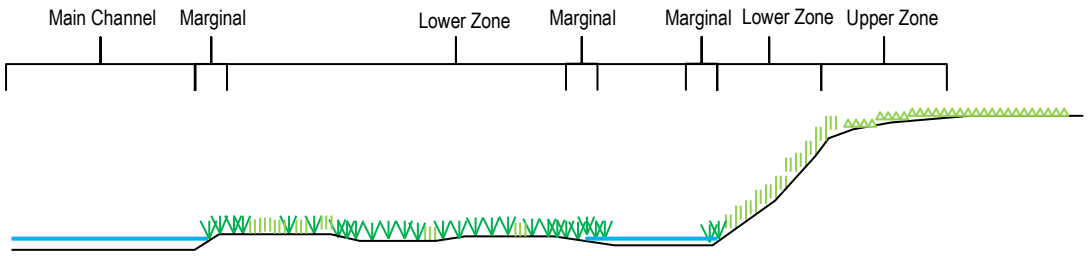

Figure 16: Diagram indicating the general appearance of the riparian zones of the river occurring downstream of the low water bridge in the northern section of the study area. The marginal and lower zones are extensive and form a braided river system.

4.3.3 Condition and importance of the affected watercourses

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section forming part of the study area (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system.

Table 4 refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river (Kleynhans & Louw 2007).

Table 5 refers to the Ecological Importance and Sensitivity (EIS) of wetlands. "Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC).

Table 4: Ecological categories for Present Ecological Status (PES).

Ecolocial Category	Description
A	Unmodified, natural
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem function has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 5: Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very High Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

According to Kleynhans (2000) a desktop assessment of the Vaal River in the study area and which will be affected by mining operations is considered to have a PES of Category D: Largely Modified. On-site observation indicate that this is relatively accurate, possibly somewhat overestimated, as this study has also calculated the river as having a PES of Category C: Moderately Modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged. Despite this the system still provides vital services including water transportation, flood dissipation, wetland and riparian habitat and support of ecological processes. The system should still be regarded as sensitive with a high conservation value and mining should endeavour to keep impacts on it to a minimum. Furthermore, the extensive marginal zone and braiding of the river in the northern section represents a unique habitat capable of sustaining a large biomass and consequently contributes to species diversity. In comparison with the river section in this region this habitat type is uncommon and takes up a small percentage of the river habitats. The braided network and marginal zone is considered especially sensitive and unique (Map 1). This must be seen in context that all watercourse systems must be regarded as sensitive systems although some habitats can be regarded as more unique than others.

The section of the Vaal River within the study area is considered to be moderately modified by several impacts. The flood dynamics of the river has been altered to a large degree by the construction of large dams upstream. The construction of large containment dams such as the

Bloemhof- and Vaal Dams has influenced the frequency and magnitude of flooding which is part of the natural system. As a result thereof the flooding of the floodplain within the upper zone does no longer take place at the same regular intervals and magnitude. The floodplain within the upper zone of the river is now more dependent on surface runoff. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site as well as previous mining which had taken place in the study area. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. Historical delving for alluvial diamonds has also taken place along the river and in many instances in the main channel. Although not extensive these areas has permanently altered the geomorphology of the river and will undoubtedly also have had an effect on sediment and flow dynamics. The impact of historical mining has diminished to some extent as the environment rehabilitates itself although the change in topography and morphology is not rehabilitatable through succession of the environment itself. Historical mining within the catchment has also occurred and the impact considered high since no rehabilitation was undertaken in those days. This is quite apparent at the study area. Deep excavations and large tailing dumps dominate in the interior of the study area. Centre-pivot irrigation takes place along the river in upstream and downstream areas and may be extensive in some areas. This will impact on the river as a result of fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. The study area itself has been heavily affected by previous mining operations as has already been discussed. This will still contribute to some ongoing impacts on the river, mostly in terms of sediment load. Currently the site is being utilised as communal grazing. Although the impact on the interior of the site will not be high the impact on the riparian zone is significant. In times of drought domestic stock is concentrated in the floodplain and banks of the river which provide a more constant grazing area. Consequently, overgrazing and trampling along the river can be high. This reduces vegetation cover, disturbs and mobilises soils and in so doing increases erosion and consequent sediment load in the river.

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix D). This is also due to the river being a large lowland river. The quaternary catchment of this area is C91E. The largest impact on the site itself is considered historical alluvial diamond mining which has had a high impact on the site. Consequently almost the entire site has been transformed from the natural vegetation type and is currently dominated by pioneer species. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant impacts as well as historical alluvial diamond mining within the study area. The unique braided morphology of the river does increase the condition to some degree.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

4.3.4 Risk Assessment

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Activities likely to be associated with the mining operations and which will likely affect the Vaal River and associated wetlands include mining in close proximity the river and mining within this system. Since access across the river is already present in the form of a low water bridge this activity has not been rated. Should a Section 21 (c) & (i) Water Use License Application (WULA) indicate additional activities these should be assessed and added to the Risk Assessment.

Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Although a comprehensive rehabilitation and monitoring regime may decrease this risk it is still unlikely to ensure the re-establishment of current natural functioning. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Furthermore, should mining take place along the banks of the river this should be confined to the upper and lower zones and the marginal zone and main channel excluded in order to provide some buffer to the resulting impacts.

Mining within close proximity to the Vaal River and associated wetland areas is anticipated to have a moderate risk and will likely still have significant impacts though unlikely to be permanent and will mostly influence sediment load and runoff values. Furthermore, through adequate mitigation these can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of this system will result.

Higher Risks: Watercourses impacted by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

Moderate Risks: Risk and impact on watercourses are notable and require mitigation measures on a higher level.

Mitigation as recommended should be implemented as far as possible which should considerably alleviate the risks on the Vaal River in the study area.

For the complete risk assessment please refer to Appendix E.

No.	Phases	Aspect	Impact	Risk Rating	Confidence level	Control measures
	Mostly Operational Phase but extending long after closure	Mining within or on the banks of the Vaal River	Mining within the main channel or the banks of the Vaal River will remove riparian vegetation, transform the soils profile and in so doing the hydrology, geomorphology, flow and flooding regime. Due to the larger volume of water transportation and general higher level of ecosystems services of the Vaal River this risk is anticipated to be higher. It is however less probable to influence the larger hydrological functioning and will impact higher at a localised scale. Increased establishment of exotic weeds and invaders due to disturbance caused by mining is also probable.	**H**	4	This impact will be mainly during the operational phase but due to its nature will extend into the closure phase and it is highly likely that the impact will have a permanent impact on the Vaal River. Due to the nature of this activity is likely to permanently affect the Vaal River to some extent. Historical mining has illustrated that this permanently alters the geomorphology although the functioning of the system does repair itself to a large extent. Consequently, should comprehensive rehabilitation and monitoring be applied the impact on the river can be contained to medium term alteration. However, some impacts to the geomorphology and biota will have a lasting impact.
	Mostly Operational Phase but also extending to a degree beyond the closure phase	Mining in close proximity to the Vaal River	Mining will require removal of the vegetation layer in the catchment of the Vaal River. Due to the large scale of this lowland river it is unlikely to significantly alter the flow- and flooding regime and will most likely have the highest impact on sediment load. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	**M**	4	This impact will be mainly during the operational phase but will only cease once rehabilitation has been completed and an indigenous vegetation layer has become established. This activity is anticipated to have a moderate risk of impact as long as the adequate mitigation and comprehensive rehabilitation is adhered to. Measures must be implemented to minimise the amount of sediment entering the river. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation layer. Due to the large scale of the river it is unlikely to alter the geomorphology and flow regime but may influence the sediment load and therefore biota of the river.

5. ANTICIPATED IMPACTS

Anticipated impacts that the development will have is primarily concerned with the loss of habitat and species diversity but will also include impacts on the Vaal River forming part of the northern and eastern borders of the site.

Alluvial diamond mining will take place by clearing the vegetation layer, stripping topsoil and excavating large volumes of material to varying depths. The main impact will therefore be the loss of vegetation, vegetation type and consequently habitat. However, previous mining has already undertaken these impacts and in addition, poor rehabilitation was implemented. Consequently the current vegetation is dominated by a sparse pioneer layer, being transformed from the natural vegetation type and the natural topography has also been altered. As a result the loss of this vegetation and habitat in the interior of the study area cannot be considered as high. Furthermore, this may present an opportunity to improve the habitat as long as adequate rehabilitation is undertaken after mining has occurred. Current rehabilitation was poorly undertaken which may however result in difficulties in terms of topsoil replacement since many areas does not contain any topsoil due to inadequate previous mining rehabilitation.

No protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site which has been transformed to a large degree.

The Vaal River forms part of the northern and eastern borders of the site and it is therefore likely to be directly affected by the mining operations (Map 1).

According to research concerning small scale mining along the Vaal River and specifically in the Kimberley/Windsorton area several impacts of alluvial diamond mining occur and is likely to take place during these operations (Heath *et al* 2004):

- Accelerated erosion of areas adjacent to workings that have been de-vegetated leads to increased suspended sediment loads in nearby streams and rivers.
- Excavation of flood terraces and riverbanks increases the instability of these riverbanks and enhances the likelihood of increased flood scouring.
- Excavation of river sediments exposes these sediments to oxidising conditions and enhances the solubility and release of any metal ions that may previously have been previously trapped as insoluble sulphides.
- Wind-blown dusts from unprotected tailings and waste rock dumps enter aquatic environment.

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Furthermore, many areas along the Vaal- and Orange Rivers were mined a century ago and the environmental footprints are still prevalent. It is important that rehabilitation is comprehensive and successful and that the impacts as listed be managed and mitigated adequately. Mining along the banks of the Vaal River is recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Furthermore, should mining take place along the banks of the river this should be confined to the upper and lower zones and the marginal zone and main channel excluded in order to provide some buffer. In addition, should any mining of the bed or banks occur the extent should be kept to a minimum. The survey has

indicated that the portion of the river along the northern part of the site consists of a more unique habitat and consequently should mining of the river banks be desired this should concentrate on the eastern, less unique, portion of the river with the mining of the northern portion being the last resort (Map 1). Where mining within the river is desired the only mitigation can be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS.

Mining in close proximity to the Vaal River will clear vegetation, disturb the soil surface and mobilise soils. This may cause high levels of sedimentation within the river. It is therefore recommended that measures be implemented to prevent sediment from entering the river. Due to the removal of vegetation and disturbance of the soil surface the mining areas will be highly susceptible to the establishment of invasive weeds. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area.

As was observed during the survey of the study area it contains several exotic weed and invader species, mostly concentrated within the degraded interior. However, mining operations will exacerbate conditions susceptible to the establishment of exotic weeds and invaders. Without mitigation this will significantly increase the establishment of exotics and if portions of the river bank is mined these areas will be even more susceptible to the establishment of exotics. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. However, as discussed, the available habitat is already transformed and mammal population would be much diminished from the natural condition. In addition, provided that adequate rehabilitation is undertaken the area will again be available to most generalist species as suitable habitat. Therefore, the resulting impact of clearing the vegetation for mining cannot be considered to have a high impact on the mammal population. In order to ensure no direct impact on the mammals on the site occur the hunting, capturing or trapping of mammals on the site should be strictly prohibited.

The impact significance has been determined and it is clear that, mostly as a result of previous mining operations, the majority of impacts will be low to moderate. However, mining of the Vaal River is still anticipated to have a high impact. Should adequate mitigation as described and most importantly comprehensive rehabilitation be implemented the impacts can be reduced to mostly low to moderate. This also includes the exclusion of mining the Vaal River as far as possible, as recommended.

Please refer to Appendix F for the impact methodology.

Significance of the impact:

Impact	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Before Mitigation								
Loss of vegetation type and clearing of vegetation	1	4	3	2.6	2	3	2.5	6.5
Loss of protected species	1	5	3	3	1	1	1	3
Impact on watercourses	5	5	4	4.6	5	4	4.5	20.7
Infestation with weeds and invaders	4	4	4	4	5	3	4.5	18
Impact on Terrestrial fauna	3	4	4	3.6	3	4	3.5	12.6
After Mitigation								
Loss of vegetation type and clearing of vegetation	1	3	2	2	2	3	2.5	5
Loss of protected species	1	5	3	3	1	1	1	3
Impact on watercourses	5	4	3	4	4	3	3.5	14
Infestation with weeds and invaders	3	3	3	3	3	3	3	9
Impact on Terrestrial fauna	2	4	4	3.3	3	3	3	9.9

6. SITE SPECIFIC RESULTS

Habitat diversity and species richness:
The natural vegetation type on the site has largely been transformed and is consequently rather uniform with a low diversity of habitats. As a result the species diversity is also low.

Presence of rare and endangered species:
No protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site which has been transformed to a large degree.

Ecological function:
The ecological function of the site has been altered to a significant degree. The site functions as habitat for a variety of fauna, supports a specific vegetation type and Vaal River forming part of the site also provides vital functions in terms of water transportation, wetland and aquatic habitats and bio-remediation. The vegetation type on the site has been transformed to a large degree and the resultant habitat provided to fauna is also altered and unable to sustain the natural population. The functioning of the Vaal River has been shown to be moderately modified but is still considered a highly sensitive system and the braided portion along the north of the site being especially sensitive and a unique habitat.

Degree of rarity/conservation value:
According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures. Furthermore, it has been mostly transformed on the site and consequently the conservation value is relatively low.

Although degraded the Vaal River still plays a vital role in water transport and is therefore considered to have a high conservation value. The braided portion along the north of the site is considered to have an especially high conservation value (Map 1).

Percentage ground cover:
The percentage vegetation cover is relatively low mostly as a result of previous mining operations and inadequate rehabilitation of the post mining environment.

Vegetation structure:
The vegetation structure is dominated by a tree/shrub- and sparse grass layer. This is natural to the region. However, previous mining has caused some significant modification to the natural vegetation structure and pioneer shrubs and exotics are common.

Infestation with exotic weeds and invader plants:
Numerous exotic weeds occur on the site, especially the interior previously being mined, but do not yet dominate and it will still be possible to eradicate these.

Degree of grazing/browsing impact:
The area is being utilised as communal grazing and consequently overgrazing and -browsing is noticeably high.

Signs of erosion:
Signs of erosion is common, especially in the interior of the site where mining excavations and overall poor rehabilitation contributes to extensive erosion.

Terrestrial animals:
It was noticeable that almost no tracks and signs of mammals were present on the site. Burrows were also conspicuously absent, also likely as a result of the rocky, gravel substrate. The modification of the study area due to mining has most likely altered the habitat to such a degree that it is not suitable for most mammals occurring in this area. Furthermore, as has been previously discussed many areas does not contain any established vegetation and where vegetation has managed to re-establish this is very sparse. Consequently the resources available to mammals is also very low and not able to sustain a viable mammal population. Communal grazing by domestic stock is also relatively high and will further provide competition for natural mammals.

The Vaal River will contain a much more substantial mammal population and with a more natural species assemblage. Surrounding vegetation transformation by previous mining will influence the mammal population along the river to some extent as a result of the transformation of surrounding habitat. Nonetheless, watercourses are able to sustain a higher bio-load which in turn supports a larger mammal population and it is likely that the mammal population along the river will be substantial. Should mining take place along the banks or main channel of the river the impact on mammals will be significant.

Table 6: Biodiversity Sensitivity Rating for the proposed mining development.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness	3		
Presence of rare and endangered species	3		
Ecological function			1
Uniqueness/conservation value			1
Vegetation condition			
Percentage ground cover	3		
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers		2	
Degree of grazing/browsing impact	3		
Signs of erosion	3		
Terrestrial animal characteristics			
Presence of rare and endangered species		2	
Sub total	15	6	2
Total		23	

7. BIODIVERSITY SENSITIVITY RATING (BSR) INTERPRETATION

Table 7: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Mining Operations	23	Acceptable	3

8. DISCUSSION AND CONCLUSION

The site proposed for mining operations has been rated as being acceptable for the development. However, this is subject to the Vaal River being excluded as far as possible from mining activities and that comprehensive rehabilitation is implemented.

The study area is situated adjacent to the Gong Gong rural settlement. The study area proposed for alluvial diamond mining is located on the southern banks of the Vaal River and has an approximate extent of 110 hectares (Map 1). The study area also includes a portion of the Vaal River including the main channel, banks and floodplain. The banks of the river in this portion is considered to still be largely natural. However, the terrestrial portion of the site, i.e. interior, has been heavily affected by previous and recent mining operations without any adequate rehabilitation having been done and consequently this area is in a relatively poor condition largely altered from the natural condition.

The entire terrestrial portion of the study area has been transformed by previous mining operations (Map 1). The riparian zone associated with the Vaal River seems to be largely intact. Rehabilitation of the post mining environment was overall poorly done and consequently the re-establishment of natural vegetation is also poor with some areas unable to establish any kind of vegetation. Portions of the study area has however been able to establish a pioneer but largely indigenous vegetation layer. Whatever the case may be, the vegetation on the site, although indigenous, must be considered to be of secondary establishment.

The previous mining operations must be regarded as the most significant impact on the terrestrial portion of the study area (Map 1). Impacts associated with this include the initial removal of the natural vegetation layer. Associated with this was also the removal of the topsoil layer, which was evidently not adequately replaced and consequently prevented the establishment of natural vegetation in many areas. This will also have implications for rehabilitation should the proposed mining operations take place. The topography has been altered to a large degree through the excavation of a large amount of material which was not replaced adequately in the post mining environment. Large areas consist of tailings of rounded gravel rocks and boulders and in these areas vegetation is unable to establish due to the absence of soil. The inadequate rehabilitation resulting from previous mining clearly indicate the high impact this has and the need for post mining rehabilitation and adequate management of topsoil.

A comparison of the vegetation in the adjacent area as derived from studies conducted by Bezuidenhout (1994) clearly shows affinities with the vegetation currently in the study area but also clearly illustrates that the study area is currently dominated by only a few species and mostly pioneers. Note also that this previous study already mentioned that the area was disturbed by mining operations which also indicates that the natural vegetation may be also different from the vegetation composition identified by them. However, this also indicates that if adequate rehabilitation is implemented that a vegetation community somewhat resembling the natural condition can be re-instated.

When comparing the results from the above mentioned study as well as the small portion of remaining natural vegetation on the site with the vegetation currently dominating the study area the following conclusion can be made; It should be clear that it is heavily degraded but that a vegetation layer is in the process of re-establishing and that it already has some affinities with

the surrounding natural or semi-natural vegetation. Given time it may be possible that the vegetation will advance to a condition which is somewhat similar to that of the surroundings.

From available aerial imagery (Google Earth 2006 – 2017) it is clear that previous mining activities has taken place for quite some time and it is also clear how vegetation has become re-established in many areas (Fig. 6 & 7).

In conclusion, from the survey of the terrestrial portion of the study area it is clear that previous mining operations has transformed and removed the natural vegetation and has also altered the topography and soil profile to a large degree (Map 1). Vegetation has become re-established in many areas but is still in an early stage of succession and dominated by pioneer species with a low species diversity. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. However, the poorly rehabilitated study area should clearly illustrate the importance of comprehensive rehabilitation, re-instatement of the natural topography as far as possible as well as the correct management of topsoil. It is also evident that through adequate rehabilitation it is possible to re-instate a natural vegetation layer similar to that of the surrounding natural areas.

The Vaal River forms part of the northern and eastern border of the proposed mining area (Map 1). Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

The wetland conditions associated with the Vaal River can be characterised as a channel wetland system (SANBI 2009).

The Vaal River was surveyed by three separate locations along the section adjacent to the site. The length of river included in the study area is relatively long, approximately 2km (Map 1). The Vaal River, though well known to be degraded and modified, still performs several vital ecosystem services as well as services rendered to downstream users. The river in the study area is quite variable in terms of geomorphology though vegetation structure and species composition remains relatively similar.

Habitat and species diversity is considered significant and diverse, especially along the northern portion of the Vaal River. The site contains numerous habitats with the braided river section considered relatively unique (Map 1). As a result of these varied and rather unique habitats the diversity of species is relatively high. The area is capable of sustaining a large biomass and consequently contributes to species diversity. In comparison with the river section in this region this habitat type is uncommon and takes up a small percentage of the river habitats. The braided network and marginal zone is considered especially sensitive and unique. This must be seen in context that all watercourse systems must be regarded as sensitive systems although some habitats can be regarded as more unique than others.

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section forming part of the study area (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system. The largest impact on the site itself is considered historical alluvial diamond mining which has had a high impact on the site. Consequently almost the entire site has been transformed from the natural vegetation type and is currently dominated by pioneer species. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant impacts as well as historical alluvial diamond mining within the study area. The unique braided morphology of the river does increase the condition to some degree.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Although a comprehensive rehabilitation and monitoring regime may decrease this risk it is still unlikely to ensure the re-establishment of current natural functioning. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Mining within close proximity to the Vaal River and associated wetland areas is anticipated to have a moderate risk and will likely still have significant impacts though unlikely to be permanent and will mostly influence sediment load and runoff values. Furthermore, through adequate mitigation these can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of this system will result.

Due to the transformed and highly degraded condition of the interior of the study the loss of vegetation and habitat due to the proposed mining cannot be considered as high. Furthermore, this may present an opportunity to improve the habitat as long as adequate rehabilitation is undertaken after mining has occurred. Current rehabilitation was poorly undertaken which may however result in difficulties in terms of topsoil replacement since many areas does not contain any topsoil due to inadequate previous mining rehabilitation.

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Mining along the banks of the Vaal River is recommended to be excluded as far as possible and where desired that rehabilitation and monitoring be implemented at a high standard in order to re-establish functioning systems. Furthermore, should mining take place

along the banks of the river this should be confined to the upper and lower zones and the marginal zone and main channel excluded in order to provide some buffer. In addition, should any mining of the bed or banks occur the extent should be kept to a minimum. The survey has indicated that the portion of the river along the northern part of the site consists of a more unique habitat and consequently should mining of the river banks be desired this should concentrate on the eastern, less unique, portion of the river with the mining of the northern portion being the last resort (Map 1). Where mining within the river is desired the only mitigation can be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS.

Mining in close proximity to the Vaal River will clear vegetation, disturb the soil surface and mobilise soils. This may cause high levels of sedimentation within the river. It is therefore recommended that measures be implemented to prevent sediment from entering the river. Due to the removal of vegetation and disturbance of the soil surface the mining areas will be highly susceptible to the establishment of invasive weeds. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area.

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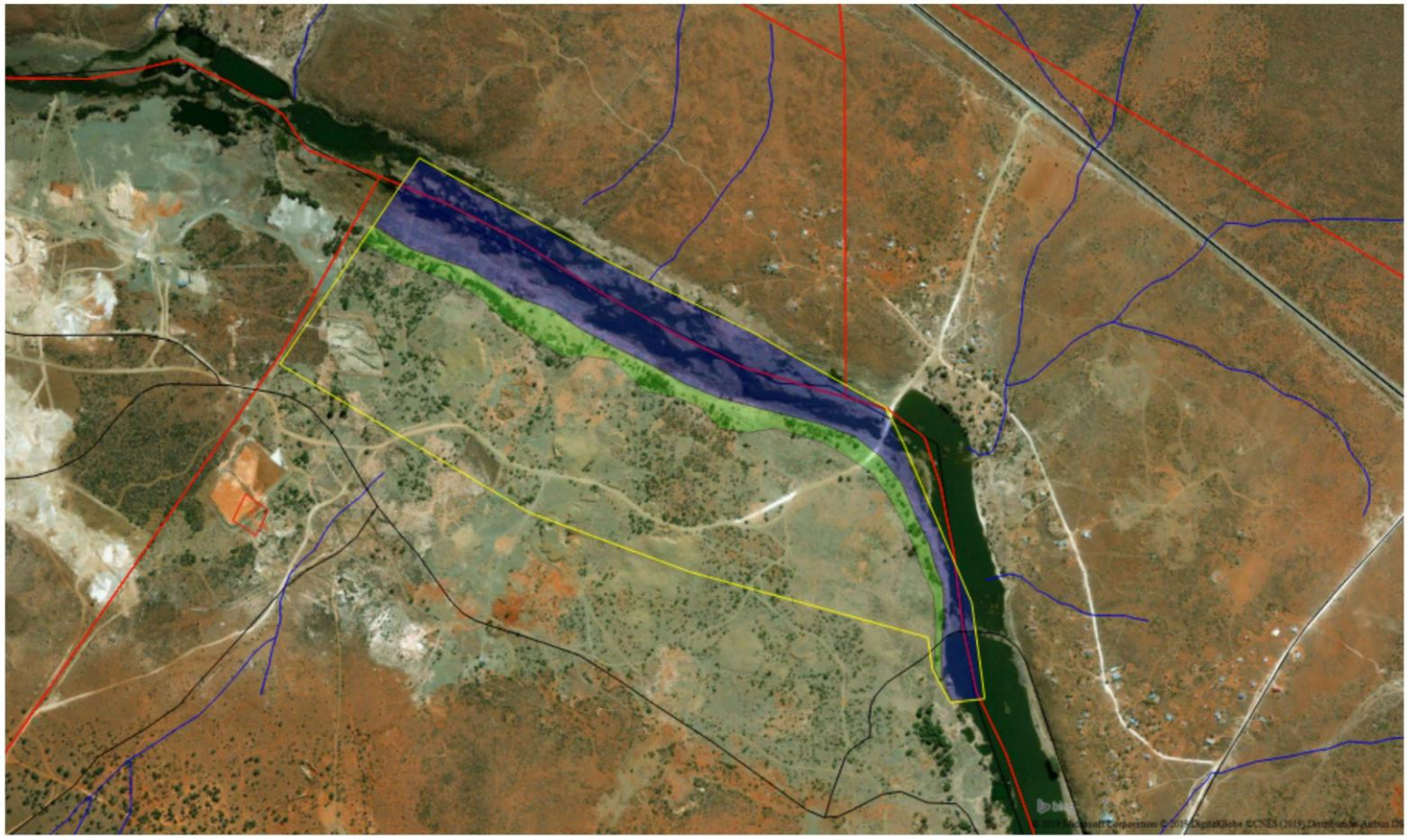
Annexure A: Maps and Site photos

Wetland delineation of the alluvial diamond mining operations on a portion of the Remainder of the Farm Pniel 218 including a portion of the Vaal River near the town of Delportshoop, Northern Cape Province.



Preparred for:
Kimswa Mining (Pty) Ltd

Legend:

- Property boundaries
- Application area
- Road network
- Watercourses
- Wetland area
- Riparian zone

Map Information

S 28.474907°
E 24.397618°

Spheroid: WGS 84
Scale: 1:10 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
darius@dprecologists.co.za
P.O. Box 12726, Brandhof, 9324
Tel: 083 410 0770

Map 1: Wetland delineation map for the proposed alluvial diamond mining operations near the town of Delportshoop. Note that the study area has been affected by previous mining which is clearly still visible. The wetland condition (Marginal and lower zones) along the river bank is indicated. The riparian zone (Upper zone) is also indicated. Note the braided river portion clearly visible along the northern section of the river. Mining should exclude the river (including riparian zone) as far as possible and should mining be desired in this area should be considered in order from low to high sensitivity, i.e. riparian zone, eastern river section, northern river section, braided main channel.

General ecology of the alluvial diamond mining operations on a portion of the Remainder of the Farm Pniel 218 including a portion of the Vaal River near the town of Delportshoop, Northern Cape Province.

Preparred for:
Kimswa Mining (Pty) Ltd

Legend:

- Property boundaries
- Application area
- Road network
- Watercourses
- Wetlands
- Kimberley Thornveld

Map Information

S 28.474907°
E 24.397618°

Spheroid: WGS 84
Scale: 1:10 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
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Map 2: General ecology map for the proposed alluvial diamond mining operations near the town of Delportshoop. Note that only one vegetation type is present in the area. Watercourses are absent from the site exceopt for the Vaal River and associated wetland conditions.

Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Bidens bipinnata*	Herb
**Boerhavia cordobensis*	Herb
**Calibrachoa parviflora*	Herb
**Cirsium vulgare*	Herb
**Echinopsis shickendantzii*	Succulent
**Myriophyllum spicatum*	Aquatic herb
**Nicotiana glauca*	Shrub
*Opuntia ficus-indica	Succulent
**Opuntia microsadys*	Succulent
**Schinus molle*	Tree
**Sphaeralcea bonariensis*	Shrub
**Xanthium spinosum*	Herb
Agrostis lachnantha	Grass
Aptosumum marlothii	Dwarf shrub
Arctotis arctotoides	Herb
Aristida adscensionis	Grass
Aristida congesta	Grass
Atriplex semibaccatta	Herb
Berula erecta	Aquatic herb
Cadaba aphylla	Shrub
Conyza podocephala	Herb
Cucumis africanus	Creeper
Cynodon dactylon	Grass
Cyperus eragrostis	Sedge
Cyperus longus	Sedge
Cyperus marginatus	Sedge
Cyperus sexangularis	Sedge
Cyperus textilis	Sedge
Diospyros lycioides	Tree
Ehretia rigida	Shrub
Enneapogon cenchroides	Grass
Eragrostis lehmanniana	Grass
Eragrostis obtusa	Grass
Eriocephalus spinescens	Dwarf shrub
Fingerhuthia africana	Grass
Gomphocarpus fruticosus	Herb
Gomphocarpus tomentosus	Herb
Gomphostigma virgatum	Aquatic shrub
Grewia flava	Shrub
Heliotropium ovalifolium	Herb

Heteropogon contortus	Grass
Hyparrhenia hirta	Grass
Jamesbrittenia atropurpurea	Herb
Jamesbrittenia sp.	Herb
Juncus exertus	Rush
Juncus rigidus	Rush
Juncus sp.	Rush
Laggera decurrens	Shrub
Lobelia thermalis	Herb
Ludwigia octovalis	Aquatic herb
Lycium hirsutum	Shrub
Lycium horridum	Dwarf shrub
Nolletia ciliaris	Dwarf shrub
Ornithogalum flexuosum	Geophyte
Panicum coloratum	Grass
Paspalum distichum	Grass
Peliostomum leucorrhizum	Herb
Persicaria lapathifolia	Aquatic herb
Phragmites australis	Reed
Phyla nodiflora	Herb
Pseudognaphalium luteo-album	Herb
Salix mucronata	Tree
Samolus valerandi	Herb
Searsia lancea	Tree
Sesamum triphyllum	Herb
Senegalia melifera subsp. *detinens*	Tree
Senna italica	Herb
Setaria incrassata	Grass
Tribulus terestris	Herb
Typha capensis	Bulrush
Vachellia karroo	Tree
Vachellia tortilis	Tree
Ziziphus mucronata	Tree

Appendix C: Soil Samples

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to confirm the wetland conditions along the Vaal River. Soil samples were taken at approximately 10 meter intervals. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils.

Within wetlands the hydrological regime differs due to the topography and landscape. For instance; a valley bottom wetland would have a main channel that is below the water table and consequently permanently saturated, i.e. permanent zone of wetness. As you move away from the main channel the wetland would become dependent on flooding in order to be saturated. As a result along this hydrological regime areas of permanent saturation, seasonal and temporary saturation would occur. At some point along this gradient the saturation of the soil would be insufficient to develop reduced soil conditions and therefore will not be considered as wetland.

Within wetland soils the pores between soil particles are filled with water instead of atmosphere. As a result available oxygen is consumed by microbes and plantroots and due to the slow rate of oxygen diffusion oxygen is depleted and biological activity continues in anaerobic conditions and this causes the soil to become reduced.

Reduction of wetland soils is a result of bacteria decomposing organic material. As bacteria in saturated soils deplete the dissolved oxygen they start to produce organic chemicals that reduce metals. In oxidised soils the metals in the soil give it a red, brown, yellow or orange colour. When these soils are saturated and metals reduced the soil attains a grey matrix characteristic of wetland soils.

Within this reduction taking place in the wetland soils there may be reduced matrix, redox depletions and redox concentrations. The reduced matrix is characterised by a low chroma and therefore a grey soil matrix. Redox depletions result in the grey bodies within the soil where metals have been stripped out. Redox concentrations result in mottles within the grey matrix with variable shape and are recognised as blotches or spots, red and yellow in colour.

Soil wetness indicator is used as the primary indicator of wetlands. The colour of various soil components are often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix.

Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils until they disappear altogether in dry soils (Collins 2005).

The following soil wetness indicators can be used to determine the permanent, seasonal and temporary wetness zones. The boundary of the wetland is defined as the outer edge of the temporary zone of wetness and is characterised by a minimal grey matrix (<10%), few high chroma mottles and short periods of saturation (less than three months per year). The seasonal zone of wetness is characterised by a grey matrix (>10%), many low chroma mottles and significant periods of wetness (at least three months per year). The permanent zone of wetness

is characterised by a prominent grey matrix, few to high chroma mottles, wetness all year round and sulphuric odour (rotten egg smell).

According to convention hydromorphic soil must display signs of wetness within 50 cm of the soil surface (DWAF 2005).

Table 1: Soil samples taken along a lateral transect of the Vaal River along the northern portion of the site (S 28.470007°, E 24.392250°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken in the lower zone of the river bank. A grey matrix (<10%) is clear and mottling is prominent indicating a seasonal zone of wetness. Wetland conditions are therefore clearly present.
	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.	

Table 2: Soil samples taken along a lateral trasect of the Vaal River adjacent to the low water bridge (S 28.474221°, E 24.403090°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Due to the gravel and rock covered lower and upper zones no soil sampling was possible in these areas although riparian vegetation was used to delineate the wetland zone.

Table 3: Soil samples taken along a lateral transect of the Vaal River along the eastern portion of the site (S 28.480369°, E 24.405510°).

	
Soil sample taken in the marginal zone of the river. A grey matrix (<10%) is present and mottling is prominent indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken in the lower zone of the river bank. A feint grey matrix (<10%) is present as well as a few feint mottles. Wetland conditions are therefore not clearly present but is still considered as part of the seasonal zone of wetness.

	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.	

Appendix D: Index of Habitat Integrity (IHI) Summary

For the complete IHI please contact the author of this report.

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.480689
UPPER LONGITUDE	E 24.405712
UPPER ALTITUDE	1034 m
LOWER LATITUDE	S 28.468841
LOWER LONGITUDE	E 24.390423
LOWER ALTITUDE	1030 m
SURVEY SITE (if applicable)	Vaal River GongGong
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Low er Vaal
QUATERNARY	C91E
ECOREGION 2	29_2
DATE	09/01/2019
RIVER	Vaal River
TRIBUTARY	
PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	2.3	1.7
PHYSICO-CHEMICAL MODIFICATION	1.5	1.1
BED MODIFICATION	1.3	4.0
BANK MODIFICATION	1.8	3.0
CONNECTIVITTY MODIFICATION	1.5	4.0
INSTREAM IHI%	66.1	
CATEGORY	C	
CONFIDENCE	2.8	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY	2.85	3.00
BANK STRUCTURE MODIFICATION	1.25	4.00
CONNECTIVITY MODIFICATION	1.50	4.00
RIPARIAN HABITAT INTEGRITY (%)	63.25	
CATEGORY	C	
CONFIDENCE	3.67	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

	MRU
INSTREAM IHI	
Base Flows	-3.0
Zero Flows	1.0
Floods	-3.5
HYDROLOGY RATING	**2.3**
pH	1.0
Salts	1.5
Nutrients	1.5
Water Temperature	1.0
Water clarity	2.0
Oxygen	1.0
Toxics	1.5
PC RATING	**1.5**
Sediment	2.0
Benthic Growth	1.0
BED RATING	**1.3**
Marginal	2.0
Non-marginal	1.5
BANK RATING	**1.8**
Longitudinal Connectivity	1.5
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.5**
INSTREAM IHI %	**66.1**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**2.8**

	MRU
RIPARIAN IHI	
Base Flows	-3.0
Zero Flows	-1.0
Moderate Floods	-3.0
Large Floods	-4.0
HYDROLOGY RATING	**2.8**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	1.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	1.5
Physico-Chemical (non-marginal)	1.0
Marginal	1.5
Non-marginal	1.0
BANK STRUCTURE RATING	**1.3**
Longitudinal Connectivity	1.5
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.5**
RIPARIAN IHI %	**63.2**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.7**

Appendix E: Risk Assessment Matrix

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP REGISTERED PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE

					Severity																
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph+Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
	Mostly Operational Phase but extending long after closure	Alluvial diamond mining operations	Mining within or on the banks of the Vaal River	Mining within the main channel or the banks of the Vaal River will remove riparian vegetation, transform the soils profile and in so doing the hydrology, geomorphology, flow and flooding regime. Due to the larger volume of water transportation and general higher level of ecosystems services of the Vaal RIver this risk is anticipated to be higher. It is however less probable to influence the larger hydrological functioning and will impact higher at a localised scale. Increased establishment of exotic weeds and invaders due to disturbance caused by mining is also probable.	4	4	4	3	3.75	4	4	11.75	4	4	5	4	17	199.75	H	4	This impact will be mainly during the operational phase but due to its nature will extend into the closure phase and it is highly likely that the impact will have a permanent impact on the Vaal River. Due to the nature of this activity is likely to permanently affect the Vaal River to some extent. Historical mining has illustrated that this permanently alters the geomorphology although the functioning of the system does repair itself to a large extent. Consequently, should comprehensive rehabilitation and monitoring be applied the impact on the river can be contained to medium term alteration. However, some
	Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to the Vaal River	Mining will require removal of the vegetation layer in the catchment of the Vaal River. Due to the large scale of this lowland river it is unlikely to significantly alter the flow- and flooding regime and will most likely have the highest impact on sediment load. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	2	3	2	1	2	2	3	7	3	3	5	3	14	98	M	4	This impact will be mainly during the operational phase but will only cease once rehabilitation has been completed and an indigenous vegetation layer has become established. This activity is anticipated to have a moderate risk of impact as long as the adequate mitigation and comprehensive rehabilitation is adhered to. Measures must be implemented to minimise the amount of sediment entering the river. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation layer. Due to the large scale of the river it is unlikely to alter the geomorphology and flow regime but may influence

Appendix F: Impact methodology

The environmental significance assessment methodology is based on the following determination:
Environmental Significance = Overall Consequence x Overall Likelihood

Determination of Consequence

Consequence analysis is a mixture of quantitative and qualitative information and the outcome can be positive or negative. Several factors can be used to determine consequence. For the purpose of determining the environmental significance in terms of consequence, the following factors were chosen: **Severity/Intensity, Duration and Extent/Spatial Scale.** Each factor is assigned a rating of 1 to 5, as described below and in tables 6, 7, 9 and 10.

Determination of Severity

Severity relates to the nature of the event, aspect or impact to the environment and describes how severe the aspects impact on the biophysical and socio-economic environment.
Table 7 will be used to obtain an overall rating for severity, taking into consideration the various criteria.

Table 7: Rating of severity

Type of criteria	**Rating**				
	1	**2**	**3**	**4**	**5**
Quantitative	0-20%	21-40%	41-60%	61-80%	81-100%
Qualitative	Insignificant / Non-harmful	Small / Potentially harmful	Significant / Harmful	Great / Very harmful	Disastrous Extremely harmful
Social/ Community response	Acceptable / I&AP satisfied	Slightly tolerable / Possible objections	Intolerable/ Sporadic complaints	Unacceptable / Widespread complaints	Totally unacceptable / Possible legal action
Irreversibility	Very low cost to mitigate/ High potential to mitigate impacts to level of insignificance / Easily reversible	Low cost to mitigate	Substantial cost to mitigate / Potential to mitigate impacts / Potential to reverse impact	High cost to mitigate	Prohibitive cost to mitigate / Little or no mechanism to mitigate impact Irreversible
Biophysical (Air quality, water quantity and quality, waste production, fauna and flora)	Insignificant change / deterioration or disturbance	Moderate change / deterioration or disturbance	Significant change / deterioration or disturbance	Very significant change / deterioration or disturbance	Disastrous change / deterioration or disturbance

Determination of Duration
Duration refers to the amount of time that the environment will be affected by the event, risk or impact, if no intervention e.g. remedial action takes place.

Table 8: Rating of Duration

Rating	Description
1: Low	Almost never / almost impossible
2: Low-Medium	Very seldom / highly unlikely
3: Medium	Infrequent / unlikely / seldom
4: Medium-High	Often / regularly / likely / possible
5: High	Daily / highly likely / definitely

Determination of Extent/Spatial Scale
Extent refer to the spatial influence of an impact be local (extending only as far as the activity, or will be limited to the site and its immediate surroundings), regional (will have an impact on the region), national (will have an impact on a national scale) or international (impact across international borders).

Table 9: Rating of Extent / Spatial Scale

Rating	Description
1: Low	Immediate, fully contained area
2: Low-Medium	Surrounding area
3: Medium	Within Business Unit area of responsibility
4: Medium-High	Within Mining Boundary area
5: High	Regional, National, International

Determination of Overall Consequence
Overall consequence is determined by adding the factors determined above and summarised below, and then dividing the sum by 4.

Table 10: Example of calculating Overall Consequence

Consequence	Rating
Severity	Example 4
Duration	Example 2
Extent	Example 4
SUBTOTAL	10
TOTAL CONSEQUENCE:(Subtotal divided by 4)	3.3

Likelihood
The determination of likelihood is a combination of Frequency and Probability. Each factor is assigned a rating of 1 to 5, as described below and in Table 11 and Table 12.

Determination of Frequency
Frequency refers to how often the specific activity, related to the event, aspect or impact, is undertaken.

Table 11: Rating of frequency

Rating	Description
1: Low	Once a year or once/more during operation/LOM
2: Low-Medium	Once/more in 6 Months
3: Medium	Once/more a Month
4: Medium-High	Once/more a Week
5: High	Daily

Determination of Probability
Probability refers to how often the activity/even or aspect has an impact on the environment.

Table 12: Rating of probability

Rating	Description
1: Low	Almost never / almost impossible
2: Low-Medium	Very seldom / highly unlikely
3: Medium	Infrequent / unlikely / seldom
4: Medium-High	Often / regularly / likely / possible
5: High	Daily / highly likely / definitely

Overall Likelihood
Overall likelihood is calculated by adding the factors determined above and summarised below, and then dividing the sum by 2.

Table 13: Example of calculating the overall likelihood

Consequence	Rating
Frequency	Example 4
Probability	Example 2
SUBTOTAL	6
TOTAL LIKELIHOOD (Subtotal divided by 2)	3

Determination of Overall Environmental Significance
The multiplication of overall consequence with overall likelihood will provide the environmental significance, which is a number that will then fall into a range of LOW, LOW-MEDIUM, MEDIUM, MEDIUM, MEDIUM-HIGH or HIGH, as shown in the table below.

Table 14: Determination of overall environmental significance

Significance or Risk	Low	Low-Moderate	Moderate	Moderate-High	High
Overall Consequence X Overall Likelihood	1 - 4.9	5 - 9.9	10 - 14.9	15 – 19.9	20 - 25

Qualitative description or magnitude of Environmental Significance
This description is qualitative and is an indication of the nature or magnitude of the Environmental Significance. It also guides the prioritisations and decision making process associated with this event, aspect or impact.

Table 15: Description of the environmental significance and the related action required.

Significance	Low	Low-Moderate	Moderate	Moderate-High	High
Impact Magnitude	Impact is of very low order and therefore likely to have very little real effect. Acceptable.	Impact is of low order and therefore likely to have little real effect. Acceptable.	Impact is real, and potentially substantial in relation to other impacts. Can pose a risk to the company	Impact is real and substantial in relation to other impacts. Pose a risk to the company. Unacceptable	Impact is of the highest order possible. Unacceptable. Fatal flaw.
Action Required	Maintain current management measures. Where possible improve.	Maintain current management measures. Implement monitoring and evaluate to determine potential increase in risk. Where possible improve	Implement monitoring. Investigate mitigation measures and improve management measures to reduce risk, where possible.	Improve management measures to reduce risk.	Implement significant mitigation measures or implement alternatives.