Ecological and Wetland Assessment for alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.

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Prepared by:

Darius van Rensburg
Pr.Sci.Nat. 400284/13
T 083 410 0770
darius@dprecologists.co.za
P.O. Box 12726 | 61 Topsy Smith Street
Brandhof | Langenhovenpark
9324 | 9300

Prepared for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

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**		
Title	**Ecological and Wetland Assessment for alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.**		
Author	**DP van Rensburg (Pr.Sci.Nat)**		**Aug'18**

Executive Summary

The study area is considered to be in a largely natural condition with relatively few impacts except for impacts caused by current alluvial diamond mining operations.

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will, for the time being not be subjected to mining. This study will therefore focus on the former farms (Map 1).

The study area is situated within the Savanna Biome and therefore contains a well-developed tree layer with grass and dwarf shrub understorey (Map 2). The region is considered to have a low rainfall and forms part of an arid area. The study areas contains a varied topography also due to the large size of the area. Topography includes relatively flat plains with uneven and rocky terrain in the central portion of the study area with a high amount of ridges and hills.

The majority of the study area is still largely natural except for portions which have already been subjected to mining. Mining activities is currently concentrated in the south western and western portions of the study area and the floodplain of the Vaal River. Mining operations is considered the only significant impact on the area.

The topography of the study area can divide it into roughly three separate areas (Map 3). The **south western portion** of the study area consists of an undulating plain with soils varying from shallow to deep and a relatively high percentage surface rock in most areas. The **central and south eastern portion** of the study area is dominated by uneven, rocky terrain with shallow soils and high percentage surface rock dominated by andesitic lava. The **northern and eastern portion** of the study area contains a relatively flat area which contains areas of much deeper sandy soils but also shallow soils with high percentage calcrete. The northern and southern portions with several similarities and the central, rocky area being more distinct.

The time of the survey was not optimal in terms of species identification as many herbs, annuals and geophytes were unidentifiable or not present at this time and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall

South western portion

In terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Central and south eastern portion

In terms of terrestrial ecology this central portion of the study area does not contain elements of exceptionally high conservation value although the combination of a varied topography, higher species diversity and occurrence of protected species and presence of high amounts of

watercourses provide it with a high level of sensitivity (Map 3). Furthermore, the low quartzite ridge is considered a unique habitat with unique species assemblage and therefore a very high level of sensitivity (Map 3). This ridge should be excluded from mining activities. Numerous protected species occur and although none are listed as rare or endangered they still retain a significant conservation value and recommended mitigation should be applied for these.

Northern and eastern portion

In terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Overview of terrestrial fauna (actual & possible)

Being a game reserve consisting of natural vegetation in relatively good condition and being utilised almost exclusively for game farming the study area contains a varied faunal population with relatively high diversity. The study area also has a very large extent and consequently will be able to sustain population dynamics at a much larger scale, i.e. localised migration, varied genetic pool, pristine habitats for reclusive and rare species. The mammal population on the site therefore has a high conservation value.

The most significant impacts that mining operations will have is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population. This impact is considered to be significant but 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. Areas which was already mined and which has been rehabilitated has also illustrated that it may be possible to re-establish a similar habitat to that prior to mining.

Watercourses and wetlands

Section 4.4 provides a short description of each watercourse within the study area (Table 6) (Map 1 - 4). The study area consists of the entire diamond mining area and contains floodplains, seasonal streams, pans, wetland areas and numerous drainage lines especially the areas closer to the Vaal River (Map 1 - 4).

Obligate wetland vegetation was utilised to determine the presence and border of wetland conditions. Due to time constraints and the extent of the study area soil samples were only used to confirm the presence of wetland conditions where obligate wetland vegetation indicated wetland conditions (Section 4.4). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils (Appendix B).

Soil samples indicated that the majority of watercourses, especially smaller drainage lines, were devoid of wetland conditions (Table 6). However, larger stream systems as well as pans, backwaters, the banks of the Vaal River and other waterbodies did contain clear wetland conditions. These systems are discussed separately in Section 4.4.

Impacts and condition of watercourses and wetlands

The Vaal River and its associated floodplains are considered a fifth order watercourse. This is also due to the Vaal River being a large lowland river. The largest impact on the study area is the construction of large upstream containment dams in the Vaal River. These impacts alter flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix C). The results of the IHI indicated that the Vaal River has an Inseam IHI of category C: Moderately Modified and Riparian IHI of category C/D: Moderately to Largely Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Vaal River and associated wetlands and floodplains are considered to be somewhat altered and degraded by historical and current impacts.

The watercourses and wetlands within the interior of the study area is considered to be affected by relatively few impacts and consequently still in a relatively natural condition. Current mining operations are however considered to have a significant impact. An Index of Habitat Integrity (IHI) was conducted for these watercourses within the study area (Appendix C). The results of the IHI indicated that the watercourses in the interior of the study area has an Instream IHI of category B: Largely Natural and Riparian IHI of category B: Largely Natural. This is considered accurate since they are located in their entirety in a natural area with few impacts. Current mining has not yet affected a large proportion of watercourses and is therefore not yet considered to have decreased the condition of watercourses significantly.

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 D). Assessment of the highly sensitive artesian fountain system has not been included as it is assumed to be excluded form mining activities.

Mining within the interior, main channel or banks of watercourses, the Vaal River or wetland areas as described will likely cause permanent modification of these systems. 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 watercourses, the Vaal River and 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 watercourses, Vaal River and 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 these systems.

Construction of roads and other infrastructure such as pipelines and canals through watercourses and wetland systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. Furthermore, watercourses being linear by nature is almost unavoidable although circular wetland systems are much more easily avoided.

Anticipated Impacts

The proposed alluvial diamond mining activities proposed for the study area will mostly take place in the western portion whilst the eastern portion (portions of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98) will not be subjected to mining (Map 1). The remainder of the study area is anticipated to be subjected to extensive mining operations which will transform large portions of the vegetation and habitat. As can be expected this will result in numerous high impacts on the area.

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. Although the vegetation types in the study area is not considered to have a high conservation value they do form part of an area which is managed as private game reserve and contain smaller portions of unique habitat such as watercourses, wetlands, the central rocky portion of the study area and the low quartzite ridge (Map 2 & 3). However, overall the vegetation seems to be rather uniform and the species diversity was not determined to be high.

As previously discussed, it has been shown that the site contains numerous protected species although when seen in context with the large size of the study area it is not considered to be high. However, mining activities will still clear vegetation and this will therefore require removal of protected species. The impact on these species will therefore still be considered to be relatively high.

Mining within the study area will undoubtedly lead to high impacts on the watercourses in the study area. As a result strict mitigation measures will have to be implemented to ensure that impacts are kept to a minimum. Predicted impacts include increased sedimentation of watercourses, increased establishment of weeds and invaders and increased erosion due to clearance of vegetation and disturbance of the soil profile. It is recommended that watercourses and wetlands as described in this report be excluded from mining as far as possible and where mining within watercourses or wetlands are desired the only mitigation can therefore be strict adherence to a comprehensive rehabilitation and monitoring plan.

As was observed during the survey of the study area it contains relatively few exotic species, especially the terrestrial interior which is almost devoid of exotics. As a result proposed mining operations will create conditions highly susceptible to the establishment of exotic weeds and invaders.

The most significant impacts that mining operations will have on the faunal population is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population.

The impact significance has been determined and it is clear that most impacts prior to mitigation will be moderate to high but can be decreased significantly with mitigation to low/moderate. The impact on natural vegetation and watercourses are not easily mitigated and is anticipated to remain moderate/high.

Table of contents

Ecological and Wetland Assessment

1. Introduction

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 biological diversity ranks as one the ten highest 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.

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.

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

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will for the time being not be subjected to mining. This study will therefore focus on the former farms whilst the latter portions excluded from mining will only be discussed in basic review (Map 1). The study area is also situated in its entirety within the Rooipoort Nature Reserve. This is not a formally proclaimed reserve but managed as a private game reserve. The study area is located on the eastern banks of the Vaal River to the east of the town of Schmidtsdrif. The extent of the study is approximately 40 000 ha with the portions where mining will mostly take place covering 25 000 ha (Map 1). Almost the entire study area still consists of

natural vegetation although portion along the western border, especially along the floodplain of the Vaal River, where current and previous mining has occurred.

A site survey of the study area was conducted from 18 to 25 June 2018. The entire study area was surveyed although focused on those portions as described above where mining will mostly take place (Map 1). Due to the extent of the area the survey could not include a detailed analysis of all areas though the survey is still considered comprehensive with most areas included. The time of the survey is no longer considered optimal in terms of seasonality although it was still possible to identify dominant vegetation and riparian and wetland vegetation. Accurate identification of the species diversity is therefore considered a limitation of the survey.

For the above reasons it is necessary to conduct an ecological and wetland assessment of an area which is proposed for alluvial diamond mining operations.

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

1.1 Background

The current mining entity, Rooipoort Developments, is in possession of an existing Mining right (MR) and Record of Decision (RoD) to allow it to mine in the study area. However, the mining company currently desires to conduct mining activities outside the scope of the current MR and RoD and conduct mining operations within watercourses, including the Vaal River, major drainage lines and other sensitive areas.

The proposed mining area is situated in its entirety within the Rooipoort Nature Reserve. This is not a formally proclaimed reserve but managed as a private game reserve. It is however one of the largest and oldest private reserves in the country and should clearly be considered to have a high conservation value. Furthermore, in 1985 it was declared as the fourth South African Natural Heritage Site (Bezuidenhout 2009).

As a result of the above, the applicant will apply for a Water Use License (WUL) and Environmental Authorisation (EA) from the Department of Water and Sanitation (DWS) and the Department of Mineral Resources (DMR) respectively in terms of the National Water Act 36 of 1998 and the 2017 EIA Regulations under the National Environmental Management Act 107 of 1998.

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 (Johnson 2005).

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 (including riparian and wetland) and watercourses and wetlands included within the study area. The importance of the ecological function and condition will also be assessed.
- To identify possible negative impacts that could be caused by the proposed mining operations.
- Identify and delineate watercourses including rivers, streams, pans and wetlands and ascertain condition and status therefore and recommend mitigation.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the watercourses and wetlands in the study area.
- Conduct a risk assessment and determine the likelihood that watercourses and wetlands will be adversely affected by the development.

2.1 Vegetation

Aspects of the vegetation that will be assessed include:

- The vegetation types of the region with their relevance to the study area.
- The overall status of the vegetation including riparian vegetation in the study area.
- Species composition with the emphasis on dominant-, rare- and endangered species.
- Boundary of wetlands using obligate wetland riparian species.

The amount of disturbance present on the study area 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 encountered in the study area using visual observations of species as well as evidence of their occurrence in the region (burrows, excavations, animal tracks, etc). This will be based on terrestrial fauna with aquatic fauna being assessed by a separate study. The majority of watercourse systems in the interior of the study area are seasonal and therefore only contain aquatic fauna for short periods not present at the time of the survey.
- The overall condition of the habitat.
- A list of species that may occur in the region (desktop study).

2.3 Watercourses and wetlands

Aspects of the watercourses and 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 time of year very few plant species were flowering and this has made identification impossible for many of the less common species. Furthermore, several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to the season.
- Several of the streams and wetlands away from the Vaal River are seasonal in nature and do not contain an aquatic component (including invertebrates and fish species).
- Due to time constraints only limited soil sampling could be done.
- Due to the large extent of the study area only spot surveys of watercourses were undertaken. Furthermore, where a high amount of similar drainage lines occurred in close proximity only a few of them were surveyed.
- Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
- Some animal species may not have been observed as a result of their nocturnal and/or shy habits.
- Some fauna may not have been observed due to being in a dormant state or overwintering in egg or embryo form.

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 vegetation and riparian species identification (Adams 1976, Bromilow 1995, 2010, Coates-Palgrave 2002, Court 2010, Fish *et al* 2015, Gerber *et al* 2004, Gibbs Russel *et al* 1990, Hartmann 2001, Manning 2009, Roberts & Fourie 1975, Shearing & Van Heerden 2008, Smith *et al* 1998, Smith & Crouch 2009, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Rooyen 2001, Van Wyk & Malan 1998).

Terrestrial fauna:
Field guides for species identification (Smithers 1986a).
Mammal Red Data List (Child *et al* 2016, Smithers, R.H.N. 1986b)

Wetland methodology, delineation and identification:
Department of Water Affairs and Forestry 2004, 2005, 2008, Collins 2006, Duthie 1999, Kleynhans *et al* 2008, Marnewecke & Kotze 1999, Nel *et al* 2011, SANBI 2009.

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 at 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.
The state of the habitat was also assessed.

Animal species were also noted as well as the probability of other species occurring on or near the study area 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 (Table 6, Appendix B).
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.

The following were utilised to inform the condition and status of watercourses:

- Kleynhans, C.J., Louw, M.D. & Graham, M. 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity. Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08.

A Risk Assessment will be conducted for the mining in or near watercourses and wetlands 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 study area and determine the overall status of the environment.

3.3.1 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.
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.

3.3.2 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.

3.3.3 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 discussed in section 3.3 were used to determine the biodiversity sensitivity ranking for the sites. On a scale of 0 – 30, five different classes are described to assess the biodiversity of the study area. The different classes are described in the Table 1:

Table 1: Biodiversity sensitivity ranking

BSR	BSR general floral description	Floral score equating to BSR class
Totally transformed (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.	29 – 30
Advanced Degraded (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.	26 – 28
Degraded (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.	21 – 25
Good Condition (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.	11 – 20
Sensitive/Pristine (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.	0 - 10

4. Ecological and Wetland Assessment

For the purpose of this report the ecology of the study area will first be discussed followed by a discussion of the watercourse and wetland systems.

4.1 Ecology and description of the study area

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4) and Scmidtsdrif Thronveld (SVk 6) with the Hoffman's Pan system consisting of Highveld Salt Pan (AZi 10) vegetation. All of these are listed as being of Least Concern (LC) within the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). They are not currently subjected to any pronounced development pressures.

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will for the time being not be subjected to mining. This study will therefore focus on the former farms whilst the latter portions excluded from mining will only be discussed in basic review (Map 1). The study area is also situated in its entirety within the Rooipoort Nature Reserve. This is not a formally proclaimed reserve but managed as a private game reserve. The study area is located on the eastern banks of the Vaal River to the east of the town of Schmidtsdrif and approximately 60 km to the west of Kimberley. The extent of the study is approximately 40 000 ha with the portions where mining will mostly take place covering 25 000 ha (Map 1).

Almost the entire study area still consists of natural vegetation although portions along the western border, especially along the floodplain of the Vaal River, where current and previous mining has occurred. Previously mined areas are being rehabilitated and seems able to restore a significant manner of ecological function. The majority of the study however remains natural and the ecological function is largely intact. The study area is situated within the Savanna Biome and therefore contains a well-developed tree layer with grass and dwarf shrub understorey (Map 2). The tree layer may be quite dense in areas but varies from open to closed. Areas with low or no tree cover also occur in the north eastern portion of the study area. These areas are dominated by grassland. Small portions dominated by dwarf karroid shrubs are also present although in small extent. The region is considered to have a low rainfall and forms part of an arid area.

The study area contains a varied topography also due to the large size of the area. Topography includes relatively flat plains with uneven and rocky terrain in the central portion of the study area with a high amount of ridges and hills. Altitude varies from 1009 m to 1150 m and should illustrate that topography varies considerably over the study area. The majority of the study area contains a gradual slope toward the river except for hills and ridges where the slope can become quite steep. The general slope of the study area is toward the Vaal River. Where a gradual slope occurs such as in the south and north of the study area, watercourses are few. There is a definite increase in drainage lines closer to the river as the slope increases and flood sediments promote the formation of drainage lines (Map 4). Uneven terrain such as occur in the central portion of the sturdy area contains a high amount of watercourses (Map 3 & 4). The north eastern portion contains a very low slope and deep sandy soils. In this area watercourses are largely absent

although a few drainage lines and pans occur. The floodplain of the Vaal River can also become quite extensive in areas of the study area. According to Bezuidenhout (2009), the following topographical positions occurs in the study area: crest, scarp, midslope, footslope, plain, floodplain, pan and riverbank.

The immediate region has an approximate mean annual rainfall of 400 mm occurring mainly between January and March. It is highly erratic and can vary between 300 mm and 700 mm. The temperature is less erratic and cold winter temperatures as low as 4˚ C occurs while summer highs can reach 44˚C (Bezuidenhout 2009). As a result wetlands are uncommon in the area although several wetland areas are associated with the floodplain of the Vaal River, large seasonal streams and pan systems.

The study area is located at the base and to the east of the Ghaap plateau. Geology of the study area is underlain by outcrops of andesitic lavas of the Ventersdorp Supergroup occurring as hills with outliers of dolomite also occurring. A low flat ridge of quartzite occurs in the northern portion of the study area. The portion north of this ridge is underlain by aeolian sand with surface limestone and alluvial gravels of Tertiary to Recent age. Five landtypes occur in the area consisting of Ah, Ae, Dc, Fb and Fc land types (Bezuidenhout 2009).

No extensive infestation by exotic weeds and invaders occur in the study area although the areas subjected to current mining activities has promoted the establishment of pioneer weeds and exotics. In addition, the banks of the Vaal River is subjected to a natural disturbance regime as a result of annual flooding. As a result several exotic weeds also establish along the banks of the river.

The majority of the study area is still largely natural except for portions which have already been subjected to mining. Mining activities is currently concentrated in the south western and western portions of the study area and the floodplain of the Vaal River. Mining operations is considered the only significant impact on the area. Mining causes the removal of vegetation and large-scale disturbance of the soil profile. Areas where rehabilitation has taken place does illustrate that an indigenous vegetation layer does establish, with some resemblance to the natural vegetation, low amount of erosion occurring and exotic weeds not dominating. Rehabilitation therefore seems to be relatively successful and comprehensive. However, due to the complete removal of vegetation and disturbance of the soil profile and topography its unlikely that the naturally occurring vegetation structure and species composition will be able to re-establish. As a result, it will also be important to apply comprehensive and continuous monitoring of the vegetation succession in these rehabilitated areas which will also indicate the success of rehabilitation and the manner to which the original occurring natural vegetation can be re-established.

The study area, being managed as a game reserve consisting of natural vegetation, is affected by relatively few impacts associated with this land use. Numerous small dirt tracks transect the area which, in terms of the large extent of the study area, are not considered a large impact. They cause local erosion where they occur and cause localised clearance of the vegetation and is consequently considered a relatively low impact. A few watering points also cause localised trampling of the vegetation. The game stocking levels of the reserve is not known but it is evident that some overgrazing, -browsing and associated trampling does take place, especially in certain areas. This is quite evident in and around pans such as the Hoffman's Pan as well as near dirt tracks which are notably utilised by game to gain easier access to uneven terrain. A few small lodgings and small buildings and structures cause localised transformation of the natural vegetation but is considered minimal. The impacts associated with the game farm land use is

considered relatively low and small with the most significant impact associated with the overgrazing, -browsing and trampling by game.

A detailed ecological study of the major plant communities was conducted for the Rooipoort Nature Reserve which includes the study area for the proposed mining operations by Bezuidenhout (2009). This study area contains all of these except for the last mentioned which is located along the eastern border of the study area and was not included within this study. These fifteen communities consist of:

1. *Schmidtia pappophoroides - Themeda triandra* Grassland
2. *Schmidtia pappophoroides - Acacia erioloba* Woodland
3. *Tarchonanthus camphoratus* Shrubland
    - 3.1 *Eragrostis lehmanniana - Tarchonanthus camphoratus* Shrubland
    - 3.2 *Ziziphus mucronata - Tarchonanthus camphoratus* Shrubland
4. *Acacia mellifera -Acacia tortilis* Shrubland
5. *Acacia mellifera* Shrubland
    - 5.1 *Tarchonanthus camphoratus - Acacia mellifera* Shrubland
    - 5.2 *Digitaria eriantha - Rhigozum obovatum* Shrubland
    - 5.3 *Heteropogon contortus - Tarchonanthus camphoratus* Shrubland
6. *Diospyros lycioides* Woodland
    - 6.1 *Diospyros lycioides - Acacia karroo* Woodland
    - 6.2 *Salsola rabieana - Diospyros lycioides* Shrubland
7. *Pentzia globosa - Eragrostis truncata* Forbland
8. *Eragrostis bicolor* Grassland
    - 8.1 *Salsola rabieana - Eragrostis bicolor* Grassland
    - 8.2 *Osteospermum species - Eragrostis bicolor* Grassland
9. *Cynodon dactylon - Sporobolus ioclados* Grassland
10. *Scirpus species - Diplachne fusca* Grassland

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

A. erioloba - Vachellia erioloba
A. torilis - Vachellia tortilis
A. mellifera - Senegalia mellifera
A. karroo - Vachellia karroo

This study will also make use of these determined vegetation communities (Bezuidenhout 2009) to describe sections of the study area and to simplify the description of specific areas within the study area.

The topography of the study area can divide it into roughly three separate areas (Map 3). The **south western portion** of the study area consists of an undulating plain with soils varying from shallow to deep and a relatively high percentage surface rock in most areas. The **central and south eastern portion** of the study area is dominated by uneven, rocky terrain with shallow soils and high percentage surface rock dominated by andesitic lava. The **northern and eastern portion** of the study area contains a relatively flat area which contains areas of much deeper sandy soils but also shallow soils with high percentage calcrete. The northern and southern portions with several similarities and the central, rocky area being more distinct.

4.1.1 South western portion

The south western portion of the study area consists of an undulating plain with prominent hills and ridges mostly absent (Map 3). However, due to the undulating topography low stony ridges is present. Soils consists of deep sandy to clayey soils in the southern portion of this area as well as along the floodplain of the river with more shallow, stony soils dominating the northern and western portion of the area. The vegetation structure consists of a well-developed tree layer and sparse grass layer with a dwarf karroid shrub layer becoming prominent in the norther portion where stony soils are common. Here the tree layer also decreases in height, most likely also attributed to the shallower, stonier soils. This portion is situated within four vegetation communities as described by Bezuidenhout (2009), namely:

2. Schmidtia pappophoroides - Acacia erioloba Woodland
3.2 Ziziphus mucronata - Tarchonanthus camphoratus Shrubland
4. Acacia mellifera -Acacia tortilis Shrubland
8.1 Salsola rabieana - Eragrostis bicolor Grassland

Soil conditions associated with these vegetation communities consist of very deep well-drained, yellow-brown or red-brown sandy soils(vegetation community 2), deep, poorly drained clayey soils (vegetation community 8.1) without any visible surface rocks and intergrades into areas where surface rock and outcrops becomes much more prominent including Mispah soil forms with a depth varying from 0,3 to 0,8 meters with andesitic lava and limestone outcrops (vegetation community 3.2) and shallow, rocky soils (0,3 meters) with a high percentage covering of andesitic lava, dolemite and calcrete rocks (Bezuidenhout 2009).

Areas containing deeper soils without surface rock will be discussed first followed by those areas where shallower soils and higher percentages surface rock occur.

Areas with deeper soils contain, overall, a higher tree canopy, well-developed but may be somewhat sparser than more rocky areas. The grass layer is much better developed in these areas although it may also be quite sparse in areas. A distinction in the description of this area will be made between the floodplain with clay soils and interior with more sandy soils.

The floodplain of the Vaal River in this portion consists of vegetation community 8.1 and is quite easily discerned as a distinct vegetation community. According to Bezuidenhout (2009) this area was also subjected to historical ploughing for crop cultivation but was no longer evident at the time of the survey. In addition, a large portion of this area has recently also been mined and the original vegetation composition is not easily discerned. Aerial images (Google Earth 2003) do indicate portions having been ploughed although remaining large natural areas are still evident. These portions of remaining natural vegetation is composed of a short, sparse grass layer dominated by pioneer grasses, a prominent, low shrubs layer dominated by *Vachellia tortilis* and scattered larger trees. The grass layer is dominated by *Chloris virgata*, with other abundant grasses including *Tragus berteronianus, Eragrostis obtusa, Aristida congesta, Eragrostis lehmanniana* and *Enneaogon desvauxii*. All of these are pioneer grass species. Other dwarf shrubs occurring here include *Salsola rabieana, Pentzia incana, Rosenia humilis, Lycium horridum, Cadaba aphylla, Gnidia polycephala* and *Felicia muricata*. As already mentioned the shrub layer is dominated by *Vachellia tortilis*, though a few specimens of *Senegalia mellifera* and *Grewia flava* is also present. Larger trees are represented by *Diospyros lycioides, Ziziphus mucronata* and *Vachellia erioloba*. The last named of these is also a protected tree species under the National Forests (NFA) Act No 84 of 1998 and therefore of significant conservation value.

The understorey beneath trees and shrubs consist of a few species adapted to shadier conditions and include *Cenchrus ciliaris, Pupalia lappachea* and *Phyllanthus parvulus*. This species composition indicates a climax tree layer with a pioneer grass layer. This is considered largely natural to such floodplain communities where the clayey silt deposited by flooding is rich in nutrients and promote the establishment of a pioneer species assemblage which is adapted to periodic disturbance. The vegetation community is considered to be relatively low in terms of species and habitat diversity and does not represent a unique habitat. It does not contain elements of high conservation value although large specimens of protected *V. erioloba* (Camel Thorn) is of conservation significance. Recently mined areas of the floodplain were also surveyed to compare with the remaining natural areas. The natural topography has largely been re-instated in this area and an indigenous vegetation layer has succeeded in establishing. The vegetation is dominated by a pioneer grass layer with dominant species including *Aristida congesta* and *Chloris virgata* and other abundant grasses including *Eragrostis echinichloidea, E. bicolor, Tragus berteronianus* and *Enneapogon desvauxii.* The shrub, *Vachellia tortilis,* occurs as rare small specimens. As can be seen, rehabilitation succession seems to be progressing successfully although the species composition and abundance of species are not the same as natural areas and a tree layer is only now starting to establish. It is important that these areas be monitored closely and continuously in order to document the success/failure of rehabilitation and will aid greatly in improving or maintaining rehabilitation techniques.

Figure 1: Panorama of the remaining natural vegetation within the floodplain. Vegetation structural elements are clearly visible, sparse grass layer, dense shrub layer and scattered trees.

Figure 2: Scattered specimens of the protected Camel Thorn (*Vachellia erioloba*) was observed in the floodplain community.

Figure 3: View of a portion of the floodplain community which was subjected to recent mining. An indigenous grass layer has established although a tree layer is still absent.

The southern and western portions in this area contains deeper soils with less surface rock (though not everywhere) and this also intergrades with areas of shallower soils with a high percentage of surface rock in the northern portion of the area, especially around the area called "diamantkoppie". This area is situated within vegetation communities 2 and 4. The vegetation structure in the southern portion is dominated by a tree/shrub layer which may vary from open to closed but may become quite dense in some areas. A sparse grass layer is also present with scattered dwarf karroid shrubs. Dominant shrubs/trees include *Vachellia tortilis, Grewia flava, Senegalia mellifera* and *Rhigozum trichotomum*. The protected Camel Thorn (*Vachellia erioloba*) is rare but scattered individuals do occur. Grasses include *Aristida congesta, Eragrotsis lehmanniana, E. obtusa, Enneapogon desvauxii* and *Schmidtia pappophoroides*. The last named, *S. pappophoroides*, is considered a reliable indicator of sandy soils and will therefore reliably indicate the vegetation communities associated with these areas. The dwarf karroid shrub, *Pentzia incana*, and herb, *Sericorema remotiflora*, is scattered within the grass layer. The geophyte, *Lapeirousia plicata,* is also scattered within these sandy vegetation communities. This is also a protected species and considered uncommon and therefore of significant conservation value.

Figure 4: Areas with deeper sandy soils are clearly devoid of surface rock, a sparse grass layer, well-developed shrub layer, with scattered trees are clearly visible.

Figure 5: *Lapeirousia plicata*, occurs in the sandy soils of this community (S 28.672785°, E 24.082828°). It is an uncommon and protected species.

Towards the northern and eastern portions of this area soils become shallower with surface rock becoming much more dominant. Surface stones, rock and pebbles can become quite dominant on the surface of this area and often limestone/calcrete is dominant. This also includes the area called “diamantkoppie” which was previously also subjected to diamond mining operations. The area is situated within vegetation communities 3.2 and 4. The vegetation structure is again dominated by a shrub/tree layer which can be quite dense in many areas. A sparse grass layer is present and the dwarf karroid shrub component is also much more prominent. The shrub/tree layer is dominated by *Vachellia tortillis* and *Senegalia melifera* with *Tarchonanthus camphoratus* and *Grewia flava* scattered. The protected shepherds tree (*Boscia albitrunca*) is also scattered and of some conservation significance. The understorey underneath trees and shrubs is represented by grasses and herbs adapted to shadier conditions and include *Cenchrus ciliaris, Phyllanthus parvulus, Pupalia lappachea, Setaria verticillata, Lantana rugosa* and *Pavonia burchellii*. The grass layer is dominated by *Eragrostis obtusa, E. lehmanniana, Enneapogon desvauxii* and *Aristida congesta*. Other common but not dominating grasses include *Cymbopogon pospischillii, Fingerhuthia africana, Stipagrostis obtusa, Sporobolus coromandelianus* and *Eragrostis truncata*. The last named is also an indicator of limestone soils and indicative of these habitats. The dwarf karroid shrub component is represented by *Pentzia incana, Eriocephalus ericoides, Rhigozum trichotomum, Pteronia sordida, Lycium horridum* and *Barleria rigida*. The herb, *Geigeria foilifolia*, is also common. Areas with shallow soils and a high percentage surface stone often creates suitable habitat for dwarf growth forms as is the case here, but also especially conservation significant dwarf succulents. During the current study the survey also specifically targeted such species. However, these areas are largely devoid of such species. Two species which were identified were *Titanopsis clacarea* represented by only a few specimens and *Orbea sp.* Also represented by a few scattered specimens. Neither form colonies which would normally constitute a sensitive habitat. Furthermore, neither species are endangered or exceptionally rare. Despite this they are not considered overly common and are still considered to be of conservation significance.

Figure 6: View of a portion of the area where superficial calcrete is abundant, here dwarf karroid shrub coverage is high, grass coverage low with scattered trees.

Figure 7: View of another portion of this area where the tree/shrub canopy cover is much higher. Note again an increase in superficial calcrete.

Figure 8: Two protected species encountered in this area are *Orbea sp.* (left) and *Titanopsis calcarea* (right) (S 28.672785°, E 24.079374°).

4.1.2 Conclusions

The south western portion of the study area has an undulating but relatively uniform topography. Different habitats and vegetation communities are however varied and contain four different communities which are mostly separated on the basis of soil and percentage rock cover. Areas with high percentages surface pebbles occur around the "diamantkoppie" which provide suitable habitat for geophytes and dwarf succulents. However, such species could not be identified here and except for *Orbea sp., Titanopsis calcarea* and *Drimia sp.* no other noteworthy species could be identified. These habitats can therefore not be considered to be of significantly high conservation value.

The overall diversity of species is not considered high and the occurrence of protected, rare or endangered species are limited to a few species. Although seemingly suitable habitat occurs for the establishment of dwarf succulents of the families Mesembrynathemaceae and Asphodelaceae only one species from the former and none from the latter could be observed. The time of the survey was however not optimal in terms of species identification as many herbs, annuals and geophytes were unidentifiable or not present at this time and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall.

This portion of the study area does not contain a significant amount of protected species although a few do occur. The floodplain and southern areas with deep sands contain scattered specimens of the protected Camel Thorn Tree (*Vachellia erioloba*). The species is widespread and relatively common and is therefore not of high concern but as protected species it remains of significant conservation value. This has also been confirmed by studies conducted by Seymour & Milton (2003). Another protected tree but which occurs as scattered specimens in more rocky areas is the Shepherds Tree (*Boscia albitrunca*). Likewise, this species is also widespread and relatively common and therefore not of high concern but as protected species it remains of significant conservation value. These trees are protected under the National Forests (NFA) Act No 84 of 1998. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Furthermore, where trees were removed these should be replaced by saplings during the rehabilitation phase. This can be attained by establishing a small nursery area on the site. Other protected species Include the geophyte, *Lapeirousia plicata*, and succulents, *Orbea sp.* and *Titanopsis calcarea*. These species transplant easily and it is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

No unique habitats or areas of exceptional diversity could be identified which would warrant exclusion from mining operations. However, this does not include any watercourse, wetland or water related system which will be discussed in detail in Section 4.3. This portion of the study area does not contain a high amount of watercourses though several smaller drainage lines as well as one significant stream drain this portion (Map 4). The majority drain toward the Vaal River although a few smaller drainage lines also drain toward the south and east of the study area. A small pan area was also observed in the eastern section of this area.

Recently mined areas occur within the floodplain portion of the area. The natural topography has largely been re-instated in this area and an indigenous vegetation layer has succeeded in establishing. It is important that these areas be monitored closely and continuously in order to document the success/failure of rehabilitation which will aid greatly in improving or maintaining rehabilitation techniques.

In conclusion, in terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

4.1.3 Central and south eastern portion

The central and south eastern portion consists and is dominated by a very uneven rocky terrain dominated by hills and ridges (Map 3). A high amount of ravines and drainage lines also drain this portion (Map 4). Overall, soils are considered relatively shallow with a high percentage surface and below-surface rock content. Bezuidenhout (2009) also confirms this and gives a description of the soil-rock complex as a mixture of 80% rock covering and shallow well-drained Mispah soil form, with outcrops of andesitic lava and quartzite. Areas with somewhat deeper soils occur within basins formed within the interior of this mountainous portion. The vegetation structure is dominated by a well-developed and relatively dense tree/shrub layer. This layer is relatively low and dominated largely by Blackthorn (*Senegalia mellifera*) and is relatively dense though this still varies between different slope aspects. A grass layer is also well-developed and often dominated by *Cenchrus ciliarus*. This mountainous portion essentially divides the study area into the south western portion and northern and eastern portion. This portion is situated within five vegetation communities as described by Bezuidenhout (2009), namely:

3.2 Ziziphus mucronata - Tarchonanthus camphoratus Shrubland
4. Acacia mellifera -Acacia tortilis Shrubland
5.1 Tarchonanthus camphoratus - Acacia mellifera Shrubland
5.2 Digitaria eriantha - Rhigozum obovatum Shrubland
5.3 Heteropogon contortus - Tarchonanthus camphoratus Shrubland

Soil conditions within this portion is considered to be quite uniform without differing much between the vegetation communities. Overall the soil is considered to be relatively shallow but may vary to moderately deep Mispah soil form along the footslopes of the hills (vegetation community 3.2) with shallower, but still deeper than the hillslopes, soils occurring in basins formed in in the interior of the hill portion (vegetation community 4). The geology of this portion is also relatively uniform and dominated by andesitic lava outcrops although some variation may occur. The footslopes are dominated by andesitic lava outcrops, though some limestone outcrops and areas with dolomite and shale rocks also occur. The midslopes and plateaus of the mountainous area is dominated almost exclusively by andesitic rock, covering about 80% of the surface (vegetation communities 5.1 & 5.2) (Bezuidenhout 2009). An exception to the above is a portion of low hills and ridges in the north of this area which consists almost exclusively of a quartzite outcrop (vegetation community 5.3), this area will be discussed separately from the rest.

The vegetation of this portion is considered relatively uniform and will therefore be discussed as a whole. The exception is the low quartzite outcrop in the north which will be discussed separately as its vegetation is considered significantly different.

The hills in the eastern area of this portion have a predominately east facing aspect. Vegetation here is dominated by a relatively dense canopy cover with a significant and well-developed grass layer. The shrubs/tree layer is well-developed but has a low height and is dominated by *Senegalia mellifera*. Other shrubs scattered within this layer include *Ehretia rigida, Vachellia tortilis, Tarchonanthus camphoratus, Boscia albitrunca, Searsia ciliata* and *Rhigozum obovatum*. Of these *B. albitrunca* is also a protected species also identified as occurring in the southwestern portion of the study area. In addition, a few scattered individuals of the Lantern Bush (*Nymania capensis*) were also identified. This is also a protected species which is much less widespread and uncommon and therefore of high conservation value. The grass layer in these hills are also represented by a variety of species with *Cenchrus ciliaris* becoming a dominant feature with

altitude, i.e. plateaus. Grass species include *Heteropogon contortus, Cenchrus ciliaris, Cymbopogon pospischillii, Eragrostis obtusa, E. lehmanniana, Aristida congesta, A. diffusa, Enneapogon scoparius* and *Digitaria eriantha*. Herbs, dwarf shrubs and geophytes are also common within the understorey. Small herbs and dwarf shrubs include *Chascanum pinnatifidium, Barleria lictensteiniana, B. rigida, Felicia muricata, Phyllanthus parvulus, Sericorema remotiflora, Corbichonia decumbens, Hermannia vestita, Pollichia campestris* and *Euryops subcarnosus*. On shadier slopes and underneath boulders, etc. small ferns are present including *Pellaea calomelanos* and *Cheilanthes hirta*. Small geophytes include *Eriospermum porphyrium, Oxalis sp., Haemanthus humilis, Freesia andersoniae, Moraea polystachya* and *Ornithoglossum sp.* Of these *Oxalis sp., H. humilis, F. andersoninae* and *M. polystachya* are all listed as protected in the Northern Cape Province. Succulent species present are represented by *Mestoklema tuberosum* and *Ruschia sp.* Both of these are also protected species. Therefore, although widespread and relatively common these protected species are still of significant conservation value.

Figure 9: Panorama of the hills in the eastern portion of the area. Note the relatively dense canopy cover dominated by *Senegalia melifera*.

Figure 10: Another view of these hills also illustrating the well-developed grass layer.

The portion of the mountainous area consisting of the hills in the central and north western section is much the same as the east facing hills. Differences in species composition will be discussed below. These areas are also dominated by a relatively closed canopy of *Senegalia melifera* with well-developed grass layer though this layer may be quite sparse in some of the north and west facing aspects. Dominant shrubs/trees remain the same although the shrubs, *Grewia flava, Phaeoptilum spinosum* and *Rhigozum obovatum*, becomes more prominent in some areas. The grass layer also remains largely unchanged, though north and west facing aspects may contain a much sparser grass layer. Additional grass species observed include *Fingerhuthia africana* and *Pogonarthria squarrosa*. The herb and dwarf karroid shrubs assemblage is also much the same with a few additional species observed including *Pentzia virides, Blepharis integrifolia, Lantana rugosa, Pupalia lappacea, Aptosimum lineare* and the

succulent *Sansevieria aethiopica*. The assemblage of protected species are also much the same with only two additional species identified being *Orbea sp*. and *Boophone distichia*. Again, relatively widespread species though being protected they are still of significant conservation value.

Figure 11: View of a plateau within the mountainous portion. Note a high percentage rock coverage and sparse grass layer in this area.

Figure 12: View of a footslope/midslope area of the mountainous portion. Here the tree/shrub layer is exceedingly dense.

Figure 13: Panorama of one of the hills near the Vaal River. Note again a relatively closed, but low canopy cover, dominated by *Senegalia melifera*.

Figure 14: Close-up view of one of the hills near the river. Note here a much denser grass layer, dominated by *Cenchrus ciliaris*.

As previously mentioned the quartzite outcrop along the north eastern border of the central portion is considered significantly different from the larger mountainous area. This quartzite outcrop is relatively narrow with a longitudinal shape approximately 4 km in length. The geology, as said, consists exclusively of quartzite and the hill is easily distinguished from the surroundings. It has a relatively low elevation with moderate slopes and an extensive plateau portion with flat gradient. The percentage rock surface coverage is also high. The vegetation structure consists of a relatively open shrub/tree canopy with a relatively dense grass layer. The shrubs/tree layer is composed of species such as *Senegalia melifera, Vachellia tortilis, Ehretia rigida, Tarchonanthus camphoratus, Ziziphus mucronata* and *Boscia albitrunca*. The last named is also a protected species as previously discussed and widespread in the rocky areas of the study area. The grass layer consists of *Eragrostis lehmanniana, E. nindensis, Cymbopogon pospischillii, Digitaria eriantha, Enneapogon cenchroides, Anthephora pubescens, Aristida diffusa* and *Heteropogon contortus*. A variety of herbs and other growth forms also occur and include herbs such as *Pollichia campestris, Sebaea exigua, Helichrysum zeyheri, Cleome rubella, Dianthus micropetalus* and *Pegolettia retrofracta*, the sedge *Bulbostylis hispidula,* the ferns *Pellaea calomelanos* and *Mohria sp.* and succulents *Anacampseros filamentosa* and *Portulaca kermersina*. Of these *D. micropetalus* and *Anacampseros filamentosa* are also protected species. A few geophytic species also occur and include *Moraea polystachya, Drimia platyphylla* and *Babiana hypogaea*. Of these *M. polystachya* and *B. hypogaea* are both protected. Though widespread and relatively common, as protected species these still have a significant conservation value. The quartzite ridge also contained numerous herbs of the Fabaceae family but which were unidentifiable at this time of year. The species composition along this ridge is clearly significantly different from the surroundings and contain numerous species confined to it. The diversity of species is considered moderate and it is also likely that surveys during summer months after sufficient rainfall will significantly increase the species diversity. As a result of the above combination the quartzite ridge is considered to form a rather unique habitat and species assemblage (Map 3).

Figure 15: View of the slope of the quartzite ridge. Note an open tree/shrub layer and well-developed grass layer.

Figure 16: View of the plateau of the ridge, note relatively flat gradient.

Figure 17: Another view of the ridge (red). Note the elongated shape and relatively low elevation.

4.1.4 Conclusions

The central portion of the study area consists of very uneven, rocky and mountainous terrain but with a relatively uniform vegetation structure and species composition (Map 3). It contains five vegetation communities but which are all relatively similar, except for the community occurring on the low quartzite ridge. They are grouped in their similarity as a result of the relatively shallow soils, uniform andesitic lava geology and high percentage rock coverage of this portion. Such areas with a high percentage rock coverage form arid habitats which provide suitable conditions for highly adapted succulents. However, such species are conspicuously absent and the succulent component is almost absent. Such areas would normally be considered highly sensitive but are consequently absent from the study area.

Despite this the diversity of species is somewhat higher than the surrounding plains and the occurrence of protected species are also somewhat higher. The time of the survey was also not optimal in terms of species identification as many herbs, annuals and geophytes were unidentifiable or not present at this time and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall.

As mentioned above this portion of the study area contains numerous protected species. They are mostly scattered over this portion and not confined to specific colonies or habitats. The quartzite ridge does contain a few protected species confined to it. Two protected tree/shrub species occur namely *Boscia albitrunca* and *Nymania capensis*. Both are relatively widespread with the latter more so and the former somewhat uncommon. Accordingly, though both have a significant conservation value, *N. capensis* has a somewhat higher conservation value. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Furthermore, where trees were removed these should be replaced by saplings during the rehabilitation phase. This can be attained by establishing a small nursery area on the site. Other protected species consists mostly of succulent and geophytic species which transplant relatively easily. These include *Oxalis sp., Haemanthus humilis, Freesia andersoninae, Moraea polystachya, Mestoklema tuberosum, Ruschia sp., Orbea sp*., *Boophone distichia, Dianthus micropetalus, Anacampseros filamentosa* and *Babiana hypogaea*. It is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

The mountainous portion of the study area contains a higher species diversity than the surrounding plains portion and likewise a higher number of protected species. This, coupled with the varied topography and high amount of watercourses, including drainage lines, gives the mountainous portion of the study area a high sensitivity (Map 3). The watercourses and vegetation communities associated with the Vaal River in this portion will however be discussed in detail in the following Section 4.3 (Map 4). As a result of the above any mining taking place in this portion should be approach with the necessary caution, implementing comprehensive mitigation and a high level of rehabilitation. The low, quartzite ridge in this portion also contains a unique species assemblage different from the surrounding area and represents a unique geological outcrop which is considered to provide this area with a very high level of sensitivity (Map 3). It is accordingly recommended that this area be excluded from mining operations. Fortunately, owing to its geological composition it is unlikely to be diamond bearing.

In conclusion, in terms of terrestrial ecology this central portion of the study area does not contain elements of exceptionally high conservation value although the combination of a varied topography, higher species diversity and occurrence of protected species and presence of high amounts of watercourses provide it with a high level of sensitivity (Map 3). Furthermore, the low quartzite ridge is considered a unique habitat with unique species assemblage and therefore a very high level of sensitivity (Map 3). This ridge should be excluded from mining activities. Numerous protected species occur and although none are listed as rare or endangered they still retain a significant conservation value and recommended mitigation should be applied for these.

4.1.5 Northern and eastern portion

The northern and eastern portion of the study area consists of a relative flat to slightly undulating plain with prominent hills and ridges mostly absent (Map 3). The easternmost corner of this portion may contain low hills though does not form part of the portion which will be subjected to proposed mining and has therefore been excluded from this assessment. This portion can relatively easily be sub-divided into two distinct areas based on soil with the north eastern section containing deeper, sandy soils without visible surface rock and the south western section with shallower soils and a high percentage calcrete rock covering quite prominent. The vegetation structure, though represented by savannah over this entire portion, also differs significantly between these two areas. The north eastern section contains a well-developed, dense grass layer with a sparse but well-developed, open woodland with tall trees common whilst the south western section contains a much sparser grass layer with more closed canopy shrub/tree layer but with a significantly lower height. This portion is situated within four vegetation communities as described by Bezuidenhout (2009), namely:

1. Schmidtia pappophoroides - Themeda triandra Grassland
2. Schmidtia pappophoroides - Acacia erioloba Woodland

3.1 Eragrostis lehmanniana - Tarchonanthus camphoratus Shrubland
3.2 Ziziphus mucronata - Tarchonanthus camphoratus Shrubland

4. Acacia mellifera -Acacia tortilis Shrubland

A note should be made about distinct vegetation communities associated with the Hoffman's Pan and surroundings and backwater areas along the Vaal River. Being associated with wetland areas and watercourses these will be discussed within the next Section 4.3 (Map 4).

Soil conditions associated with these vegetation communities also clearly indicate two distinct conditions. Soils in the north eastern section is dominated by deep, well-drained, yellow-brown to red-brown sandy soils (vegetation communities 1, 2, 3) whilst the soil in the south western section is dominated by shallow, well-drained, rocky soils (vegetation community 4) (Bezuidenhout 2009). These two different areas will be discussed separately.

The north eastern portion with deeper, sandier soils is dominated by a well-developed grass layer which can become quite dense with a well-developed but open woodland layer. Variations within this area do occur with the most northern portion consisting of a striking savannah landscape of well-developed woodland community, portions of the central area dominated by a dense grass layer almost devoid of trees/shrubs and the southern portion containing a much denser but low shrub layer. The woodland portion in the north contains a dense grass layer dominated by *Scmidtia pappophoroides* with scattered clumps of *Themeda triandra, Cymbopogon pospischillii, Cenchrus ciliaris* and *Eragrostis pallens*. The suffrutex, *Elephantorrhiza elephantina*, is also common in the grass layer. The small geophyte, *Oxalis sp.*, is also common in the grass layer. The open, woodland tree layer is dominated by large specimens of *Vachellia erioloba* (Camel Thorn) with clumps of the low shrub, *Grewia flava* and *Tarchonanthus camphoratus*, also scattered. *V. erioloba* is also a protected species and therefore of significant conservation value. Longitudinal patches in the central area of this north eastern portion is dominated by a dense grass layer with the woodland component largely absent. The grass layer is dominated by *Schmidtia pappophoroides* with *Aristida congesta* also abundant. The southern portion of this area is much the same but contains a much more prominent and denser shrub layer in addition to the grass and woodland layers dominated by *Tarchonanthus camphoratus*. Other abundant shrubs include *Grewia flava, Vachellia tortilis, Phaeoptilum spinosum* and *Searsia ciliata*. Dwarf

karroid shrubs such as *Pentzia incana*, also become more prominent in this area. From the above it should be evident that the area is relatively uniform in terms of species composition but that some variation in terms of the vegetation structure is evident and easily distinguished between these areas. Furthermore, the species diversity is considered relatively low and dominated by a few prominent species. This species diversity may be increased during summer months and after sufficient rains as the time of the current survey is not considered optimal in terms of species identification though it is unlikely that this will increase species diversity to a large degree.

Figure 18: View of the northern area within this portion. Note an open tree layer with large specimens of *V. erioloba*, a dense, well-developed grass layer and scattered shrubs.

Figure 19: View of the central area within the portion. The absence of trees/shrubs and dense grass layer is prominent.

Figure 20: View of the southern area in this portion where the shrub component becomes more prominent.

Figure 21: Another view of the southern area where the shrub component becomes dominant and the tree layer is largely absent.

The south western section within this portion consists of shallower, well-drained, rocky soils dominated by a sparse grass layer with a prominent shrub layer. The karroid layer is also more prominent and represented by a dwarf karroid shrub component. Dominant shrubs are *Tarchonanthus camphoratus* and *Grewia flava* with scattered specimens of *Zizizphus mucronata* also present. The grass layer is dominated by *Eragrostis lehmanniana* and *Enneapogon desvauxii*. The dwarf karroid shrub element includes *Pentzia virides, Zygophyllum incrustata, Lycium horridum* and *Microloma armatum*. Other smaller herbs and geophytes include *Nemesia sp., Oxalis sp., Drimia sp.* and *Geigeria filifolia*. The difficulty in identifying species during this period should be evident and it is considered highly likely that the species diversity will be significantly increased during summer months and after sufficient rainfall. *Orbea sp*., a small succulent occurs sporadically as scattered individuals. This is a protected species which is considered to be of significant conservation value. It is also the only protected species observed, though it is highly likely that other protected species would also occur.

Figure 22: Panorama of the south western portion. Note the high percentage of surface calcrete covering. A sparse grass layer and dense shrub layer is evident.

Figure 23: Another view of the south western portion. Again, note the sparse grass layer.

4.1.6 Conclusions

The northern and eastern portion of the study area has a relatively flat to slightly undulating topography and is relatively uniform (Map 3). However, the portion still contains varied vegetation communities which are mostly coupled to soil conditions and percentage rock cover. No specialised terrestrial habitats occur and although the portions which contain a high percentage of surface calcrete often harbours dwarf succulent species these are largely absent. These habitats can therefore not be considered to be of significantly high conservation value.

The overall diversity of species is considered relatively low with the north eastern area having a visibly low species diversity while the south western area contains a somewhat higher species diversity though still not significant. Although seemingly suitable habitat occurs for the establishment of dwarf succulents of the families Mesembrynathemaceae and Asphodelaceae none could be identified. A single succulent species of the family Apocynaceae was identified but occurs as scattered specimens. The time of the survey was however not optimal in terms of species identification as many herbs, annuals and geophytes were unidentifiable or not present at this time and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall.

This portion of the study area contains the lowest amount of protected species. The sandy soils of north eastern area of this portion contains relatively high amount of the protected Camel Thorn Tree (*Vachellia erioloba*). The species is widespread and relatively common and is therefore not of high concern but as protected species it remains of significant conservation value. This has also been confirmed by studies conducted by Seymour & Milton (2003). This species is protected under the National Forests (NFA) Act No 84 of 1998. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. As a result it is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Furthermore, where trees were removed these should be replaced by saplings during the rehabilitation phase. This can be attained by establishing a small nursery area on the site. This habitat, open woodland savannah, is also aesthetically pleasing but is not a rare or unique habitat and is relatively widespread. The only other protected species observed was *Orbea sp*. This succulent species transplants easily and it is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected. Furthermore, the time of the study was not optimal in terms of species identification and it is highly likely that surveys during summer months and after sufficient rainfall will reveal several other protected species.

As mentioned, the habitats present in this portion are not considered unique or containing an exceptional species diversity. However. This does not include any watercourse, wetland or water related system which will be discussed in detail in Section 4.3 (Map 4). This portion of the study area does not contain a high amount of watercourses though a few large streams are present and several unique wetland systems are also present. These are considered to have a very high conservation value. Furthermore, the Vaal River and associated floodplain and backwaters also occur on the western border of this portion and will also have a high conservation value.

No mining has taken place in this portion which does increase its conservation value somewhat as a natural area in almost pristine condition.

In conclusion, in terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

4.2 Overview of terrestrial fauna (actual & possible)

Being a game reserve consisting of natural vegetation in relatively good condition and being utilised almost exclusively for game farming the study area contains a varied faunal population with relatively high diversity. The study area also has a very large extent and consequently will be able to sustain population dynamics at a much larger scale, i.e. localised migration, varied genetic pool, pristine habitats for reclusive and rare species. The mammal population on the site therefore has a high conservation value.

The most significant impacts that mining operations will have is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size, i.e. X amount of habitat is only able to sustain Y number of mammals. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population. This impact is considered to be significant but 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. Areas which was already mined and which has been rehabilitated has illustrated that it may be possible to re-establish a similar habitat to that prior to mining and which will therefore significantly decrease the impact on the faunal population.

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.

Of high importance will be the presence of threatened or Red Listed species. From available literature of species likely to occur in the region as well as the mammal list for the reserve it is clear that numerous Red Listed species occur and is likely to occur in the study area.

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

Of the above listed species, the Leopard (*P. pardus*) is known to occur along the river (Corné Andesron 2018, pers.comm.). Furthermore, a dung heap near the remains of a Giraffe of a Brown Hyena (*H. brunnea*) also indicates the actual occurrence of that species in the study area. It is also considered highly likely that several if not all of the remaining species will also occur within the study area. Introduced game such as roan or sable has not been included in this assessment and only fauna which occurs naturally or historically in this area has been included.

Figure 24: Dung which can be positively identified as that of the Brown Hyena (*H. brunnea*) occurring near the remains of a Giraffe adjacent to the Vaal River in the study area.

A brief mention will also be made to the occurrence of a population of Warthog (*Phacochoerus africanus*). This species does not currently or historically occur in this region and it has been shown to have several detrimental impacts, especially in arid environments (Swanepoel 2016). This population is therefore likely to affect the natural vegetation in the study area and decrease the condition to some extent.

Although this assessment is only based on terrestrial fauna a note should be made on some avifauna of conservation significance. A significant population of Kori Bustard (*Ardeotis kori*) was observed on the site. This species is currently listed as being Near Threatened according to the Red Data List (2015). The species is therefore of high conservation value. The population in the study area also forms a healthy breading population and will contribute to the stability of the

larger population. Mining operations may impact on this species in terms of habitat loss. The impact can be decreased by adequate rehabilitation.

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 Mouse	*Zelotomys woosnami*
		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*
Perissodactyla	Equidae	Burchell's Zebra	*Equus burchellii*
Artiodactyla	Bovidae	Common Eland	*Taurotragus oryx*
		Black Wildebeest	*Connochaetes gnau*
		Blesbok	*Damaliscus pygargus phillipsi*
		Blue Wildebeest	*Connochaetes taurinus*
		Gemsbok	*Oryx gazella*
		Giraffe	*Giraffa camelopardalis*
		Impala	*Aepyceros melampus*
		Mountain Rheedbuck	*Redunca fulvorufula*

		Red Hartebeest	*Alcelaphus buselaphus*
		Warthog	*Phacochoerus africanus*
		Greater Kudu	*Tragelaphus strepsiceros*
		Springbok	*Antidorcas marsupialis*
		Steenbok	*Raphicerus campestris*
		Common Duiker	*Sylvicapra grimmia*

4.3 Wetland and Watercourses Assessment

4.3.1 Introduction

The study area consists of the entire diamond mining area and contains floodplains, seasonal streams, pans, wetland areas and numerous drainage lines especially the areas closer to the Vaal River (Map 1 - 4). These will all be discussed below.

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.

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

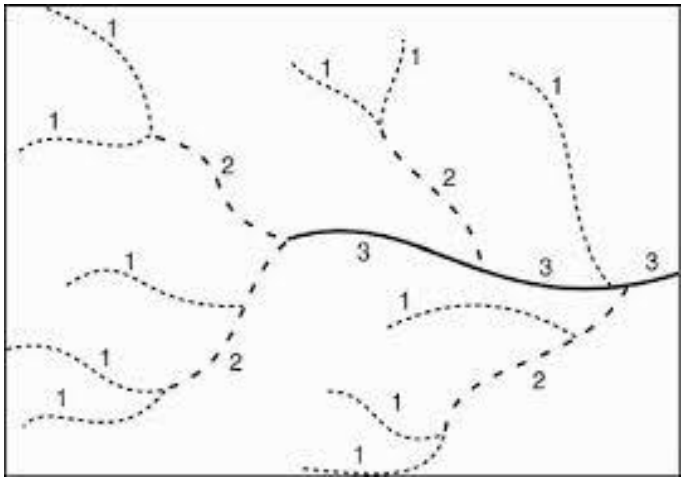


Figure 25: The classification of stream orders from 1 to 3 (Strahler 1952)

4.3.2 Overview of watercourses in the interior of the study area

All of the watercourses within the interior of the study area which will be affected by the mining operations are seasonal but mostly ephemeral in nature (Map 4). The Vaal River being perennial, but will be discussed separately. Seasonal, and especially ephemeral, systems are still poorly understood and their functioning is markedly different from perennial systems. This section will give an overview of the functioning of these systems.

The interior of study area contains a high amount of drainage lines and seasonal streams which increase in number in proximity to the Vaal River (Map 4). The uneven rocky terrain in the central and south western portion of the study area also contain a high amount of drainage lines as a result of the undulating terrain. The north eastern and south western portions of the study area with a lower slope gradient contain much less watercourses although several are still present in these areas. All of the streams and drainage lines has their origin within the study area. The streams and drainage lines are largely free of artificial impoundments except for dirt roads which may lead to some flow retardation and they are consequently considered to be largely natural with few impacts on them. Vegetation along the streams area readily identified as riparian vegetation. Tree species along the streams are characteristic of watercourses in these arid areas. These species include *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), S*earsia lancea* (Karree) and *Diospyros lycioides* (Bluebush). Indicators of wetland conditions increase with proximity to the river as the amount of runoff increases. Due to the arid climate and limited runoff the volume of water transport is low and not conducive to the formation of wetland conditions. Furthermore, these watercourses are characterised by flash flooding after heavy rainfall by which a relatively large amount of water is transported through these systems in a relatively short period. However, the larger stream system and in close proximity to the Vaal River do contain wetland conditions as a result of the increased water volumes and lower gradient leading to prolonged soil saturation and formation of wetland conditions. Where the larger streams mouth into the Vaal River, especially those in the central rocky portion, they form extensive alluvial fans which form part of the floodplain of the river. Here the silty soils cause significant gulley erosion which is natural in occurrence and forms part of the floodplain. As the stream exits the rocky terrain into the alluvial fan, the slope gradient is decreased to almost flat, water flow slows considerably and sediments in suspension is deposited, forming the alluvial fan. The slowdown in water flow also causes it to fan out and take on a form similar to a delta. The vegetation within the main channel of watercourses in the interior of the study area varies over their length as well as between them. This is due to the difference in slope, catchment size, pools,

etc, within and between the watercourses. Although differing, all of the vegetation consist of riparian species of grasses and sedges which support the presence of a watercourse. The streams are easily identifiable and distinguished from the surrounding terrestrial habitats by the presence of riparian trees and wetland species such as sedges and riparian grasses.

Non-perennial rivers are systems in which surface flow stops and may disappear for some period of most years (Uys & Keeffe 1997). They can further be divided into seasonal and ephemeral systems where seasonal systems have a continuous channel flow during the rainy season and ephemeral systems have a highly variable frequency of connected channel flow, a high degree of natural disturbance and a lack of baseflow (Hughes 2008). Seasonal systems can be regarded as flowing between 20 % and 80 % of the year and ephemeral systems less than 20 % of the year (Kleynhans & Louw 1999). It is considered highly likely that almost all of the watercourses in the study area are of ephemeral nature with only the largest perhaps leaning toward a seasonal flow regime.

Precipitation in the catchments of ephemeral rivers are generally highly sporadic, localised and of short duration as is the case in the study area. This can be more pronounced during periods of drought as was recently experienced. Consequently, runoff is highly variable and peak discharges may be reached within minutes. As a result of the variable climatic conditions runoff may be generated over small areas so that tributary and even mainchannel flow occurs whilst large portions of the channel system remains dry. The downstream reduction in flow after flooding events is caused by the infiltration into channel and floodplain sediments as well as evaporative losses. This accurately describes the functioning and flow of the watercourses in the study area.

Floods are essential to the existence, productivity and interactions of many biotic elements in seasonal and ephemeral ecosystems. The longitudinal transfer must play a vital role where any deliverance of moisture may serve to supplement available resources. Floods transfer materials laterally and longitudinally, but more importantly, water triggers ecosystem processes. Floods activate a diverse range of terrestrial decomposer communities which otherwise are inactive during dry stages. An ephemeral system functions as a floodplain without a river where the highly variable hydrologic regime supports a terrestrial biota, dependent upon flooding (Jacobsen 1997).

Small flow events play an important role in connecting isolated pools and thus exchange of genetic material. Small flow events also recharge pools. Larger flow events influence the channel geomorphology with regard to channel size and shape and sediment dynamics (Hughes 2008). During large flood events flow occurs laterally into the floodplain and reside there, the duration of this event depends on the rainfall, but typically lasts about 4-5 days (Rassam *et al.* 2006). These floods play a critical role in regulating organic matter transport and deposition and secondary production (Kleynhans & Louw 1999).

Floods have also been shown to play an important role in structuring riparian communities. Different plant species differ in their ability to withstand or regenerate after major floods. As floods alter the species composition of a community, invariably the ecosystem functions are also altered, especially where shifts occur in plant functional types (Stromberg, Lite & Dixon 2010).

From the above it should be clear that flooding is essential to the continued and natural functioning of the watercourses in the study area. It is also a real occurrence during the annual cycle of these watercourses and will occur annually in the larger stream systems but infrequently and perhaps only during years of high rainfall in the smaller ephemeral systems. Should mining

within stream systems take place this should also be taken into consideration as flooding may occur whilst mining is taking place. Where mining takes place inside watercourses the impact is anticipated to be high.

The distribution of riparian communities in semi-arid rivers has been shown to be correlated to variation in topography. Flooding frequency and duration as well as water availability due to this variation in topography has often been cited as the reason for these distribution patterns. The catchment geology together with the hydrogeomorphic processes of a river causes a heterogeneous landscape with different morphologic units that also changes through space and time. This heterogeneous landscape is an important factor in vegetation development and gives rise to distribution of different vegetation types (Van Coller, Rogers & Heritage 1997).

Soil salinity is a factor that significantly affects the distribution, morphology and productivity of many riparian species. Soil enrichment by soluble salts occurs where flood waters contain a significant salt load. Soils that become enriched generally occur in the lower reaches of the watercourse where water flow is slowed and together with infiltration and evaporation, salts are deposited (Jacobson 1997). This has also been found to be the case within the study area. Several of the larger stream systems lead to the formation of extensive alluvial fans adjacent to the Vaal River and in several cases a higher salt concentration is evident. Vegetation is also a clear indicator of higher salt concentrations and species such as *Salsola spp.* can be used as such indicators.

The above description should give a general idea of the functioning of the watercourses in the interior of the study area and should also serve to indicate that although they may seem small and flow only occur sporadically they still have a complex functioning which provides several unique ecosystem services. They should consequently still be considered as sensitive systems which may be easily altered or affected by activities associated with the proposed mining activities (Map 3 & 4).

Figure 26: View of one of the larger streams in the southern portion of the study area. Note a clearly defined main channel is present, wetland vegetation is absent although the banks contain riparian tree species.

Figure 27: View of another large stream in the southern portion of the study area. This portion closer to the Vaal River contains wetland condition albeit on a seasonal basis.

Figure 28: One of the smaller drainage lines in close proximity to the Vaal River. Note a main channel is still clearly visible although the drainage line is small. Erosion is also much more prominent in the silty soils of the floodplain.

Figure 29: View of one of the drainage lines within the interior of the rocky, uneven central portion. A main channel is still prominent although riparian vegetation is largely absent.

Figure 30: View of one of the drainage lines within the rocky, uneven central portion as it flows toward the Vaal River.

Figure 31: View of one of the larger streams closer to the Vaal River. The stream increases in magnitude in proximity to the river and riparian trees are prominent along the banks.

Figure 32: View of an alluvial fan caused by a significant stream flowing into the Vaal River. Note extensive erosion caused by silty soils and diffuse surface flow from the stream.

4.3.3 Wetland indicators

Obligate wetland vegetation was utilised to determine the presence and border of wetland conditions. Due to time constraints and the extent of the study area soil samples were only used to confirm the presence of wetland conditions where obligate wetland vegetation indicated wetland conditions (Section 4.4). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils (Appendix B).

Soil samples indicated that the majority of watercourses, especially smaller drainage lines, were devoid of wetland conditions (Table 6). The majority of these are also ephemeral systems, i.e. having active main channel flow only every other year. However, larger stream systems as well as pans, backwaters, the banks of the Vaal River and other waterbodies did contain clear wetland conditions. These systems will be discussed separately in Section 4.4. It should also be kept in mind that wetland conditions occur as a result of saturated soils and not active flow or visible surface water. As a result where soils in ephemeral systems become saturated for short periods wetland conditions may occur.

Along ephemeral systems wetland conditions may also not occur along the entire length of the stream. This was also prominent in the study area where stream systems may be devoid of wetland conditions for most of their length though as water volumes accumulates in downstream segments wetland conditions establish in the lower sections close to the Vaal River.

All of the stream systems in the study have a distinctive main channel. As a result the topography was also used to substantiate the occurrence of wetland conditions.

Obligate wetland species clearly indicate the presence of wetland conditions in these watercourses. These species are listed for each specific watercourse (Section 4.4). Obligate wetland species are confined to wetlands and cannot occur in conditions outside of these systems. As a result, where they occur, wetland conditions can be considered to occur.

The floodplain and banks of the Vaal River is associated with wetland conditions in many areas. A few backwater systems in the north of the study area, associated with the river, also contain unique wetland areas. In addition to these several smaller pans systems, an artesian fountain and large pans occur, also associated with wetland systems. These wetland systems will also be discussed separately.

4.3.4 Description and associated wetland conditions along the Vaal River

The Vaal River form the western border of the study area and will also form part of the mining area (Map 1 & 4). This is an extensive length of the river situated in the study area, approximately 30 km. 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 floodplain and banks of the river is relatively uniform along the length of the study area though smaller portions with differing and, in some areas, rather unique riparian habitats occurring. Detailed surveys at six locations along the Vaal River were undertaken in order to give an overall description of the banks of the Vaal River along the study area. An overall description of the river will be given below whilst the six surveyed areas will be described in detail within Table 6.

Soil samples taken along the banks of the river 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 whilst the floodplain (Upper Zone) does not contain distinctive wetland soil indicators. An exception to this being the backwater systems associated with the river in the northern portion of the study area. The floodplain contains a minimal grey matrix, no mottles and is not considered as being a wetland area. However, the marginal and lower portion of the lower zone of the Vaal River contains

distinctive wetland soil indicators. The upper portion of the lower zone does not contain any distinctive wetland condition and this can therefore be taken as the border of wetland conditions. The lower portion of the 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 although the boundary of the floodplain is not clearly defined.

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 majority of the Vaal River. Here the wetland conditions are most prominent along the main channel and decrease in distance from the channel. However, the backwater systems in the north also sustain a floodplain wetland system.

The above description accurately describes the wetland areas along the Vaal River in the study area. They are situated adjacent to the Vaal River which is a lowland river of large scale. These areas are undoubtedly inundated on an annual basis during flooding although the magnitude and frequency of these have been diminished due to building of large dams in the river which now regulate flooding events. These wetland areas vary from narrow to extensive along the river. The riparian trees, *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), *Searsia lancea* (Karree), *Combretum erythrophyllum* (Bushwillow), *Salix mucronata* (Cape Willow) and *Diospyros lycioides* (Bluebush) occur exclusively associated with the higher moisture regime of the floodplain and can therefore be taken as indicators of the riparian zone. The floodplain of the Vaal River can be substantial, especially in the southern and northern portion of the study area. The central portion of the study area with steeper, uneven rocky terrain surrounding the river contains a narrow upper zone and consequently the floodplain is relatively narrow in this portion.

The backwater systems occurring in the north of the study area are characteristic of floodplain wetland systems (SANBI 2009):

A floodplain wetland and lowland river floodplain: the mostly flat or gently sloping wetland area adjacent to and formed by a lowland floodplain river and subject to periodic inundation by overtopping of the channel bank of the river. The location of the wetland adjacent to the river in

the lowland floodplain zone is the key criterion for distinguishing a floodplain wetland from a channelled valley-bottom wetland. Water and sediment input to floodplain wetland areas is mainly via overtopping of a major channel, although there could be some overland or subsurface flow from adjacent valley side-slopes (if present). Water movement through the wetland is dominantly horizontal and bidirectional, in the form of diffuse surface flow and interflow, although there can be significant temporary containment of water in depressional areas (within which water movement is dominantly vertical and bidirectional). Water generally exits as diffuse surface flow and/or interflow, but infiltration and evaporation of water from a floodplain wetland can also be significant, particularly if there are a number of depressional areas within the wetland.

This accurately describes the backwater system associated with the Vaal River in the northern portion of the study area (Map 4). These are represented by two separate, longitudinal systems situated parallel to the river and in close proximity to it (approximately 300 meters) and within the floodplain. The southern system is isolated and has no defined in- or outflow while the northern system has no inflow but a defined outflow into the Vaal River is present at its southern tip. The vegetation is dominated by a grass layer with the dwarf shrub, *Salsola rabieana*, also abundant. Trees and shrubs are largely absent. These areas contain a few Facultative- and one Obligate Wetland species. Soil samples also indicate a low grey matrix without distinctive mottling and is considered indicative of a temporary zone of wetness. This indicates that these areas contain saturated soil conditions on an ephemeral basis, i.e. infrequently. Furthermore, due to significant modification of the flooding regime of the river it is highly likely that the frequency which these areas are being inundated has decreased significantly. Despite this these areas are still being considered as highly sensitive and especially the northern wetland area containing the outflow system. These areas still form part of the floodplain of the Vaal River and will play a vital role in terms of flooding and the functioning of the floodplain. They are also considered a more uncommon type of wetland system, further increasing their conservation value.

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 33 & 34). The marginal zone within the Vaal River as it occurs within the study area is well defined and easily identifiable by the presence of a dense riparian and sedge layer which are inundated on an annual nature. These marginal areas may be quite extensive in many areas where they constitute a perennial wetland area. These areas are predominately consisting of alluvial deposits on the outside of the river bends and the inflows of tributary streams. The majority of this zone seems to be largely natural although the opposite bank has been affected by mining in close proximity to the marginal zone.

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 33 & 34). The lower zone along the Vaal River can also be clearly defined and is easily visible as a definite and steep increase in slope over a short distance where after it levels off into the upper zone. The lower zone is inundated infrequently and only during larger flooding events. In small sections of the river and especially where the marginal zone is extensive the lower zone extends over a larger distance and the increase in slope and elevation is more gradual. The boundary between the zones in these areas are more difficult to discern. It is also clearly defined

by a grass layer often dominated by *Cynodon dactylon*. This can also be explained by the flooding of the lower zone. Large-scale flooding has a disturbance effect whereby vegetation is removed and allows for vegetation to re-establish through an ongoing cycle which is well known in river systems. Trees are also being affected most by flooding due to their increased volume presented to floods. Grasses, sedges and the like growth forms are much better adapted to flooding and able to withstand being uprooted to a much better degree. As a result the marginal and lower zones contain almost no trees whereas the upper zone is dominated by trees. The lower zone is largely natural within 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 33 & 34). The upper zone along the Vaal River is clearly visible as a decrease in slope and an increase in the woodland component. 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 *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn) and *Diospyros lycioides* (Bluebush) which then also indicate the border of the upper zone.

The upper zone consists of the *Diospyros lycioides - Acacia karroo* Woodland vegetation community (Bezuidenhout 2009). The description of the vegetation community accurately coincides with the upper zone of the river. The community is described as a well-developed tree layer up to 9 m tall, a shrub component up to 3 m tall and an understorey dominated by pioneer herbaceous species. The diagnostic tree species include *Vachellia karroo, Combretum erythrophyllum, Searsia lancea* and *Salix mucronata*. Other woody species include *Ziziphus mucronata* and *Diospyros lycioides*. The pioneer herbaceous layer is dominated by *Setaria verticillata, Cynodon dactylon, Ariplex semibaccata* and the exotic weeds *Argemone ochroleuca* and *Datura stramonium*.

The floodplain of the Vaal River can be extensive in areas, especially the southern portion of the study area. Here the floodplain is associated with the *Salsola rabieana - Diospyros lycioides* Shrubland vegetation community (Bezuidenhout 2009). The description of the vegetation community accurately coincides with the upper zone and floodplain of the Vaal River. Characteristic species of the community include the grasses *Chloris virgata, Panicum coloratum, Eragrostis lehmanniana* and *Aristida congesta* and the dwarf shrubs *Pentzia globosa* and *Salsola rabieana*. A tree/shrub layer is also present and consists of *Ziziphus mucronata* and *Diospyros lycioides*.

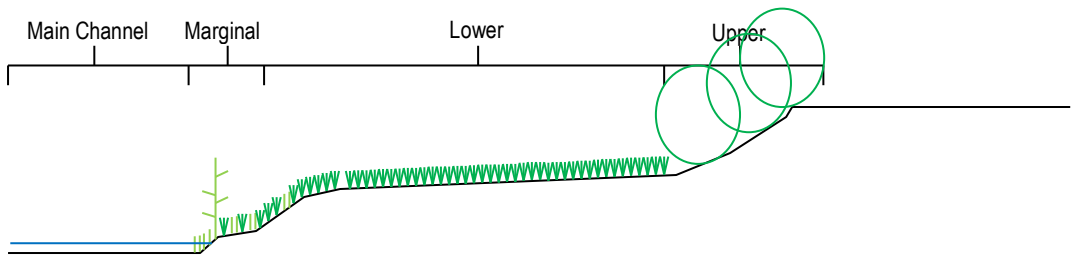


Figure 33: Illustration showing the different riparian zones of the Vaal River in the study area.

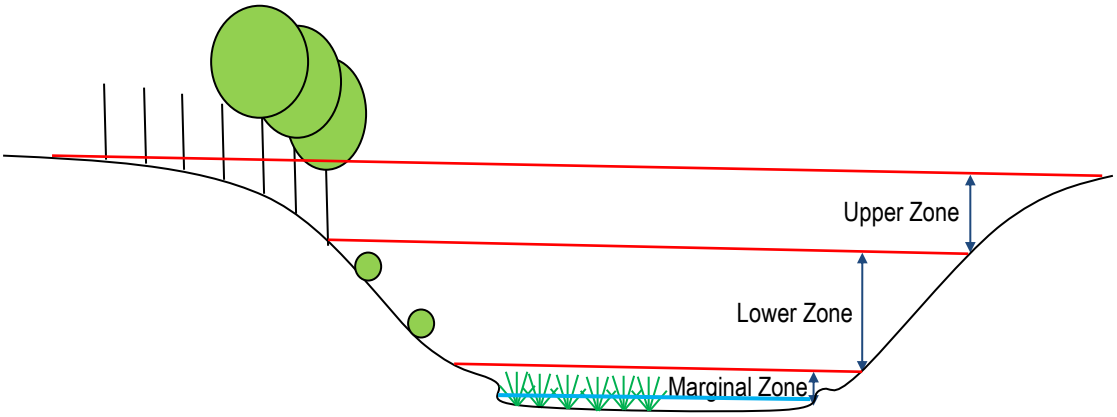


Figure 34: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation over the majority of the section in the study area. Note the narrow marginal zone and steep lower zone.

4.3.4 Description of large pans, fountain and other wetland systems

Dotted within the study area are several small pans (Map 4). These will be discussed within Section 4.4. Two larger and much more significant pan systems will be discussed in this section. The larger of the two is named Hoffman's Pan situated along the southern border of the study area (Map 4). The other, smaller though still large pan is situated to the north of Hoffman's Pan (Map 4). The pans are situated along the eastern side of a rocky ridge which also drains into these pans by means of numerous small drainage lines. The Hoffman's Pan has a length of approximately 3.5 km with the pan to its north approximately 1 km in length. It should be evident that both are of exceptionally large size. These pans are flat-bottomed with their interiors mostly devoid of vegetation, relatively deep soils and without prominent surface stone. The floodplain or shore of these pans is quite extensive along their eastern borders. Here the vegetation is dominated by a short grass layer and karroid component represented by dwarf karroid shrubs. The interior of the pans, being devoid of vegetation, does not indicate clear wetland conditions. However, soil do have a low grey matrix and some feint mottling indicating that wetland conditions are present. Furthermore, their topography undoubtedly characterises them as depression wetland systems. The extensive shore portion along the pan's eastern border do not contain any wetland conditions but still form part of the pans and are therefore also included within the border of the delineated wetland systems. The hydrological regime of these pans are considered to be ephemeral and will only contain surface water after exceptional rainfall. These pans and their shore is considered to be rather unique systems, largely as a result of their extensive size and are considered to be highly sensitive. It is recommended that as far as possible these be excluded from mining activities.

The two large pans in the study area can be categorised as a depression wetlands (SANBI 2009):

A depression wetland is a basin shaped area with a closed elevation contour with an increase in depth from the perimeter to the central areas that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. For 'depressions with channeled inflow', concentrated overland flow

is typically a major source of water for the wetland, whereas this is not the case for 'depressions without channeled inflow'. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flatbottomed (in which case they are often referred to as 'pans') or round-bottomed (in which case they are often referred to as 'basins') and may have any combination of inlets and outlets or lack them completely. For 'exorheic depressions', water exits as concentrated surface flow while, for 'endorheic depressions', water exits by means of evaporation and infiltration.

This accurately describes these large pan systems. They are flat bottomed and therefore pan systems, without defined outflow though some channelled inflow is present from drainage lines along their western borders. These pans are considered to contain wetland conditions on a seasonal basis though the occurrence of surface water will only occur on an ephemeral basis. Both pans are considered to be natural with relatively few impacts on them.

Figure 35: View of the central portion of the Hoffman's Pan. Due to the vast extent of the pan the shape and characteristics of the pan is not easily visible.

Figure 36: View of the shore/floodplain of the pan to the eastern border. Again, the vast size does not easily illustrate the characteristics of this area.

The northern portion of the study area consists of a relatively flat topography (refer to section 4.1.5) with the result that it contains few watercourses. However, a few are still present, especially one large stream draining the interior of this portion (Map 4). Consequently, a significant volume is drained by this stream. However, due to the flat topography areas of ponding is easily formed. As a result of this, wetland areas have formed in and around the main channel of this stream system. These areas are mostly flat, without a channel, and contain a relatively dense vegetation layer dominated by hygrophilous grasses and sedges. The central portions of these wetland areas may also be devoid of vegetation. Obligate wetland vegetation is prominent and soil samples also indicate clear wetland conditions occurring. These wetland areas are considered to have a seasonal regime and will contain surface water on a seasonal basis. These areas are also considered to be relatively unique, especially wetland areas adjacent to the quartzite outcrops along the western tributary of this large stream. Consequently these wetland areas are considered to be highly sensitive and of high conservation value.

The wetland areas associated with the large seasonal stream can be categorised as an unchanneled valley-bottom wetland (SANBI 2009):

A mostly flat valley-bottom wetland area without a major channel running through it, characterised by an absence of distinct channel banks and the prevalence of diffuse flows, even during and after high rainfall events. Water inputs are typically from an upstream channel, as the flow becomes dispersed, and from adjacent slopes (if present) or groundwater. Water generally moves through the wetland in the form of diffuse surface flow and/or interflow (with some temporary containment of water in depressional areas), but the outflow can be in the form of diffuse or concentrated surface flow. Infiltration and evaporation from unchannelled valley-bottom wetlands can be significant, particularly if there are a number of small depressions within the wetland area. Horizontal, unidirectional diffuse surface-flow tends to dominate in terms of the hydrodynamics.

This is a quite accurate description of these wetland areas. They are flat bottomed, do not contain a channel and is fed by the main channel of the seasonal stream. Outflow from these wetland areas is also via the seasonal stream. Furthermore, it is considered relatively certain that these wetland areas will also undergo significant infiltration and evaporation as stated and it is also clear that they contain depression areas.

Figure 37: View of one of the flat wetland areas situated within the large seasonal stream.

Figure 38: View of one of the other wetland areas (red) adjacent to the quartzite outcrop.

In close proximity to the above described wetland areas but considered a separate system is a very unique artesian fountain which seems to be entirely of natural origin (Table 6, Map 4). Systems such as this is exceptionally rare and considered highly unique. The fountain originates within a quartzite outcrop and flows down a gentle slope into a small natural rocky depression from where it overflows to the south into a sandy area. Here a low berm is present and considered

an artificial modification to capture the surface flow in an artificial impoundment. The extent of this entire fountain is no more than 1 hectare. During the survey surface water was present and a constant flow was also still present indicating that this fountain is a perennial system and provides a watersource throughout the year. Soil sampling is not possible due to the bedrock nature of the fountain. However, due to its perennial nature obligate wetland vegetation has become established around the fountain and clearly indicate the presence of wetland conditions. The fountain is considered a very unique system with a high conservation value. As a result it is recommended that it be excluded from mining operations. Furthermore, should mining within 500 meters of this fountain be desired the necessary geohydrological studies must be undertaken in order to determine a suitable buffer around it in order for its functioning to remain unaffected.

The natural fountain is difficult to place within a wetland type due in part to its unique nature but best fits the category of a hillslope seep (SANBI 2009):

A wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Water inputs are primarily from groundwater or precipitation that that enters the wetland from an up-slope direction in the form of subsurface flow. Water movement through the wetland is mainly in the form of interflow, with diffuse overland flow ('sheetwash') often being significant during and after rainfall events. Water leaves a 'hillslope seep with channelled outflow' mostly by means of concentrated surface flow, whereas water leaves a 'hillslope seep without channelled outflow' by means of a combination of diffuse surface flow, interflow, evaporation and infiltration.

This is a relatively accurate description of the fountain. The fountain is situated on the gentle slope of a quartzite outcrop and flows from cracks in the exposed rock. Outflow at the time of the site visit was present and the surrounding area indicates that the fountain may increase significantly in outflow during the rainy season. This is also confirmed by aerial images. The fountain does not form a distinct channel and does not give rise to a watercourse. Outflow is likely to infiltrate and recharge groundwater. The fountain is situated within the quartzite formation with no soils present and therefore wetland soils are absent. However, the sedge, *Schoenoplectus decipiens*, occurs in the fountain and indicates wetland conditions. The fountain is considered perennial in nature as a pool occurred during the site visit indicating that it functions throughout the year. It is considered a very unique system that consequently has a high conservation value.

Figure 39: View of the rock pool formed by the fountain.

Figure 40: From the rock pool water overflows downslope (red).

Figure 41: Water from the fountain accumulates in a shallow depression adjacent to an artificial berm (red).

4.3.5 Condition and importance of the affected watercourses

The determination of the condition of the watercourses and wetlands in the study area will be based on an overall determination of the Index of Habitat Integrity (IHI). Due to the high number of watercourses within the interior of the study area a determination of the Index of Habitat Integrity (IHI) will be limited to an overall IHI for the watercourses and a separate IHI for the Vaal River. The watercourses in the interior of the study area all drain into the Vaal River and therefore forms part of one system, located in close proximity to each other, are affected by the same impacts, situated in the same environmental setting and will all affect the same downstream section of the Vaal River (Map 4). Therefore, one IHI will be conducted for these watercourses to represent the overall condition and a separate IHI conducted for the Vaal River in the study area. This is considered to give a good representation of the condition of the systems within the study area as all affected watercourses and wetlands drain into the Vaal River and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

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 C: Moderately Modified. On-site observation indicate that this is relatively accurate 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.

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. 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. Shallow excavations and rock heaps are common in upstream areas. 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 is utilised for game farming and consequently the impacts associated with this is relatively low. However, it was noted that overgrazing was relatively high in many areas and here trampling is also significant. This was especially prevalent in and around pan systems. Areas used for gaining access to the river was also noted to contain high levels of trampling. Adjacent and upstream areas are also utilised for domestic stock grazing which will have some impact on the sediment load of the river.

The Vaal River and its associated floodplains are considered a fifth order watercourse. This is also due to the Vaal River being a large lowland river. The quaternary catchment of this area is C92A and C92B. The largest impact on the study area is the construction of large upstream containment dams in the Vaal River. These impacts alter flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix C). The results of the IHI indicated that the Vaal River has an Inseam IHI of category C: Moderately Modified and Riparian IHI of category C/D: Moderately to Largely Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Vaal River and associated wetlands and floodplains are considered to be somewhat altered and degraded by historical and current impacts.

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.

The watercourses and wetlands within the interior of the study area has not previously been assessed by the National Freshwater Ecosystems Priority Areas (NFEPA) (Kleynhans 2000), most likely due to their small size.

The watercourses and wetlands within the interior of the study area has been subjected to several impacts of which the majority is of small magnitude although alluvial diamond mining operations is considered a significant impact. Grazing and browsing by introduced game is the most widespread impact but is not considered to have a high impact. However, grazing was noted to be considerable especially around the pan systems including the Hoffman's Pan. Coupled with this was also high levels of trampling in these areas. Furthermore, along dirt tracks which afford game much easier access routes, trampling was also significant. This was also noted along access routes and game paths to the Vaal River. The above impact will cause a decrease in vegetation cover, disturbance of the soil surface and consequent increased erosion and sediment loads in watercourses. However, as stated this impact is still considered relatively low. The study area contains a dirt road network which also often cross streams, drainage lines and wetland areas including pans. These act as flow barriers and alter the flow regime of the

watercourses they also alter the bed and banks to a low degree and act as sediment and nutrient traps. Furthermore, dirt tracks, especially those in uneven, rocky terrain are subjected to higher levels of erosion and this was also evident in many areas. This will contribute to an increased sediment load in watercourses. The most significant impact which has affected watercourses in the study area is however the current alluvial diamond mining operations. Up to now the watercourses and wetland areas has been excluded from mining and a buffer of 30 meters has been afforded to these areas. Despite this their catchment has been transformed and disturbed and will undoubtedly affect the watercourses. Mining removes the natural vegetation cover, disturbs the soil surface and consequently causes mobilisation of sediments. The effect on watercourses is an increase in erosion and a significant increase in the sediment load. This will in turn also affect the Vaal River. Furthermore, disturbance causes conditions susceptible to the establishment of exotic weeds and consequently the watercourses also contain a higher percentage exotic weeds. Rehabilitation however seems to be affective and the impacts as discussed above should be of limited duration.

The watercourses and wetlands within the interior of the study area is considered to be affected by relatively few impacts and consequently still in a relatively natural condition. The most widespread impact associated with the landuse is overgrazing, -browsing and trampling by game though this is not considered a high impact. Current mining operations are however considered to have a significant impact. An Index of Habitat Integrity (IHI) was conducted for these watercourses within the study area (Appendix C). The results of the IHI indicated that the watercourses in the interior of the study area has an Instream IHI of category B: Largely Natural and Riparian IHI of category B: Largely Natural. This is considered accurate since they are located in their entirety in a natural area with few impacts. Current mining has not yet affected a large proportion of watercourses and is therefore not yet considered to have decreased the condition of watercourses significantly.

The EI&S of the floodplains associated with the watercourses and wetlands in the interior of the study area 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.

4.4 Overview of each watercourse crossing

The following section will provide a short description of each watercourse within the study area (Table 6) (Map 2 - 4). Where FW or OW is indicated it refers to Facultative or Obligate Wetland species. A facultative wetland species is often associated with wetlands but is also able to occur in non-wetland areas. 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.

This section can also be utilised during the mining operations to inform the location and nature of affected watercourses and wetlands.

Table 6: Description of each watercourse and wetland within the study area (FW – Facultative wetland species, OW – Obligate wetland species, * - Exotic species).

Watercourse name: #1 Unnamed	**Coordinates of crossing:** S 28.696636°, E 24.082677°	**Flow regime:** Seasonal stream
Description of watercourse: A large and significant stream in the southern portion of the study area. The flow regime of the stream is not clear though it is of significant size and is considered borderline seasonal to ephemeral. It flows from east to west and into the Vaal River and consists of several smaller tributaries which confluence with this significant stream. The catchment is undulating to flat. It contains a clearly defined main channel with gravel/sandy bed and round stream rocks. Vegetation along the stream is clearly of riparian composition though obligate wetland vegetation is absent. The riparian grass, *Cynodon dactylon*, does indicate elevated moisture levels. Soils consist of gravel/sand without any wetland moisture indicators. Wetland conditions are therefore absent at the point of sampling though it is likely that wetland conditions will occur in the section near the confluence with the Vaal River. The stream is natural without any significant impacts although crossing by two haul roads will cause some retardation of flow and flooding.		
Dominant plant species: *Ziziphus mucronata, Grewia flava, Eragrostis superba, Cynodon dactylon* (FW), *Aristida congesta, Cenchrus ciliaris, Sporobolus fimbriatus, Schmidtia pappophoroides, Eragrostis lehmanniana, Themeda triandra, Vachellia tortilis*		
Soil sample: 		

Watercourse name:	Coordinates of crossing:	Flow regime:
#2 Unnamed	S 28.685581°, E 24.066288°	Ephemeral drainage line

Description of watercourse:

A relatively small drainage line in the south western portion of the study area flowing into the Vaal River. The drainage line is representative of approximately five other smaller drainage lines adjacent to it. The flow regime will most likely be ephemeral in nature and although it is likely to flow for very short periods on an annual basis it cannot be considered to be of a seasonal nature. These drainage lines are short in length and form in the floodplain of the Vaal River where an increase in slope cause an increase in runoff and therefore a concentration within channels, thereby forming drainage lines. All these drainage lines flow from east to west and into the Vaal River and is relatively short in length. The catchment is small with a gentle slope toward the river and confined to the floodplain of the Vaal River. They contain clear main channels with a silt/clayey bed without any prominent rocks/pebbles. Vegetation along the drainage line is clearly of riparian composition and the occurrence of grass species considered Facultative Wetland grasses does indicate that some wetland conditions may be present. Soil samplings also exhibit a low degree of grey matrix and is also considered to indicate a temporary zone of wetness. The presence of wetland conditions are therefore considered borderline present but will increase closer to the river where it should be represented much clearer. All of these drainage lines are situated within the floodplain which was previously subjected to mining operations. This has had a significant impact on them and also indicated by the presence of a few exotic weeds, absent from other natural watercourses. Impacts include a decrease in vegetation cover and an increase in erosion and sediment load.

Dominant plant species:

*Diospyros lycioides, *Bidens bipinnata, Panicum coloratum* (FW), *Eragrostis lehmanniana, Chloris virgata, Cynodon dactylon* (FW), *Moraea pallida, Vachellia karroo, Dichantium annulatum* (FW)*, Eragrostis obtusa, Pupalia lappacea, Setaria verticillata, Ziziphus mucronata*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#3 Unnamed	S 28.675168°, E 24.127259°	Small ephemeral pan

Description of watercourse:

A small ephemeral pan is situated to the east of "Diamantkoppie" and at the origin of #4 Drainage Line. The pan is considered to have an ephemeral hydrological regime and will only contain surface water after exceptional rainfall events. The pan is one of the smaller systems in the study area and has a diameter of approximately 170 m. Although existing maps indicates it having an outflow, the on-site survey did not illustrate an in- or outflow. The pan is flat bottomed, situated in a plain and vegetation is dominated by a fringe of riparian trees and a short grass layer in the interior of the pan. The vegetation in the pan contain Obligate Wetland species and indicate definite wetland conditions even though only of temporary wetness. Soil samples contain a high clay content though a grey matrix or mottling was not evident at the time of sampling. Wetland conditions are considered present though of a temporary zone of wetness. An artificial watering point has been constructed in the pan and consequently trampling by game has become prominent. This has led to some degradation of the vegetation layer and will influence the hydrological regime of the pan to some extent, i.e. increased infiltration rates, etc. The presence of exotic weeds also confirm the disturbance of the vegetation layer.

Dominant plant species:

Ziziphus mucronata, Cynodon dactylon (FW), **Xanthium spinosum, Alternanthera sessilis* (OW), *Chloris virgata, *Alternanthera pungens*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#4 Unnamed	S 28.687363°, E 24.125879°	Ephemeral drainage line

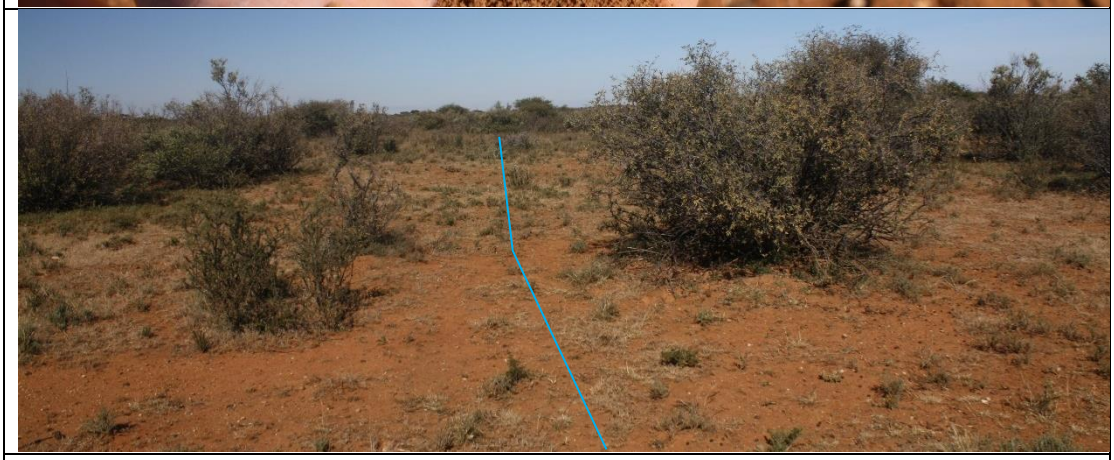
Description of watercourse:

A relatively small drainage line but with a significant length draining from #3 Ephemeral Pan but according to available map information, not draining into any other watercourse. The drainage line is representative of two other drainage lines adjacent to it. The flow regime will be ephemeral and will only contain surface water after exceptional rains. These drainage lines are all of significant length but they do not drain into any larger system, i.e. they infiltrate into the sandy soils without any definite flow pattern. As a result they are also not easily identified and do not contain a clearly defined main channel. These drainage lines flow from north to south and infiltrate into the sandy soils without a confluence with a larger system. Vegetation is dominated by terrestrial species with riparian species confined to a few riparian trees. Soil samples indicate a sandy soil with some calcrete pebbles and without any indications of wetland conditions. These drainage lines are obscure, not easily visible and not readily identifiable as watercourses. However, it is clear that concentrated surface runoff occurs and these areas should still be considered as forming watercourses. They are not affected by any significant impacts.

Dominant plant species:

Ziziphus mucronata, Pentzia incana, Chloris virgata, Aristida congesta, Grewia flava, Rhigozum trichotomum

Soil sample:



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#5 Hoffman and unnamed pan	S 28.694027°, E 24.173278°	Large ephemeral pan systems

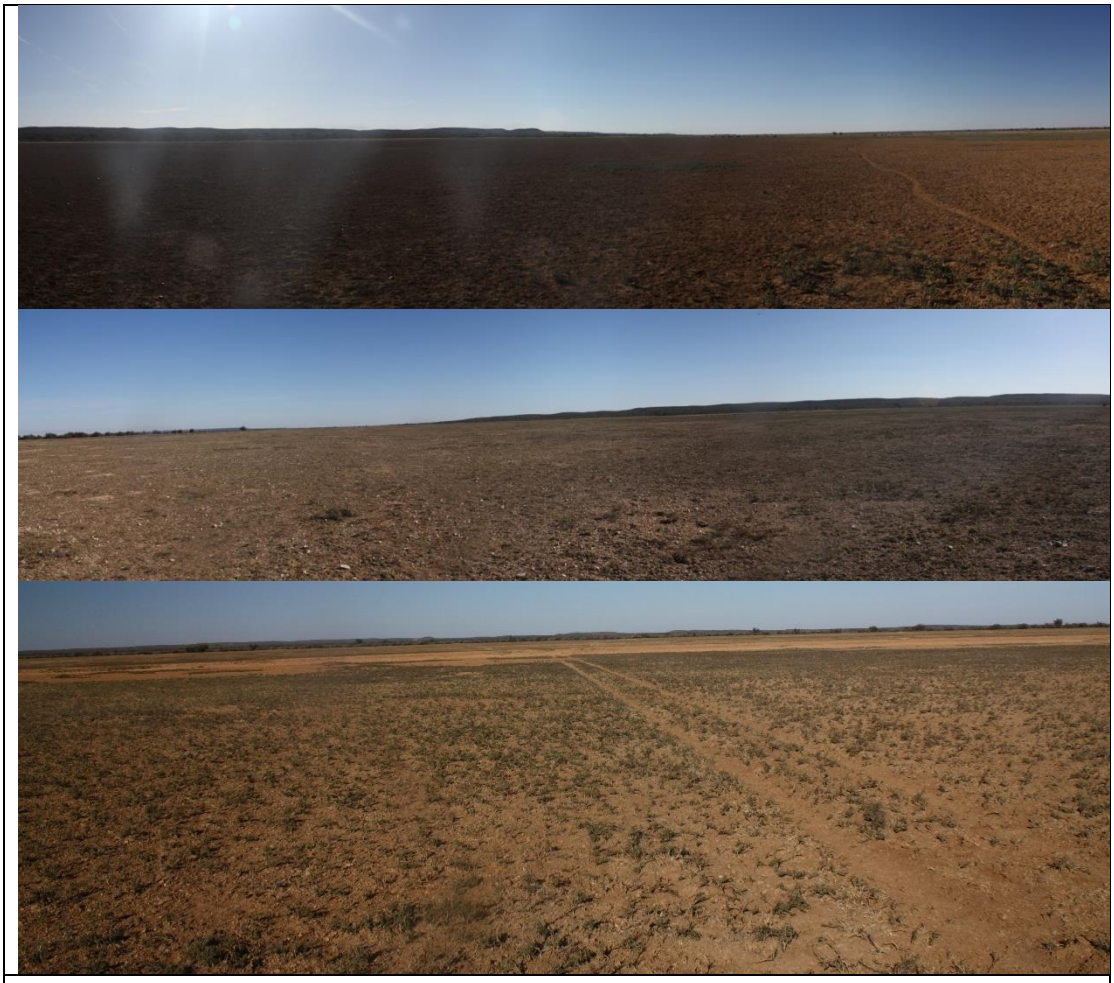
Description of watercourse:

Two large ephemeral pan systems occur in the south eastern portion of the study area and to the east of a prominent ridge. These pans have an ephemeral hydrological regime and will only contain surface water after exceptional rainfall events. These pans are very large and described in detail under section 4.3.4. The vegetation along the shore/floodplain of the pan consists of a karroid type vegetation dominated by dwarf grasses and -shrubs with geophytes and succulents present. The protected succulent, *Nananthus sp.,* is also present here. The pans themselves are devoid of vegetation within the central portions but with large portions, especially around the perimeter dominated by grasses or dwarf shrubs. The grass species such as *E. truncata, E. bicolor* and *S. ioclados* are diagnostic of pan habitats. Soil samples are variable but some samples have a definite grey matrix and wetland conditions must therefore be considered to be present. They are depression wetlands and due to their large size are also considered to be of high sensitivity and conservation value. The pans are being affected by high levels of overgrazing and trampling by game and vegetation composition indicates that this has a significant impact. Areas dominated by *Lycium pilifolium* indicate overgrazed areas.

Dominant plant species:

Drimia sp., Enneapogon desvauxii, Pentzia virides, Eragostis truncata, Eriospermum corymbosus, Oxalis sp., Oropetium capense, Nananthus sp., Lycium pilifolium, Eragrostis bicolor, Cynodon dactylon (FW), *Sporobolus ioclados*

Soil sample:



Watercourse name:	Coordinates of crossing:	Flow regime:
#6 Unnamed	S 28.663771°, E 24.165048°	Ephemeral drainage line

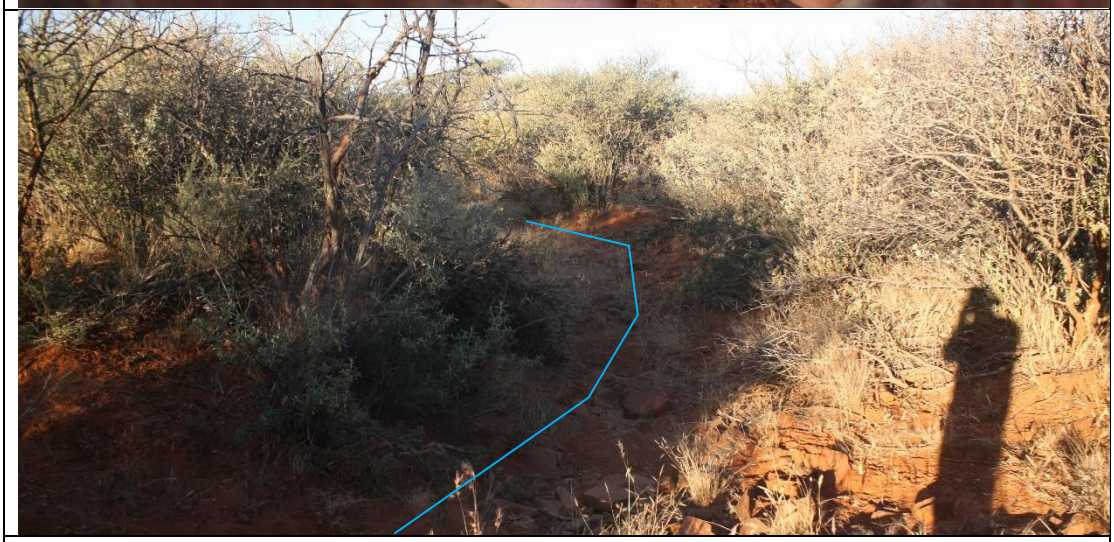
Description of watercourse:

A relatively small drainage line in the south eastern portion of the study area flowing into the Hoffman's Pan. The drainage line is representative of a series of drainage lines which drain from the rocky ridge to the west of the pan and feeds into this pan. The flow regime will undoubtedly be ephemeral though draining the rocky ridge it is likely to flow for very short periods (hours) after heavy rainfall. These drainage lines are all of short length and drain from the crest of the ridge toward the east and into the pan. They have a distinct main channel with a significant slope. The bed and banks of these drainage lines are dominated by red, sandy soils but with a matrix of large rocks. A high percentage surface rock is also present. Vegetation along the drainage line is of terrestrial composition without any riparian species. This is most likely due to high velocity discharge, small size and therefore limited moisture retention. Despite this the clear main channel confirm the presence of a watercourse. Soil samples also confirm the absence of any wetland conditions. None of these drainage lines are affected by any significant impacts. Some crossings by dirt tracks do cause erosion of the watercourses but not to a high degree.

Dominant plant species:

Eragrostis lehmanniana, Eragrostis obutsa, Chloris virgata, Aristida congesta, Enneapogon cenchroides, Tarchonanthus camphoratus, Lantana rugosa, Cenchrus ciliaris

Soil sample:



Watercourse name:	Coordinates of crossing:	Flow regime:
#7 Unnamed	S 28.642075°, E 24.168717°	Ephemeral drainage line

Description of watercourse:

A relatively small drainage line in the south eastern portion of the study area flowing into the pan to the north of Hoffman's Pan. The drainage line is representative of a series of drainage lines which drain from the rocky ridge to the west of the pan and feeds into this pan. The flow regime will undoubtedly be ephemeral though draining the rocky ridge it is likely to flow for very short periods (hours) after heavy rainfall. These drainage lines are all of short length and drain from the interior of the ridge toward the east and into the pan. They have a distinct main channel with a significant slope. The bed and banks of these drainage lines are dominated by red, sandy soils but with a matrix of large rocks. A high percentage surface rock is also present. Vegetation along the drainage line is of terrestrial composition without any riparian species. This is most likely due to high velocity discharge, small size and therefore limited moisture retention. Despite this the clear main channel confirm the presence of a watercourse. Soil samples also confirm the absence of any wetland conditions. None of these drainage lines are affected by any significant impacts. Some crossings by dirt tracks do cause erosion of the watercourses but not to a high degree.

Dominant plant species:

Senegalia mellifera, Chloris virgata, Aristida congesta, Tarchonanthus camphoratus, Eragrostis lehmanniana, Pentzia incana, Enneapogon cenchroides, Boscia albitrunca

Soil sample:

Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#8 Unnamed	S 28.665490°, E 24.082655°	Ephemeral Drainage Line

Description of watercourse:

A relatively small drainage line along the western border of the study area which flows into the Vaal River. It drains from an exceedingly rocky ridge into a shallow valley and into the river. It is of relatively short length and drains from south to north and into the river. The flow regime will undoubtedly be ephemeral though draining the rocky ridge it is likely to flow for very short periods (hours) after heavy rainfall. A distinct main channel is present with a significant slope. The bed is dominated by gravel with a high percentage surface rock and bedrock also outcropping in areas. Vegetation along the drainage line is of terrestrial composition without any riparian species. This is most likely due to high velocity discharge, small size and therefore limited moisture retention. Despite this the clear main channel confirm the presence of a watercourse. Soil samples also confirm the absence of any wetland conditions. It is not currently affected by any significant impact.

Dominant plant species:

Senegalia mellifera, Eragrostis lehmanniana, Heteropogon contortus, Ehretia rigida, Aristida diffusa, Ennepogon cenchroides, Asparagus larcinus, Olea europaea subsp. *africana, Grewia flava*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#9 Unnamed	S 28.659735°, E 24.084015°	Ephemeral drainage line

Description of watercourse:

A relatively small drainage line in close proximity and to the north of #8 Drainage Line which also drains into the Vaal River. This drainage line was however surveyed in closer proximity to the Vaal River and contains a more significant floodplain and alluvial deposits. It also drains an exceedingly rocky ridge. It is of relatively short length and drains from south to north and into the river. The flow regime will undoubtedly be ephemeral though draining the rocky ridge it is likely to flow for very short periods (hours) after heavy rainfall. Furthermore, the alluvial floodplain portion is expected to retain moisture for longer periods. A distinct main channel is

present and some natural erosion occurs in the alluvial floodplain with a relatively low slope gradient at this point. The bed is dominated by gravel without any significant surface rock. Vegetation at this point contains a significant riparian composition. This is most likely as discussed above due to the alluvial floodplain and longer retention of moisture. Vegetation and soil however indicate the absence of wetland condition though it must clearly be regarded as a watercourse. It is being crossed by a relatively large gravel road which will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime. Disturbance is also confirmed by the presence of some exotic weeds.

Dominant plant species:
*Chloris virgata, Aristida congesta, Enneapogon cenchroides, Eragrostis lehmanniana, *Argemone ochroleuca, Ziziphus mucronata, Diospyros lycioides*

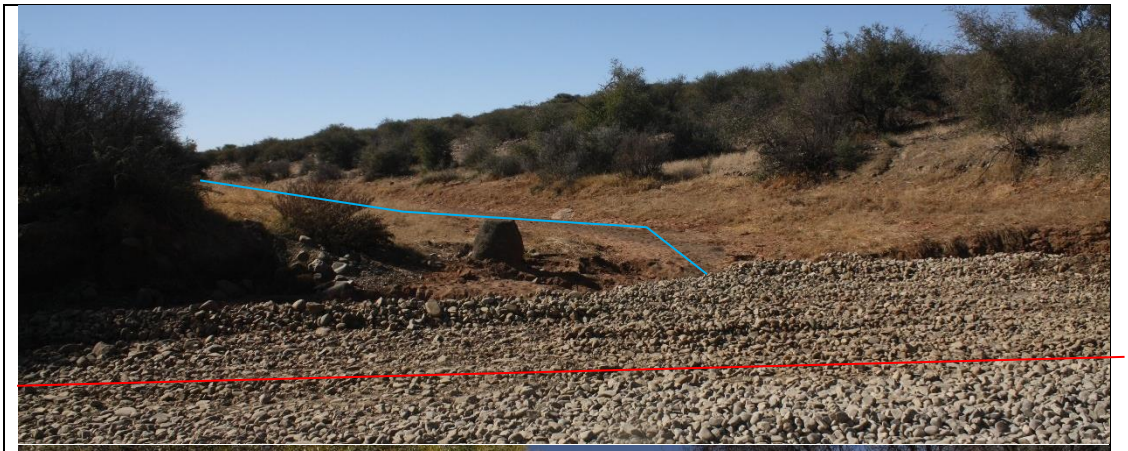
Soil sample:

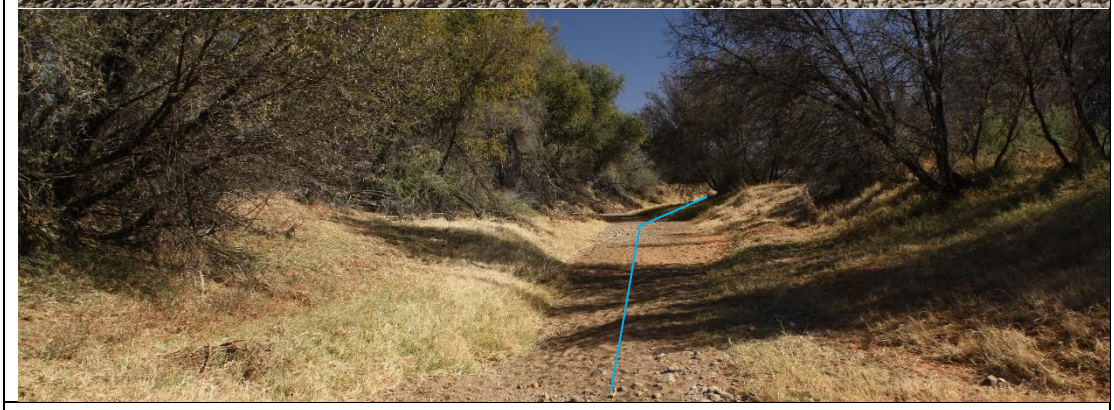
Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#10 Unnamed	S 28.654967°, E 24.088345°	Seasonal stream

Description of watercourse:
One of the largest streams in the study area draining a portion of the central rocky terrain. The point of the survey was near its confluence with the Vaal River. Two subsequent survey points higher upstream in this stream was also done and included as survey points #11 and #12. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. This is confirmed by a high moisture even during the dry period of the study. The stream generally flows from east to west and into the Vaal River and consists of several smaller tributaries conferencing into this significant stream. The catchment is largely rocky, uneven terrain. It contains a large and clearly defined main channel with gravel/sandy bed and round stream rocks. Vegetation along the stream is clearly of riparian composition though obligate wetland vegetation is absent. The riparian grass, *Cynodon dactylon*, does indicate elevated moisture levels. Soils consist of gravel/sand though some feint mottling is present indicating at least a temporary zone of wetness. Consequently wetland conditions are regarded as present. The stream is natural without any significant impacts although crossing by a large gravel road will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime. Disturbance is also confirmed by the presence of some exotic weeds.

Dominant plant species:
**Argemone ochroleuca, *Xanthium spinosum, Moraea pallida, Setaria verticillata, Cynodon dactylon* (FW), *Chloris virgata, Searsia lancea, Ziziphus mucronata, Eragrostis lehmannniana, Vachellia karroo*

Soil sample:





Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#11 Unnamed	S 28.663899°, E 24.134726°	Seasonal Stream

Description of watercourse:

An upstream section of #10 Seasonal Stream to the east of #10 in the foothills of the stream and within a rockier area. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. The flow volumes will however be much lower as compared to #10 and moisture content lower. The section also flows from east to west. A large and clearly defined main channel is also present with gravel/sandy bed and round stream rocks. Vegetation along the stream is mostly of terrestrial species composition though abundant riparian species are also present. Obligate wetland vegetation is absent. Soils consist of gravel/sand without any indictors of wetland conditions. The stream is natural without any significant impacts though crossing by a small dirt track will act as flow barrier and contribute to erosion within the stream.

Dominant plant species:

Cymbopogon pospischillii, Tarchonanthus camphoratus, Senegalia mellifera, Boscia albitrunca, Diospyros lycioides, Eragrostis lehmanniana, Chloris virgata, Eragrostis rotifer

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#12 Unnamed	S 28.641931°, E 24.137384°	Seasonal Stream

Description of watercourse:

A section within the upper reach of #10 Seasonal Stream to the east of #11 near the origin of the stream and situated in the rocky, uneven, mountainous terrain in the study area. The flow regime here will be ephemeral and will flow for very short periods after heavy rainfall events. The flow volume will be low and only as a result of tributaries and accumulated runoff will the downstream section attain a seasonal nature. The section flows from north to south. A small but clearly defined main channel is present with a sandy soil and very high rock content. Vegetation along the watercourse is exclusively of terrestrial composition without any riparian or wetland species. This is also due to high velocity runoff and low volumes which decrease the retention of moisture. Soils consist of red sand without any indictors of wetland conditions. The stream is without any visible impacts.

Dominant plant species:

Senegalia mellifera, Tarchonanthus camphoratus, Eragrostis lehmanniana, Aristida congesta

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#13 Unnamed	S 28.627865°, E 24.101653°	Ephemeral stream

Description of watercourse:

A large and significant stream draining part of the rocky, uneven terrain in the central portion of the study area. The point of survey was in the downstream portion of the stream. The flow regime is considered as ephemeral. It is evident that short periods of flow must occur annually during the rainy season though not enough to be considered a seasonal system. The stream flows from east to west and into the Vaal River and consists of several smaller tributaries which confluence with this significant stream. The catchment is largely rocky, uneven terrain. It contains a large and clearly defined main channel with gravel/sandy bed and round stream rocks. Vegetation along the stream is clearly of riparian composition with some Facultative Wetland species present. This indicates that a temporary zone of wetness wetland conditions may be present but is however not confirmed by soil samples. Soil consists of red sand without a grey matrix or mottling. The presence of wetland conditions can therefore not be confirmed although plant species indicate that a temporary zone of wetness may be present. The stream is natural without any significant impacts although crossing by a large gravel road will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime.

Dominant plant species:

Ziziphus mucronata, Eragrostis rotifer, Panicum coloratum (FW), *Cenchrus ciliaris, Searsia lancea*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#14 Unnamed	S 28.623914°, E 24.109690°	Seasonal stream

Description of watercourse:

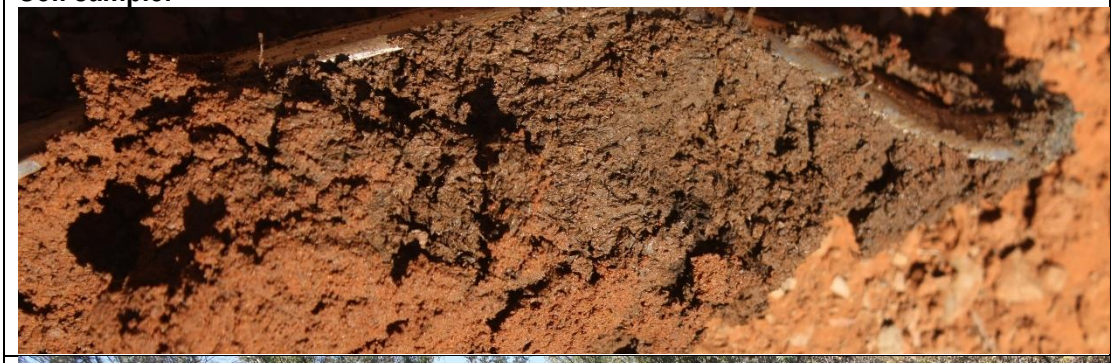
A large stream draining a portion of the central, uneven, rocky terrain. The point of the survey was near its confluence with the Vaal River. One other survey point upstream near the origin of the stream was also surveyed and included in survey point #15. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. This is confirmed by a high moisture content even during the dry period of the study. The stream generally flows from the north east to the south west and into the Vaal River and consists of several smaller tributaries which confluence with this significant stream. The catchment is largely rocky, uneven terrain. It contains a large and clearly defined main channel with a sandy and very rocky bed. The main channel is subjected to significant levels of scouring by floodwaters and consequently the vegetation layer is absent or sparse. The banks are however lined with a dense riparian tree thicket. Obligate wetland vegetation is absent.

The riparian grass, *Cynodon dactylon*, does indicate elevated moisture levels. Soil samples contained a high moisture level, a grey matrix and some mottling. Consequently wetland conditions are regarded as present. The stream is natural without any significant impacts although crossing by a large gravel road will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime.

Dominant plant species:

Cynodon dactylon (FW), *Searsia lancea, Vachellia mellifera, Diospyros lycioides, Ziziphus mucronata*

Soil sample:



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#15 Unnamed	S 28.620579°, 24.123743°	Seasonal stream

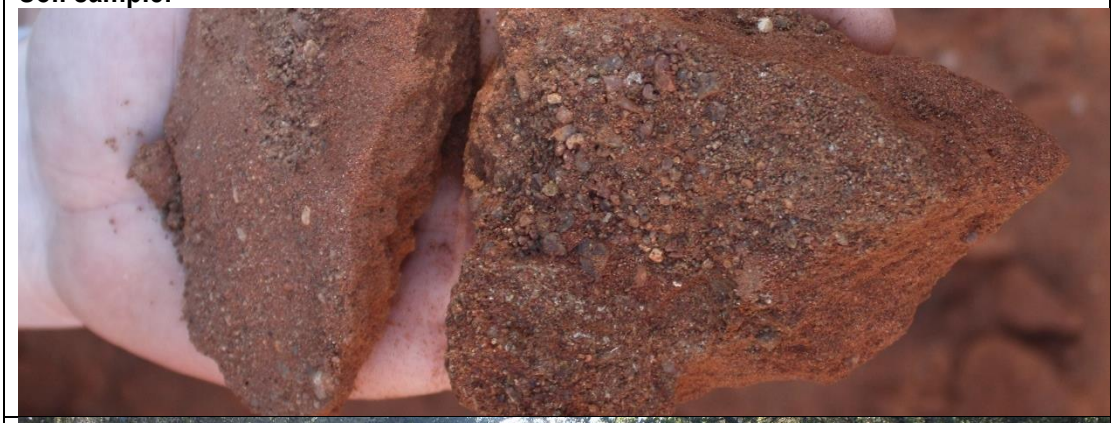
Description of watercourse:

An upstream section of #14 Seasonal Stream to the north east of #14 in the upper reaches within the uneven rocky, mountainous terrain. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. The flow volumes will however much lower as compared to #14 and moisture content lower. The section also flows from north east to south west. A large and clearly defined main channel is also present with gravel/sandy bed but without significant rocky surface coverage. Vegetation along the stream is mostly of terrestrial species composition though abundant riparian species are also present. Obligate wetland vegetation is absent. Soils consist of gravel/sand without any indictors of wetland conditions. The stream is natural without any significant impacts.

Dominant plant species:

Tarchonanthus camphoratus, Senegalia mellifera, Ziziphus mucronata, Panicum coloratum (FW), *Cenchrus ciliaris, Aristida congesta, Eragrostis obtusa, Pavonia burchellii*

Soil sample:



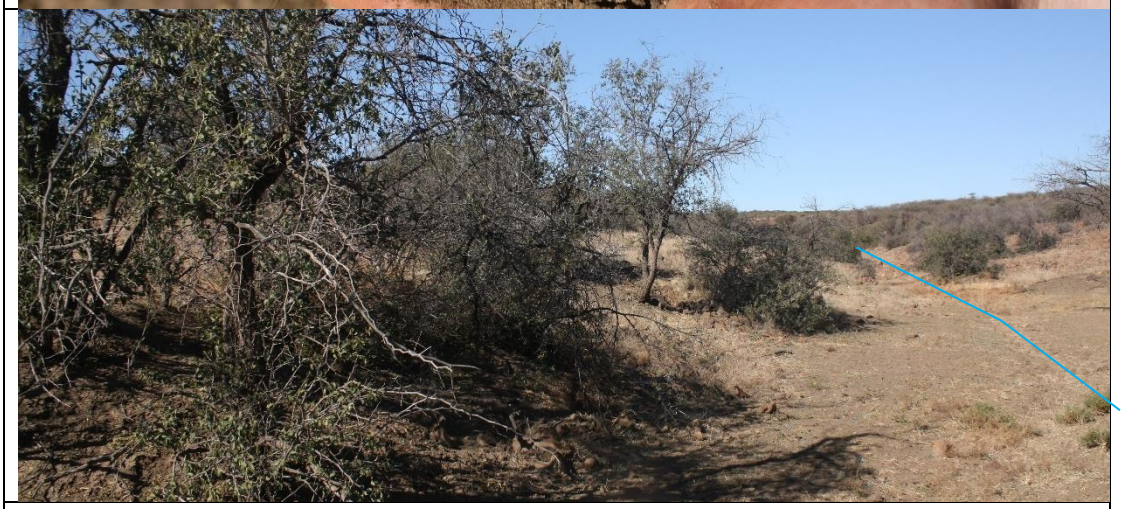
Watercourse name:	Coordinates of crossing:	Flow regime:

#16 Unnamed	S 28.617265°, E 24.107079°	Ephemeral Drainage Line

Description of watercourse:
A relatively small drainage line in close proximity and to the north of #14 Seasonal Stream which also drains into the Vaal River. This drainage line is however of relatively short length and was surveyed in close proximity to its confluence with the Vaal River. It contains an alluvial fan and significant floodplain this close to the river. It also drains an exceedingly rocky area of the central portion of the study area although the catchment is relatively small. It is of relatively short length and drains from east to west and into the river. The flow regime will undoubtedly be ephemeral though draining the rocky ridge it is likely to flow for very short periods (hours) after heavy rainfall. Furthermore, the alluvial floodplain portion is expected to retain moisture for longer periods. A distinct main channel is present and some natural erosion occurs in the alluvial floodplain with a relatively low slope gradient at this point. The bed is dominated by clayey silt sediment without any significant surface rock. Vegetation at this point contains a significant riparian composition. This is most likely as discussed above due to the alluvial floodplain and longer retention of moisture. Vegetation and soil however indicate the absence of wetland conditions though it must clearly be regarded as a watercourse. It is being crossed by a small dirt track which will have a limited impact as a flow barrier.

Dominant plant species:
Pentzia incana, Cynodon dactylon (FW), *Ziziphus mucronata, Chloris virgata, *Xanthium spinosum, *Schkuhria pinata*

Soil sample:



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#17 Unnamed	S 28.611020°, E 24.114478°	Ephemeral drainage line

Description of watercourse:
A relatively small drainage line along the western border of the study area which flows into the Vaal River. It drains from an exceedingly rocky area of the central portion of the study area

although the catchment is relatively small. It flows through a shallow valley from east to west and into the Vaal River. It is a relatively short drainage line and taken as representative of adjacent similar drainage lines. The flow regime will undoubtedly be ephemeral though draining the rocky portion it is likely to flow for very short periods (hours) after heavy rainfall. A distinct main channel is present and the bed is dominated by sand with a few round stream rocks scattered. Vegetation consists mostly of terrestrial species though riparian trees are present. This is most likely due to high velocity discharge, small size and therefore limited moisture retention. Despite this the clear main channel confirm the presence of a watercourse. Soil samples also confirm the absence of any wetland conditions. It is being crossed by a small dirt track which will have a limited impact as a flow barrier.

Dominant plant species:
Vachellia tortilis, Grewia flava, Ehretia rigida, FIngerhuthia africana, Ziziphus mucronata, Enneapogon cenchroides, Eragrostis lehmanniana

Soil sample:

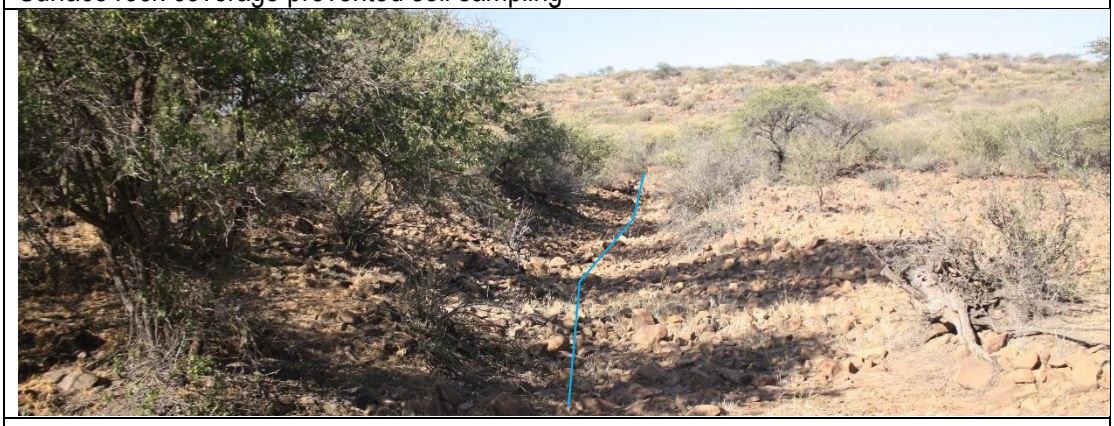
Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#18 Unnamed	S 28.602290°, E 24.120241°	Ephemeral drainage line

Description of watercourse:
A relatively small drainage line along the western border of the study area and to the north and in close proximity to #17 Ephemeral Drainage Line and very similar in all respects. It flows through a shallow valley from east to west and into the Vaal River. It is a relatively short drainage line and taken as representative of adjacent similar drainage lines to the north. The

flow regime will undoubtedly be ephemeral though draining the rocky portion it is likely to flow for very short periods (hours) after heavy rainfall. A distinct main channel is present and the bed is dominated by sand with a very high percentage rock coverage which also prevented soil sampling. Vegetation is dominated by terrestrial species though several riparian species are present indicating a higher moisture regime. Vegetation however indicate the absence of wetland condition though it must clearly be regarded as a watercourse. It is being crossed by a small dirt track which will have a limited impact as a flow barrier.

Dominant plant species:
Ziziphus mucronata, Vachellia tortilis, Panicum coloratum (FW), *Cynodon dactylon* (FW), *Eragrostis lehmanniana*

Soil sample:
Surface rock coverage prevented soil sampling



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#19 Unnamed	S 28.581448°, E 24.141855°	Ephemeral Drainage Line

Description of watercourse:
A relatively small drainage line along the western border of the study area and to the north of #17 and #18 Ephemeral Drainage Lines and very similar to them in most respects. It flows through a shallow valley from east to west and into the Vaal River. It is a relatively short drainage line and taken as representative of adjacent similar drainage lines adjacent to it. The flow regime will undoubtedly be ephemeral though draining the rocky portion it is likely to flow for very short periods (hours) after heavy rainfall. A distinct main channel is present and the bed is dominated by gravel/sand with a very high percentage rock coverage. Vegetation is dominated by terrestrial species though several riparian species are present indicating a higher moisture regime. Vegetation and soil however indicate the absence of wetland condition though it must clearly be regarded as a watercourse. It is being crossed by a small dirt track which will have a limited impact as a flow barrier.

Dominant plant species:
Ziziphus mucronata, Panicum coloratum (FW), *Vachellia tortilis*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#20 Unnamed	S 28.576840°, E 24.147116°	Ephemeral drainage line

Description of watercourse:

A relatively small drainage line along the western border of the study area and to the north of #19 Ephemeral Drainage Line and very similar to it in most respects. It flows through a shallow valley from east to west and into the Vaal River. It is a relatively short drainage line and taken as representative of adjacent similar drainage lines adjacent to it. The flow regime will undoubtedly be ephemeral though draining the rocky portion it is likely to flow for very short periods (hours) after heavy rainfall. The point of survey was taken near its confluence with the Vaal River and consequently the main channel is dominated by sand and without any visible surface rock. Vegetation this close to the river is dominated by riparian thicket which indicate a higher moisture regime. Vegetation and soil however indicate the absence of wetland condition though it must clearly be regarded as a watercourse. It is being crossed by a small dirt track which will have a limited impact as a flow barrier.

Dominant plant species:

Ziziphus mucronata, Diospyros lycioides, Searsia lancea, Panicum coloratum (FW), *Sporobolus ioclados, Decliptera leistneri, Setaria verticillata, Lycium arenicola*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#21 Unnamed	S 28.562657°, E 24.164046°	Ephemeral stream

Description of watercourse:

A large and significant stream draining a portion of the north eastern rocky, uneven terrain in the central portion of the study area. The point of survey was in the downstream portion of the stream near its confluence with the Vaal River. The flow regime is considered as ephemeral. It is evident that short periods of flow must occur annually during the rainy season though not enough to be considered a seasonal system. The stream flows from south to north and into the Vaal River and consists of several smaller tributaries which confluence with this significant stream. The catchment is largely rocky, uneven terrain. It contains a clearly defined main channel with a red sandy bed and without any visible surface rocks. Vegetation along the stream is clearly of riparian composition with some Facultative Wetland species present. This indicates that a temporary zone of wetness wetland conditions may be present but is however not confirmed by soil samples. Soil consists of red sand without a grey matrix or mottling. The presence of wetland conditions can therefore not be confirmed although plant species indicate that a temporary zone of wetness may be present. The stream is natural without any significant impacts although crossing by a dirt road will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime. This is also confirmed by the presence of a few exotic weeds.

Dominant plant species:

Vachellia karroo, Searsia lancea, Diospyros lycioides, Cynodon dactylon (FW), *Eragrostis cilianensis, Eragrostis lehmanniana, *Argemone chroleuca, Setaria verticillata, Lycium arenicola, *Bidens bippinata, Panicum coloratum* (FW), **Xanthium spinosum, Lycium hirsutum*

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#22 Unnamed	S 28.574933°, E 24.185421°	Seasonal stream

Description of watercourse:

Probably the largest stream in the study area with the largest catchment area draining a portion of the central rocky terrain but with the majority of the catchment in the plains portion in the north east of the study area. The point of this survey was in the downstream section near its confluence with the Vaal River. Several upstream survey points in this stream was also done and included in subsequent survey point #23 to #28. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. This is confirmed by a high moisture content even during the dry period of the study. The stream drains a large area but generally flows from south east to north west and into the Vaal River and consists of several smaller tributaries which confluence with this significant stream. At the point of the survey the streams main channel broadens and a main channel is largely absent and consists of a clayey substrate without any visible surface rocks. The vegetation is dominated by hygrophilous grasses and sedges with many being Obligate Wetland species. The fringe of the area also contain riparian tree species. Soils consists of clayey sediment with a visible grey matrix and feint mottling considered indicative of a seasonal zone of wetness. Consequently wetland conditions are regarded as present. The stream is natural without any significant impacts although crossing by a dirt road will impact it in terms of flow and flooding retardation and consequent alteration of the flow regime.

Dominant plant species:

Cynodon dactylonl (FW), *Panicum coloratum* (FW), *Scirpus dioecus* (OW), *Cyperus longus* (OW), *Cymbopogon pospischillii, Eragrostis lehmanniana, Aristida congesta, Eragrostis obtusa*

Soil sample:

Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#23 Unnamed	S 28.580940°, E 24.191529°	Small ephemeral pan

Description of watercourse:

A small ephemeral pan situated adjacent and to the south of #22 Seasonal Stream. The pan is considered to have an ephemeral hydrological regime and will only contain surface water after exceptional rainfall events. The pan is one of the smaller systems in the study area and has a diameter of approximately 160 m. No in- or outflow could be observed. The pan is flat bottomed, situated in a plain and vegetation is dominated by a fringe of riparian trees and a short grass layer in the interior of the pan. The pan is also taken as representative of another small and very similar pan adjacent to it. The vegetation in the pan contain Obligate Wetland species and indicate definite wetland conditions even though only of temporary wetness. Soil

samples contain a high clay content though a grey matrix or mottling was not evident at the time of sampling. The wetland conditions are considered present though of temporary zone of wetness. The small pan is not currently subjected to any significant impacts.

Dominant plant species:

**Schkuhria pinata, Eragrostis bicolor, Lotononis sp., Alternanthera sessilis* (OW), *Chloris virgata, Eragrostis obtusa, Cynodon dactylon* (FW)

Soil sample:

Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#24 Unnamed	S 28.598102°, E 24.185136°	Seasonal stream

Description of watercourse:

A site taken some distance upstream of #22 Seasonal Stream adjacent to the low quartzite ridge and forming a unique wetland area. It is adjacent to two other similar wetland areas in the stream and also taken as representative of these. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. This is confirmed by a high moisture content even during the dry period of the study. The portion of the stream at the site is also being fed by runoff and seepage from the quartzite ridge, in addition to the main channel flow. A depression has formed here and a main channel is largely absent and indistinct and consists of a clayey substrate without any visible surface rocks. The vegetation is dominated by hygrophilous grasses and sedges with many being Obligate Wetland species. Soils consists of clayey sediment with a visible grey matrix and feint mottling considered indicative of a seasonal zone of wetness. Consequently wetland conditions are regarded as present. The stream is natural without any significant impacts near this survey point although game utilising this area as water source leads to high levels of trampling.

Dominant plant species:

**Verbena oficinalis, *Gomphrena celosioides, Alternanthera sessilis* (OW), *Leptochloa fusca, Schoenoplectus muricunix* (OW)*, *Xanthium spinosum, Persicaria lapathifolia* (OW)

Soil sample:

Watercourse name:	Coordinates of crossing:	Flow regime:
#25 Unnamed	S 28.604928°, E 24.181572°	Seasonal stream

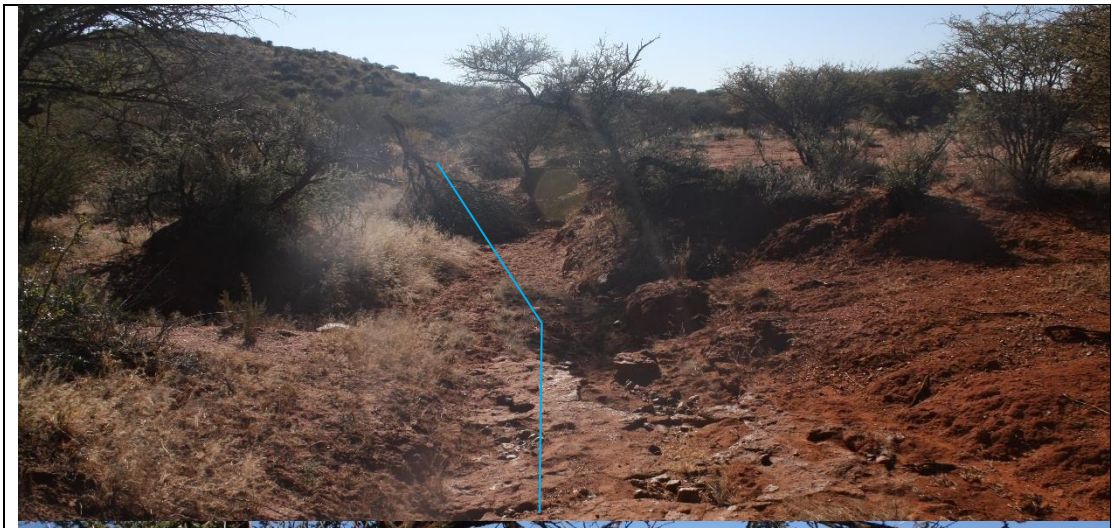
Description of watercourse:

An upstream section of #22 Seasonal Stream in the southern rocky, uneven terrain and draining this portion of the catchment. The flow regime is considered close to seasonal and will flow for short periods in the rainy season and on an annual basis. The flow volumes will however be much lower as compared to #22 and moisture content lower. The section flows from west to east. A large and clearly defined main channel is also present with gravel/sandy bed, without pronounced surface rock but with compacted sandy/clay bed. Vegetation along the stream is mostly of terrestrial species composition though abundant riparian species are also present. Obligate wetland vegetation is absent. Soils consist of gravel/sand without any indictors of wetland conditions. The stream is natural without any significant impacts though crossing by a small dirt track will act as flow barrier and contribute to erosion within the stream.

Dominant plant species:

Aristida congesta, Ziziphus mucronata, Cadaba aphylla, Eragrostis rotifer, Panicum coloratum (FW), *Vachellia tortillis*

Soil sample:



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#26 Boesmanfontein	S 28.598147°, E 24.215126°	Artesian fountain

Description of watercourse:
A very unique natural artesian fountain situated in close proximity and associated with #22 Seasonal Stream. Systems such as this is exceptionally rare and considered highly unique. The fountain originates within a quartzite outcrop and flows down a gentle slope into a small natural rocky depression from where it overflows to the south into a sandy area. A more comprehensive description of this system can be found in section 4.3.4. Soils sampling is not possible due to the bedrock nature of the fountain. However, due to its perennial nature obligate wetland vegetation has become established around the fountain and clearly indicate the presence of wetland conditions. It is not currently subjected to any significant impacts although some trampling by game occurs and would cause some impacts on the fountain.

Dominant plant species:
Kalanchoe rotundifolia, Sporobolus ioclados, Gomphrena celosioides, Chloris virgata, Cynodon dactylon (FW), *Setaria verticillata, Schoenoplectus muricunix* (OW)

Soil sample:
Surface rock coverage prevented soil sampling

Watercourse name:	Coordinates of crossing:	Flow regime:
#27 Unnamed	S 28.603473°, E 24.196949°	Small ephemeral pan

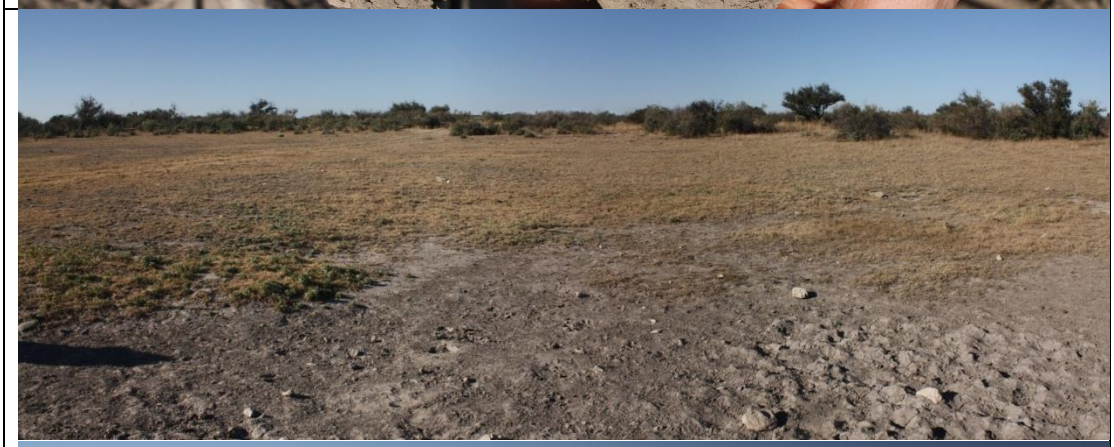
Description of watercourse:

A small ephemeral pan situated adjacent and along the southern reach of #22 Seasonal Stream. The pan is considered to have an ephemeral hydrological regime and will only contain surface water after exceptional rainfall events. The pan is one of the smaller systems in the study area and has a diameter of approximately 120 m. No in- or outflow could be observed. The pan is flat bottomed, situated in a plain and vegetation is dominated by a fringe of riparian trees and a short grass layer in the interior of the pan. The vegetation in the pan contain Obligate Wetland species and indicate definite wetland conditions even though only of temporary wetness. Soil samples contain a high clay content though a grey matrix or mottling was not evident at the time of sampling. The wetland conditions are considered present though of temporary zone of wetness. The small pan is not currently subjected to any significant impacts though a dirt road does cross it but is anticipated to have a limited impact on infiltration and hydrology.

Dominant plant species:

Cynodon dactylon (FW), *Ziziphus mucronata, Stachys sp., Schoenoplectus muricunix* (OW), *Eragrostis echinochloidea, Eragrostis lehmanniana, Eragrostis bicolor*

Soil sample:



Watercourse name:	Coordinates of crossing:	Flow regime:
#28 Unnamed	S 28.623321°, E 24.214683°	Large ephemeral pan

Description of watercourse:

A relatively large, elongated pan situated at the origin of #22 Seasonal Stream. The pan is considered to have an ephemeral hydrological regime and will only contain surface water after exceptional rainfall events. The pan is relatively large with a length of approximately 800 m. It contains an obscure outflow which is not readily distinguishable and forms part of #22 Seasonal Stream. The pan is flat bottomed, situated in a plain and vegetation is dominated by a fringe of riparian trees and a short grass layer in the interior of the pan. The vegetation in the pan contain Obligate Wetland species and indicate definite wetland conditions even though only of temporary wetness. Soil samples contain a high clay content though a grey matrix or mottling was not evident at the time of sampling. The wetland conditions are considered present though of temporary zone of wetness. The pan is not currently subjected to any significant impacts.

Dominant plant species:
Alternanther sessilis (OW), **Alternanthera pungens, Cynodon dactylon* (FW), *Chloris virgata, Osteospermum muricatum, Solanum incanum, Pentzia incana*

Soil sample:

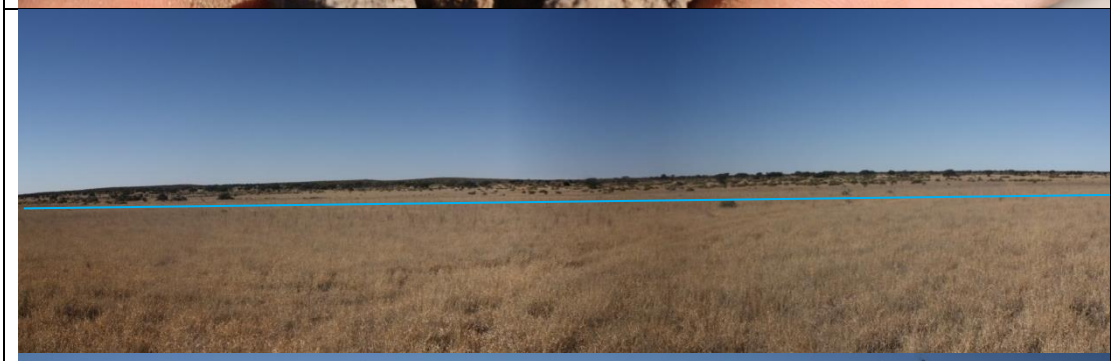
Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#29 Unnamed	S 28.559741°, E 24.219504°	Ephemeral stream

Description of watercourse:
A large and significant stream along the northern border of the study area. The flow regime of the stream will undoubtedly be of ephemeral nature. It is situated in the sandy northern portion of the study area. Due to the sandy soils the stream does not contain a very well defined main channel and surface flow will infiltrate into the soil quickly decreasing the likelihood of surface water. It is highly likely that subterranean flow may occur. The area where the stream was surveyed contains an area where the subsoil is exposed and illustrates the presence of a flow pattern. Therefore, although a distinct main channel is absent and it is not easily distinguished it must still be considered a watercourse. Several other drainage lines in close proximity also functions in this manner and this stream is taken as representative of these. The stream flows from east to west and into the Vaal River. The catchment is dominated by relatively flat, sandy plains without any visible surface rock. Vegetation along the stream is not easily identified as being riparian although the presence of the riparian tree, *Ziziphus mucronata*, and grass, *Cynodon dactylon*, does indicate elevated moisture levels. Soils at the sampling point

consisted of sandy clay though over the majority of the stream this will be exclusively sandy in the upper soil layers. Wetland conditions are therefore absent. The stream is natural without any significant impacts although trampling by game at the sampling site does impact it to some extent.

Dominant plant species:
Ziziphus mucronata, Cyndon dactylon (FW), *Lotononis sp., *Xanthium spinosum, Vachellia tortilis*

Soil sample:



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#30 Vaal River	S 28.534646°, E 24.187546°	Perennial lowland river

Description of watercourse:
This is the northernmost and furthest upstream sample of the Vaal River in the study area. The river forms the western border of the study area and flows from north east to south west.

The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. The banks of the river is relatively narrow and steep here as is the case along the majority of the river section in the study area. A dense and substantial riparian thicket is also present in the upper zone. Vegetation along the river bank is dominated by a dense riparian thicket in the upper zone. The lower zone consists of a very steep slope, over a short distance and dominated by a short grass layer. The marginal zone is also of a very small extent and exceedingly steep, dominated by a few hygrophilous grasses and sedges. Wetland conditions seems to be confined to the marginal zone and lower portion of the lower zone.

However, associated with the floodplain in this area is two distinct backwater areas. These are represented by two separate, longitudinal systems situated parallel to the river and in close proximity to it (approximately 300 meters) and within the floodplain. The southern system is isolated and has no defined in- or outflow while the northern system has no inflow but a defined outflow into the Vaal River is present at its southern tip. The vegetation is dominated by a grass layer with the dwarf shrub, *Salsola rabieana*, also abundant. Trees and shrubs are largely absent. These areas contain a few Facultative- and one Obligate Wetland species. Soil samples also indicate a low grey matrix without distinctive mottling and is considered indicative of a temporary zone of wetness. These areas are still being considered as highly sensitive and especially the northern wetland area containing the outflow system. These areas still form part of the floodplain of the Vaal River and will play a vital role in terms of flooding and the functioning of the floodplain. They are also considered a more uncommon type of wetland system, further increasing their conservation value.

Dominant plant species:

Upper Zone: *Vachellia karroo, Ziziphus mucronata, Grewia flava, Lycium hirsutum, *Sphaeralcea bonariensis, Asparagus larcinus, Setaria verticillata, Lycium arenicola, Combretum erythrophyllum, Leonotis sp.*

Lower Zone: *Cynodon dactylon* (FW), **Phyla nodiflora, *Xanthium spinosum, *Schkuhria pinata*

Marginal Zone: *Hemarthria altissima* (OW), *Persicaria lapathifolia* (OW), **Bidens bipinnata, Salix mucronata, *Myriophyllum spicatum*

Backwater wetland areas: *Chloris virgata, Sporobolus ioclados, *Xanthium spinosum, Salsola rabieana, Eragrostis obtusa, Pentzia incana, Lycium cinerium, Ziziphus mucronata, Massonia jasminiflora, Lotononis sp., *Schkuhria pinata, Eragrostis bicolor, Gomphrena celosioides, Leptochloa fusca* (OW)

Soil sample:

Upper Zone

Lower Zone

Marginal Zone

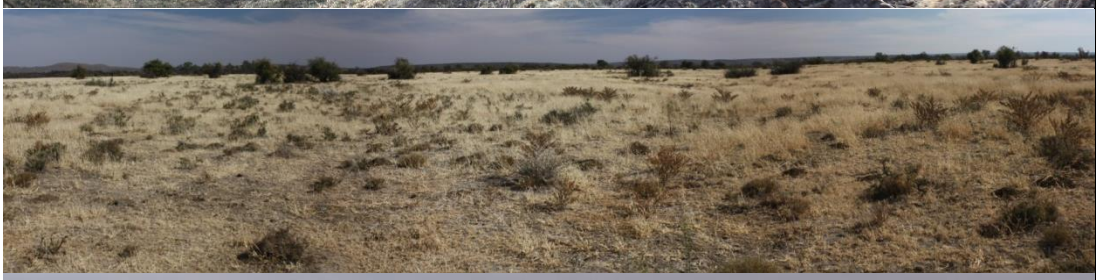
Backwater system

Upper Zone

Lower Zone

Marginal Zone

Backwater system



Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#31 Vaal River	S 28.561188°, E 24.161902°	Perennial lowland river

Description of watercourse:

A survey point at the Vaal River located to the south of #30 and at the confluence of #21 Seasonal Stream. As a consequence an alluvial fan has formed in the river. The river forms

the western border of the study area and flows from north east to south west. The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. As a result of the alluvial fan the banks of the river is much less steep with a gradual slope. As a result the riparian thicket associated with the upper zone is scattered and not as dense as most other areas. Riparian trees are however still present in the upper zone and absent in the lower zone which is dominated by a short grass layer. The slope of the lower zone is also much less steep. As a result of the gradual slope and the alluvial fan the marginal zone can also become much more extensive, dominated by hygrophilous grasses and sedges. Wetland conditions are still largely confined to the marginal zone and lower portion of the lower zone.

Dominant plant species:

Upper Zone: *Ziziphus mucronata, Setaria verticillata, Eragrostis rotifer, Maroaea pallida, Chloris virgata, Lycium arenicola, *Argemone ochroleuca, Eragrostis lehmanniana, Vachellia karroo, Pentzia incana, Grewia flava, Searsia lancea, *Alternanthera pungens, Pancum coloratum* (FW), *Lycium hirsutum, Asparagus larcinus*

Lower Zone: *Cynodon dactylon* (FW), *Eragrostis lehmanniana, *Phyla nodiflora, *Xanthium spinosum, *Schkuhria pinata, Chloris virgata, Cyperus marginatus* (OW), *Cirsium vulgare*

Marginal Zone: *Cyperus marginatus* (OW), *Hemarthria altissima* (OW), *Persicaria lapathifolia* (OW), *Lactuca sp., Salix mucronata, Cyperus longus* (OW), *Ludwigia adscendens, Berula erecta, *Myriophyllum spicatum*

Soil sample:

Upper Zone

Lower Zone (Upper limit)

Lower Zone (Lower limit)

Marginal Zone

Upper Zone

Lower Zone

Marginal Zone

Watercourse name:	**Coordinates of crossing:**	**Flow regime:**
#32 Vaal River	S 28.606331°, E 24.111787°	Perennial lowland river

Description of watercourse:

A survey point at the Vaal River located to the south of #31 and adjacent to the central, rocky portion of the study area. An extensive alluvial plain is also present in the floodplain of the river. This is most likely formed by sediment deposits formed by #17 and #18 Ephemeral Drainage lines as well as similar adjacent drainage lines. The river forms the western border of the study area and flows from north east to south west. The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. The alluvial plain is confined to the floodplain of the river without pronounced confluence/inflow into the Vaal River. Consequently the river bank is steep and not extensive with a floodplain dominated by alluvial sediments and large trees, mostly terrestrial species though many are riparian. A much denser riparian thicket occurs along the upper zone or banks of the river. Riparian trees are confined to the upper zone and absent in the lower zone which is dominated by a short grass layer. The majority of the marginal zone is relatively narrow and steep while a portion to the north of the site becomes more extensive as a result of alluvial deposits in the river. Dominant vegetation includes hygrophilous grasses and sedges. Wetland conditions are still largely confined to the marginal zone and lower portion of the lower zone.

Dominant plant species:

Upper Zone: *Vachellia karroo, *Alternanthera pungens, Lycium horridum, Vachellia tortilis, Searsia lancea, Ziziphus mucronata, Setaria verticillata, *Argemone ochroleuca, Asparagus larcinus, *Xanthium spinosum, *Bidens bipinnata, Combretum erythrophyllum, DIcliptera leistneri, Chenopodium album*

Lower Zone: *Phyla nodiflora, Vahlia capensis, Cynodon dactylon* (FW), **Cirsium vulgare, Arctotis arctotoides, Lactuca sp., Cyperus sexangularis* (OW)

Marginal Zone: *Phragmites australis* (OW), *Paspalum distichum* (OW), *Pseudoschoenus sp.* (OW), *Lactuca sp., Persicaria lapathifolia* (OW), *Cyperus marginatus* (OW), **Myriophyllum spuicatum,*

Alluvial floodplain: *Grewia flava, Vachellia tortilis, Salsola rabieana, Lycium arenicola, Chloris virgata, Pentzia incana, Pancum coloratum* (FW), *Pupalia lappacea, Asparagus suaveolens, Setaria verticillata, Lycium hirsutum, Atriplex semibaccata, *Achyranthes aspera, Sporobolus ioclados, Cynodon dactylon* (FW)

Soil sample:

Upper Zone

Lower Zone (Upper limit)

Lower Zone (Lower limit)

Marginal Zone

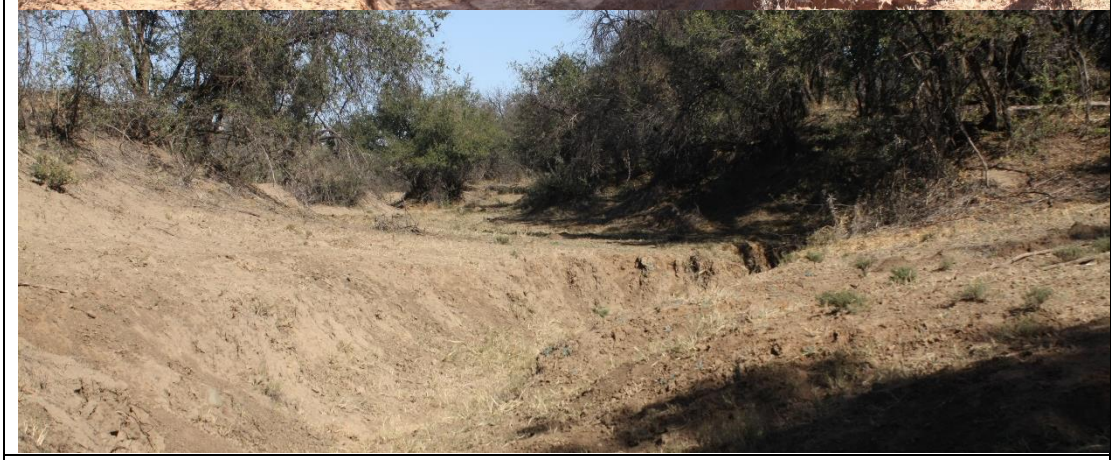
Alluvial floodplain

Upper Zone

Lower Zone

Marginal Zone

Alluvial floodplain



Watercourse name:	Coordinates of crossing:	Flow regime:

#33 Vaal River	S 28.617770°, E 24.104653°	Perennial lowland river

Description of watercourse:

A survey point located to the south of #32 and in relatively close proximity to it. The site is also located at the confluence of #16 Ephemeral Drainage Line with the Vaal River. The site is much similar to #31 Vaal River and it is evident that where smaller watercourses confluence with the river similar condition repeat themselves. As a consequence an alluvial fan has formed in the river. The river forms the western border of the study area and flows from north east to south west. The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. As a result of the alluvial fan the banks of the river is much less steep with a gradual slope. As a result the riparian thicket associated with the upper zone is scattered and not as dense as most other areas. Riparian trees are however still present in the upper zone and absent in the lower zone which is dominated by a short grass layer. *Crinum bulbispermum* (Orange River Lily), is a protected geophyte occurring in the lower zone. The slope of the lower zone is also much less steep. As a result of the gradual slope and the alluvial fan the marginal zone can also become much more extensive, dominated by hygrophilous grasses and sedges. Wetland conditions are still largely confined to the marginal zone and lower portion of the lower zone.

Dominant plant species:

Upper Zone: *Searsia lancea, Ziziphus mucronata, *Argemone ochroleuca, Aristida congesta, Tragus berteronianus, Phyla nodiflora, *Datura ferox, *Xanthium spinosum, *Parkinsonia aculeata*

Lower Zone: *Cynodon dactylon* (FW), **Phyla nodiflora, Vahlia capensis, *Schkuhria pinata, *Argemone ochroleuca, Moraea palida, Laggera decurens, *Ambrosia artemisiifolia, Arctotis arctotoides, *Datura stramonium, Nidorella resedifolia, Dicliptera leistneri, Crinum bulbispermum* (OW)

Marginal Zone: *Phragmites australis* (OW), *Lactuca sp., Cyperus longus* (OW), *Paspalum distichum* (OW), *Juncus exeretus* (OW), **Myriophyllum spicatum*

Soil sample:

Upper Zone

Lower Zone (Upper limit)

Lower Zone (Lower limit)

Marginal Zone

Lower and Upper Zone

Marginal Zone

Watercourse name:	Coordinates of crossing:	Flow regime:
#34 Vaal River	S 28.679114°, E 24.061169°	Perennial lowland river

Description of watercourse:
A survey point a considerable distance to the south of #33 and situated in the south western portion of the study area. The river forms the western border of the study area and flows from north to south. The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. The banks of the river is relatively narrow and steep here as is the case along the majority of the river section in the study area. A dense and substantial riparian thicket is also present in the upper zone. Vegetation along the river bank is dominated by a dense riparian thicket in the upper zone. The lower zone consists of a very steep slope, over a short distance and dominated by a short grass layer. The marginal zone is also of a very small extent and exceedingly steep, dominated by a few hygrophilous grasses and sedges. Wetland conditions seems to be confined to the marginal zone and lower portion of the lower zone.

Dominant plant species:
Upper Zone: *Vachellia karroo, Ziziphus mucronata, Diospyros lycioides, Combretum erythrophyllum, Lycium arenicola, Setaria verticillata, Dicliptera lestneri, *Bidens bipinnata, Atriplex semibaccatta, Lepidium sp., *Argemone ochroleuca, Panicum coloratum* (FW)

Lower Zone: *Cynodon dactylon* (FW), **Phyla nodiflora, *Xanthium spinosum, Salix mucronata, *Oenothera rosea*

Marginal Zone: *Hemarthria altissima* (OW), **Myriophyllum spicatum, *Nicotiana longituba, *Verbena bonariensis, Cyperus longus* (OW), *Phragmites australis* (OW)

Soil sample:

Upper Zone

Lower Zone (Upper limit)

Lower Zone (Lower limit)

Marginal Zone

Upper Zone

Lower and Marginal Zone

Watercourse name:	Coordinates of crossing:	Flow regime:
#34 Vaal River	S 28.693493°, E 24.067552°	Perennial lowland river

Description of watercourse:

A survey point a short distance to the south of #34, very similar in appearance to it and situated in the south western portion of the study area. The river forms the western border of the study area and flows from north to south. The flow regime is perennial with a much-altered flow and flooding regime as a result of upstream impacts on it. The banks of the river is relatively narrow and steep here as is the case along the majority of the river section in the study area. A dense and substantial riparian thicket is also present in the upper zone. Vegetation along the river bank is dominated by a dense riparian thicket in the upper zone. The lower zone consists of a very steep slope, over a short distance and dominated by a short grass layer. The marginal zone is also of a very small extent and exceedingly steep, dominated by a few hygrophilous grasses and sedges. Wetland conditions seems to be confined to the marginal zone and lower portion of the lower zone.

Dominant plant species:

Upper Zone: *Vachellia karroo, Ziziphus mucronata, Diospyros lycioides, Combretum erythrophyllum, Lycium arenicola, Setaria verticillata, Dicliptera lestneri, *Bidens bipinnata, Atriplex semibaccatta, *Argemone ochroleuca, *Sphaeralcea bonariensis, Moraea palida, Sporobolus ioclados*

Lower Zone: *Cynodon dactylon* (FW), **Phyla nodiflora, *Sphaeralcea bonariensis, Panicum coloratum* (FW)

Marginal Zone: *Phragmites australis* (OW), **Myriophyllum spicatum, *Oenothera rosea, Hemarthria altissima* (OW), *Cyperus longus* (OW), *Cyperus marginatus* (OW), *Nidorella resedifolia, *Cirsium vulgare*

Soil sample:

Upper Zone

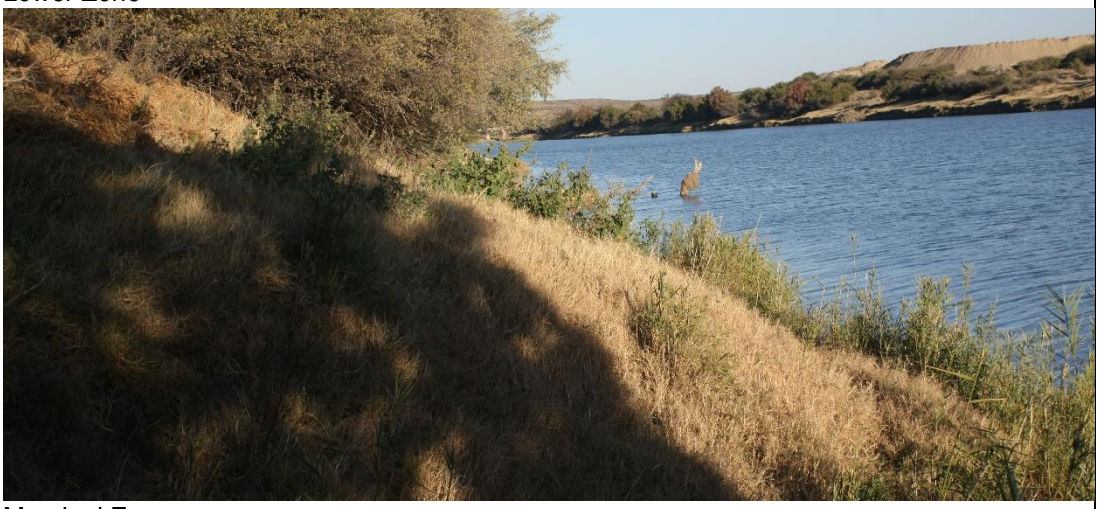
Lower Zone (Upper limit)

Lower Zone (Lower limit)

Marginal Zone

Upper Zone

Lower Zone



Marginal Zone

4.5 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 D). Activities likely to be associated with the mining operations and which will likely affect watercourses and wetlands include mining in close proximity to them, mining within these systems and crossings by roads and infrastructure and these have been assessed within the risk assessment. Should a Section 21 (c) & (i) Water Use License Application (WULA) indicate additional activities these should be assessed and added to the Risk Assessment. Assessment of the highly sensitive artesian fountain system has not been included as it is assumed to be excluded form mining activities. Should mining in or near this system be desired additional studies, including geohydrological assessments will have to be conducted.

Mining within the interior, main channel or banks of watercourses, the Vaal River or wetland areas as described will likely cause permanent modification of these systems. 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 watercourses, the Vaal River and 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 watercourses, Vaal River and 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 these systems.

Construction of roads and other infrastructure such as pipelines and canals through watercourses and wetland systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. Furthermore, watercourses being linear by nature is almost unavoidable although circular wetland systems are much more easily avoided.

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 watercourse systems in the study area.

For the complete risk assessment please refer to Appendix D.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	Mostly Operational Phase but extending long after closure	Alluvial diamond mining operations	Mining within watercourses in the interior of the study area	Mining within the main channel of the ephemeral and seasonal watercourses in the interior of the study area will remove riparian vegetation, transform the soil profile and in so doing the hydrology, geomorphology, flow and flooding regime. 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 affected watercourses. Due to the nature of this activity is likely to permanently affect the watercourses at least to some extent. Should this activity take place it is recommended that a comprehensive rehabilitation plan be compiled and monitoring be constantly applied. Despite this it is unlikely that the watercourses will be able to be rehabilitated to their condition prior to mining. Through a comprehensive rehabilitation program it is however likely to re-establish functioning watercourse.
	Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to watercourses in the study area	Mining will require removal of the vegetation layer in the catchment of the watercourses. This activity will most likely alter the flow- and flooding regime and sediment load to some extent. 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 watercourses. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation layer.
	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 higher larger volume of water transportation and general higher level of ecosystems services this rick 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 and especially the floodplain. 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	**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

				basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.			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.
	Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to wetland areas in the study area	Mining will require removal of the vegetation layer in the catchment of wetland area. This includes pans, wetland areas associated with streams and backwaters. This activity will most likely alter the flow- and flooding regime and sediment load to some extent. 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 wetland areas. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation layer. Alteration of the topography and flow patterns may alter the inflow and therefore hydrology and it is therefore important that the natural topography be accurately re-instated.
	Mostly Operational Phase but extending long after closure		Mining within wetland areas in the study area.	Mining within the wetland areas as described in the study area will entail a high risk and will include removal of the vegetation layer, transform the soil profile and in so doing the hydrology, geomorphology, flow and flooding regime. 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 affected wetlands. Due to the nature of this activity is likely to permanently affect the wetland systems to a large extent. The hydrological functioning of wetlands is complex and often associated with a saturated or impenetrable layer which will be irreversibly transformed by mining and its therefore unlikely to restore the functioning of these systems. Consequently mining within wetlands should be avoided as far as possible. Comprehensive rehabilitation and monitoring may establish a natural vegetation layer but is unlikely to re-establish a naturally functioning wetland system.
	Mostly operational phase		Construction of roads and infrastructure through watercourses and wetlands	Construction of roads and infrastructure over watercourses and wetlands will also cause disturbance although on a local scale. These structures will act as flow barriers and will alter the hydrology of these systems. Increased erosion, sediment load and exotic weed establishment is also likely.	**M**	4	The impact will be largely confined to the operational phase as long as roads and infrastructure are removed and rehabilitated. This is likely reversible impacts and therefore only has a moderate risk. It is still of paramount importance that adequate rehabilitation and monitoring thereof takes place. Mitigation should include the correct design of roads and structures so that they not act as flow barriers and minimise disturbance to the flow regime. Rehabilitation and monitoring should be comprehensive and should aim to remove all structures, re-instate the watercourse or wetland

							morphology and establish an indigenous vegetation layer. Watercourses being linear by nature is almost unavoidable although circular wetland systems are much more easily avoided.

5. Biodiversity Sensitivity Rating (BSR)

Habitat diversity and species richness:
Habitat diversity in the study area is considered relatively high. Due to the large extent of the area as well as the variety of soils, geology and topography the habitat diversity is quite varied. Furthermore, watercourses and wetland systems also provide unique habitats able to sustain a higher bio-load and therefore increase habitat diversity. However, the study is represented by only two vegetation types (Map 2). The site survey also confirmed a relatively uniform vegetation layer with a moderate species diversity. The time of the survey was however not optimal in terms of species identification and the diversity should increase somewhat during summer months and after sufficient rainfall. Studies conducted by Bezuidenhout (2011) also identified ten different vegetation communities. Overall the habitat- and species diversity is therefore considered to be moderate.

Presence of rare and endangered species:
No exceptionally rare or endangered species could be identified in the study area and the area is not known to contain such species. A few protected species were observed in the study area though areas with high densities of such species are absent.

Observed protected species in the study area includes *Vachellia erioloba, Lapeirousia plicata, Boscia albitrunca, Titanopsis clacarea, Orbea sp., Haemanthus humilis, Freesia andersoniae, Moraea polystachya, Mestoklema tuberosum, Ruschia sp., Boophone distichia, Dianthus micropetalus, Anacampseros filamentosa, Babiana hypogaea, Crinum bulbispermum, Combretum erythrophyllum, Olea europaea* subsp. *africana* and *Nananthus sp.*

The majority of these species are relatively widespread and common and therefore not of exceptionally high conservation value. However, as protected species all of them still retain some conservation significance.

The *Nananthus sp.* occurs along the fringe of the Hoffman's Pan. It is a protected species which is also considered relatively rare and with an uncertain taxonomy. The genus is currently under revision which may reveal that the species is of conservation significance.

The season of the survey was not optimal for the identification of bulbs which are deciduous during winter and it is therefore likely that several other protected bulb species may also occur in the study area.

It is known that the rare living stone plant, *Lithops sp.*, occurs in the area and would be a species of conservation importance should it occur. Although this was a target species during the survey it could not be identified in the study area. Due to its cryptic nature there remains some likelihood that it may occur.

Ecological function:
The ecological functioning and condition of watercourses and wetlands in the study area is still largely intact and natural and therefore in a good condition. The Vaal River, watercourses and wetland systems within the study area play a vital role in the continued functioning in terms of water transport and drainage of the area (Map 4). The habitat provided by the watercourses and wetlands and associated habitats support a rich faunal component and is considered to perform an important ecological function in this regard. Although the Vaal River itself has been altered to a large degree in terms of flow and flooding regime it still remains a sensitive system. The

watercourses and wetlands in the interior of the study area, although of smaller magnitude, is still in a largely natural condition and therefore also considered highly sensitive in spite of their smaller size (Appendix C).

The terrestrial component of the study area also performs several ecological functions. The study area functions in the support of a natural vegetation type, which in turn sustains a specific faunal community and acts as part of the catchment of surrounding watercourses. Being of natural and unmodified composition these functions are still considered to be intact.

Degree of rarity/conservation value:

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4) and Scmidtsdrif Thronveld (SVk 6) with the Hoffman's Pan system consisting of Highveld Salt Pan (AZi 10) vegetation. All of these are listed as being of Least Concern (LC) within the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). They are not currently subjected to any pronounced development pressures. The rarity/conservation value of these areas are therefore not exceptionally high. Smaller elements such as the low quartzite do represent habitats which are of more significant conservation value.

A biodiversity plan for this region has not yet been published and the study area does not form part of a Critical Biodiversity Area (CBA) or Ecological Support Area (ESA).

Numerous protected species were observed in the study area. However, none are rare or endangered and the majority is widespread and relatively common. The conservation value is nonetheless still considered as high.

The watercourses and wetlands, especially those within the interior of the study area is in a good condition and largely natural (Appendix C). All watercourses including the Vaal River, wetland systems, floodplains, streams, drainage lines, pans and fountain areas are considered sensitive ecosystems and their conservation value must therefore be considered as relatively high (Map 3). Normally all watercourses are considered as sensitive systems, consequently the affected watercourses being in a good condition should be considered even more so.

Percentage ground cover:
The region is in an arid area with a low annual rainfall. As a result the percentage ground cover is relatively low. This is natural to the area. However, the impact of overgrazing is considered likely in decreasing the ground cover to some extent.

Vegetation structure:
The study area is situated within the Savanna Biome with a well-developed tree layer which is considered natural to the area. A grass layer and dwarf shrub layer is present amongst the tree layer. Overgrazing may increase the tree/shrub canopy cover to some extent though this is not considered to alter it significantly.

Infestation with exotic weeds and invader plants:
Several weed species occur on the site predominately associated with the Vaal River and where localised disturbance has occurred. Overall the site is however considered to contain a relatively low abundance of exotic species.

Degree of grazing/browsing impact:
The study area is being utilised for game farming. The stocking levels of the study area is not accurately known but significant levels of trampling and overgrazing were noted in pan systems, some wetland areas and along dirt tracks and this is therefore considered as moderate.

Signs of erosion:
Due to the slope, sandy soils and drainage lines in the area it is subjected to moderate erosion. However, this erosion is considered as part of the natural ecosystem but has been exacerbated by previous mining activities and is also evident where dirt tracks and gravel roads cross over watercourses.

Terrestrial animals:
Being a game reserve consisting of natural vegetation in relatively good condition and being utilised almost exclusively for game farming the study area contains a varied faunal population with relatively high diversity. The study area also has a very large extent and consequently will be able to sustain population dynamics at a much larger scale, i.e. localised migration, varied genetic pool, pristine habitats for reclusive and rare species. The mammal population on the site therefore has a high conservation value.

Table 9: Biodiversity Sensitivity Rating for the Rooipoort diamond mining study area.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness		2	
Presence of rare and endangered species		2	
Ecological function			1
Uniqueness/conservation value			1
Vegetation condition			
Percentage ground cover		2	
Vegetation structure			1
Infestation with exotic weeds and invader plants or encroachers		2	
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species			1
Sub total	0	12	4
Total		16	

6. Biodiversity Sensitivity Rating (BSR) interpretation

Table 10: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Rooipoort mining area	16	Good Condition	2

7. Anticipated impacts

The proposed alluvial diamond mining activities proposed for the study area will mostly take place in the western portion whilst the eastern portion (portions of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98) will not be subjected to mining (Map 1). The remainder of the study area is anticipated to be subjected to extensive mining operations which will transform large portions of the vegetation and habitat. As can be expected this will result in numerous high impacts on the area.

The main impacts will be associated with the loss of habitat including species of conservation value and also associated impacts on the watercourses and wetlands in the study area.

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. Although the vegetation types in the study area is not considered to have a high conservation value they do form part of an area which is managed as private game reserve and are therefore in relatively good condition and represent unaltered natural vegetation (Map 2). This will therefore significantly increase the impact of vegetation clearing. Furthermore, some areas are more unique and therefore have a higher conservation value. Mining in such areas will therefore also increase the impact. Such area includes watercourses, wetlands, the central rocky portion of the study area and the low quartzite ridge (Map 3). These areas should be avoided as far as possible and where mining occurs, rehabilitation and monitoring measures should be increased. However, overall the vegetation seems to be rather uniform and the species diversity was not determined to be high. This may however increase during summer months and after sufficient rainfall and it should therefore be considered to conduct follow-up surveys to document accurate species diversity in the study area.

As previously discussed, it has been shown that the site contains numerous protected species although when seen in context with the large size of the study area it is not considered to be high. However, mining activities will still clear vegetation and this will therefore require removal of protected species. The impact on these species will therefore still be considered to be relatively high. Most of these protected species are scattered throughout the site and not confined to specific areas. Consequently they cannot be preserved by excluding certain areas and they will be affected over the entire site. Tree species are easy to identify and include *Vachellia erioloba* (Camel Thorn), *Boscia albitrunca* (Shepherds Tree), *Nymania capensis* (Lanternbush), *Combretum erythrophyllum* (Bushwillow) and *Olea europaea* subsp. *africana* (Wild Olive). They can therefore easily be avoided by mining activities or where this is not possible, permits be obtained to remove them. However, where they are removed, it is recommended that they be replaced by saplings grown in a nursery on the site from seed obtained in the study area. In contrast to these trees and shrubs the remaining protected species largely consist of succulent or geophytic species which are small and cryptic and therefore not easily identified. They are however easily transplanted and mining does not need to avoid them but they can easily be transplanted to adjacent or rehabilitated areas where they will remain unaffected. Permits should also be obtained to do this. Due to the difficulty in identifying these plants it is recommended that a walkthrough survey of each mining portion, i.e. M4, M5, be conducted prior to mining taking place. Protected species should then be identified and marked for easy transplanting. The walkthrough survey should preferably be conducted by ecologist or botanist with adequate knowledge of the vegetation in the area. Should the above mitigation be implemented the impact on protected species can be considerably decreased.

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 prevalent impacts as listed be managed and mitigated adequately.

Mining within the study area will undoubtedly lead to high impacts on the watercourses in the study area. This is especially so for unique wetland systems or watercourses which are in a largely natural condition. As a result strict mitigation measures will have to be implemented to ensure that impacts are kept to a minimum. Predicted impacts include increased sedimentation of watercourses, increased establishment of weeds and invaders and increased erosion due to clearance of vegetation and disturbance of the soil profile.

Mining in close proximity to watercourses will clear vegetation, disturb the soil surface and mobilise sandy soils. This may cause high levels of sedimentation within the watercourses. It is therefore recommended that measures be implemented to prevent sediment from entering the watercourses. 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. Mining within watercourses will cause disturbance of the bed and banks and will mobilise sediments from these watercourses. Due to the clearing of vegetation these sediments will be transported downstream and into the Vaal River. Disturbance of the bed surface and streamflow after rain events will also lead to erosion of the streambed and banks. It is therefore recommended that these watercourses as described in this report be excluded from mining as far as possible and where mining within watercourses or wetlands are desired the only mitigation can therefore be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations within 100 meters or within the floodplain of watercourses and within 500 meters of wetland areas will require authorisation from DWS.

As was observed during the survey of the study area it contains relatively few exotic species, especially the terrestrial interior which is almost devoid of exotics. As a result proposed mining operations will create conditions highly susceptible to the establishment of exotic weeds and invaders. Without mitigation this is anticipated to be a relatively high impact as the area is largely

natural and any alteration to the vegetation structure will easily affect its integrity. 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 impacts that mining operations will have on the faunal population is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size, i.e. X amount of habitat is only able to sustain Y number of mammals. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population. This impact is considered to be relatively high but 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. Areas which was already mined and which has been rehabilitated has illustrated that it may be possible to re-establish a similar habitat to that prior to mining and which will therefore significantly decrease the impact on the faunal population. 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.

The impact significance has been determined and it is clear that most impacts prior to mitigation will be moderate to high but can be decreased significantly with mitigation to low/moderate. The impact on natural vegetation and watercourses are not easily mitigated and is anticipated to remain moderate/high.

Please refer to Appendix E 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	5	4	5	4.6	5	4	4.5	20.7
Loss of protected species	3	5	5	4.3	4	3	3.5	15
Loss of watercourses	5	5	5	5	5	4	4.5	22.5
Infestation with weeds and invaders	4	4	4	4	4	3	3.5	14
Impact on Terrestrial fauna	4	4	5	4.3	4	3	3.5	15
After mitigation								
Loss of vegetation type and clearing of vegetation	5	3	4	4	5	4	4.5	18
Loss of protected species	2	5	3	3.3	2	3	2.5	8.2
Loss of watercourses	5	4	4	4.3	5	4	4.5	19.3
Infestation with weeds and invaders	2	2	3	2.3	4	2	3	7
Impact on Terrestrial fauna	4	4	4	4	4	3	3.5	14

8. Discussion and conclusions

The study area is considered to be in a largely natural condition with relatively few impacts except for impacts caused by current alluvial diamond mining operations.

The proposed mining development entails alluvial diamond mining within the study area and includes sensitive areas such as wetlands and watercourses (Map 3). The study area consists of the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0. Mining will mostly take place on Zandplaats 102/5, Bergplaats 100/0 and Klipfontein 99/0 whilst the eastern portion of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98 will, for the time being not be subjected to mining. This study will therefore focus on the former farms (Map 1). The study area is also situated in its entirety within the Rooipoort Nature Reserve. This is not a formally proclaimed reserve but managed as a private game reserve. The study area is located on the eastern banks of the Vaal River to the east of the town of Schmidtsdrif and approximately 60 km to the west of Kimberley. The extent of the study area is approximately 40 000 ha with the portions where mining will mostly take place covering 25 000 ha (Map 1).

8.1 Terrestrial ecological component

The study area is situated within the Savanna Biome and therefore contains a well-developed tree layer with grass and dwarf shrub understorey (Map 2). The region is considered to have a low rainfall and forms part of an arid area. The study areas contains a varied topography also due to the large size of the area. Topography includes relatively flat plains with uneven and rocky terrain in the central portion of the study area with a high amount of ridges and hills.

The majority of the study area is still largely natural except for portions which have already been subjected to mining. Mining activities is currently concentrated in the south western and western portions of the study area and the floodplain of the Vaal River. Mining operations is considered the only significant impact on the area. Areas where rehabilitation has taken place does illustrate that an indigenous vegetation layer does establish, with some resemblance to the natural vegetation, low amount of erosion occurring and exotic weeds not dominating. Rehabilitation therefore seems to be relatively successful and comprehensive. However, due to the complete removal of vegetation and disturbance of the soil profile and topography it's unlikely that the naturally occurring vegetation structure and species composition will be able to re-establish. As a result, it will also be important to apply comprehensive and continuous monitoring of the vegetation succession in these rehabilitated areas which will also indicate the success of rehabilitation and the manner to which the original occurring natural vegetation can be re-established.

The study area, being managed as a game reserve consisting of natural vegetation and is affected by relatively few impacts associated with this land use. Numerous small dirt tracks transect the area which, in terms of the large extent of the study area, are not considered a large impact. The game stocking levels of the reserve is not known but it is evident that some overgrazing, -browsing and associated trampling does take place, especially in certain areas. This is quite evident in and around pans such as the Hoffman's Pan. The impacts associated with the game farm land use is considered relatively low.

The topography of the study area can divide it into roughly three separate areas (Map 3). The **south western portion** of the study area consists of an undulating plain with soils varying from

shallow to deep and a relatively high percentage surface rock in most areas. The **central and south eastern portion** of the study area is dominated by uneven, rocky terrain with shallow soils and high percentage surface rock dominated by andesitic lava. The **northern and eastern portion** of the study area contains a relatively flat area which contains areas of much deeper sandy soils but also shallow soils with high percentage calcrete. The northern and southern portions with several similarities and the central, rocky area being more distinct.

The time of the survey was not optimal in terms of species identification as many herbs, annuals and geophytes were unidentifiable or not present at this time and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall

South western portion

The south western portion of the study area has an undulating but relatively uniform topography (Map 3). Different habitats and vegetation communities are however varied and contain four different communities which are mostly separated on the basis of soil and percentage rock cover. Areas with high percentages surface pebbles occur around the "diamantkoppie" which provide suitable habitat for geophytes and dwarf succulents. However, such species could not be identified here and except for *Orbea sp., Titanopsis calcarea* and *Drimia sp.* no other noteworthy species could be identified. These habitats can therefore not be considered to be of significantly high conservation value.

This portion of the study area does not contain a significant amount of protected species although a few do occur. The floodplain and southern areas with deep sands contain scattered specimens of the protected Camel Thorn Tree (*Vachellia erioloba*). Another protected tree but which occurs as scattered specimens in more rocky area is the Shepherds Tree (*Boscia albitrunca*). It is recommended that these trees be avoided as far as possible and where they require removal the necessary permits be obtained to do so. Furthermore, where trees were removed these should be replaced by saplings during the rehabilitation phase. Other protected species Include the geophyte, *Lapeirousia plicata*, and succulents, *Orbea sp.* and *Titanopsis calcarea*. These species transplant easily and it is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

Recently mined areas occur within the floodplain portion of the area. The natural topography has largely been re-instated in this area and an indigenous vegetation layer has succeeded in establishing. It is important that these areas be monitored closely and continuously in order to document the success/failure of rehabilitation which will aid greatly in improving or maintaining rehabilitation techniques.

In conclusion, in terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Central and south eastern portion

The central portion of the study area consists of very uneven, rocky and mountainous terrain but with a relatively uniform vegetation structure and species composition (Map 3). It contains five vegetation communities but which are all relatively similar, except for the community occurring

on the low quartzite ridge. They are grouped in their similarity as a result of the relatively shallow soils, uniform andesitic lava geology and high percentage rock coverage of this portion. Such areas with a high percentage rock coverage form arid habitats which provide suitable conditions for highly adapted succulents. However, such species are conspicuously absent and the succulent component is almost absent.

This portion of the study area contains numerous protected species. They are mostly scattered over this portion and not confined to specific colonies or habitats. Two protected tree/shrub species occur namely *Boscia albitrunca* and *Nymania capensis*. Where these trees will be affected by mining operations it will not be possible to transplant them and they will require removal. Other protected species consists mostly of succulent and geophytic species which transplant relatively easily. These include *Oxalis sp., Haemanthus humilis, Freesia andersoninae, Moraea polystachya, Mestoklema tuberosum, Ruschia sp., Orbea sp*., *Boophone distichia, Dianthus micropetalus, Anacampseros filamentosa* and *Babiana hypogaea*. It is therefore recommended that prior to mining taking place in an area that permits be obtained to transplant them to areas where they will remain unaffected.

The mountainous portion of the study area contains a higher species diversity than the surrounding plains portion and likewise a higher number of protected species. This, coupled with the varied topography and high amount of watercourses, including drainage lines, gives the mountainous portion of the study area a high sensitivity (Map 3). As a result of the above any mining taking place in this portion should be approached with the necessary caution, implementing comprehensive mitigation and a high level of rehabilitation. The low, quartzite ridge in this portion also contains a unique species assemblage different from the surrounding area and represents a unique geological outcrop which is considered to provide this area with a very high level of sensitivity. It is accordingly recommended that this area be excluded from mining operations.

In conclusion, in terms of terrestrial ecology this central portion of the study area does not contain elements of exceptionally high conservation value although the combination of a varied topography, higher species diversity and occurrence of protected species and presence of high amounts of watercourses provide it with a high level of sensitivity (Map 3). Furthermore, the low quartzite ridge is considered a unique habitat with unique species assemblage and therefore a very high level of sensitivity (Map 3). This ridge should be excluded from mining activities. Numerous protected species occur and although none are listed as rare or endangered they still retain a significant conservation value and recommended mitigation should be applied for these.

Northern and eastern portion

The northern and eastern portion of the study area has a relatively flat to slightly undulating topography and is relatively uniform (Map 3). However, the portion still contains varied vegetation communities which are mostly coupled to soil conditions and percentage rock cover. No specialised terrestrial habitats occur and although the portions which contain a high percentage of surface calcrete often harbours dwarf succulent species these are largely absent. These habitats can therefore not be considered to be of significantly high conservation value.

This portion of the study area contains the lowest amount of protected species. The sandy soils of north eastern area of this portion contains relatively high amount of the protected Camel Thorn Tree (*Vachellia erioloba*). Where these trees will be affected by mining operations it will not be

possible to transplant them and they will require removal. The only other protected species observed was *Orbea sp*. This succulent species transplants easily.

No mining has taken place in this portion which does increase its conservation value somewhat as a natural area in almost pristine condition.

In conclusion, in terms of terrestrial ecology this portion of the study area does not contain any elements of exceptionally high conservation value (Map 3). The area consists predominately of natural vegetation in a good condition but with a relatively low diversity of species and unique habitats absent. A few protected species were identified and these are of some conservation value and recommended mitigation should be applied for these.

Overview of terrestrial fauna (actual & possible)

Being a game reserve consisting of natural vegetation in relatively good condition and being utilised almost exclusively for game farming the study area contains a varied faunal population with relatively high diversity. The study area also has a very large extent and consequently will be able to sustain population dynamics at a much larger scale, i.e. localised migration, varied genetic pool, pristine habitats for reclusive and rare species. The mammal population on the site therefore has a high conservation value.

The most significant impacts that mining operations will have is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population. This impact is considered to be significant but 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. Areas which was already mined and which has been rehabilitated has also illustrated that it may be possible to re-establish a similar habitat to that prior to mining.

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.

Of high importance will be the presence of threatened or Red Listed species. From available literature of species likely to occur in the region as well as the mammal list for the reserve it is clear that numerous Red Listed species occur and is likely to occur in the study area.

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

Of the above listed species, the Leopard (*P. pardus*) and Brown Hyena (*H. brunnea*) are known to occur in the study area. It is also considered highly likely that several if not all of the remaining species will also occur within the study area.

8.2 Watercourses and wetlands

Section 4.4 provides a short description of each watercourse within the study area (Table 6) (Map 1 - 4). The study area consists of the entire diamond mining area and contains floodplains, seasonal streams, pans, wetland areas and numerous drainage lines especially the areas closer to the Vaal River (Map 1 - 4).

All of the watercourses within the interior of the study area which will be affected by the mining operations are seasonal but mostly ephemeral in nature. Seasonal, and especially ephemeral, systems are still poorly understood and their functioning is markedly different from perennial systems. The functioning of these watercourses in the interior of the study area should also serve to indicate that although they may seem small and flow only occur sporadically they still have a complex functioning which provides several unique ecosystem services. They should consequently still be considered as sensitive systems which may be easily altered or affected by activities associated with the proposed mining activities (Map 3).

Obligate wetland vegetation was utilised to determine the presence and border of wetland conditions. Due to time constraints and the extent of the study area soil samples were only used to confirm the presence of wetland conditions where obligate wetland vegetation indicated wetland conditions (Section 4.4). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils (Appendix B).

Soil samples indicated that the majority of watercourses, especially smaller drainage lines, were devoid of wetland conditions (Table 6). However, larger stream systems as well as pans, backwaters, the banks of the Vaal River and other waterbodies did contain clear wetland conditions. These systems are discussed separately in Section 4.4.

The Vaal River forms the western border of the study and will also form part of the mining area (Map 1). This is an extensive length of the river situated in the study area, approximately 30 km. 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 floodplain and banks of the river is relatively uniform along the length of the study area though smaller portions with differing and, in some areas, rather unique riparian habitats do occur. Detailed surveys at six locations along the Vaal River were undertaken in order to give an overall description of the banks of the Vaal River along the study area (Table 6). Wetland conditions are most prominent along the main channel and decrease in distance from the channel. However, the backwater systems in the north also sustain a floodplain wetland system.

Two large and significant pan systems, Hoffman's Pan situated along the southern border of the study area and the other, smaller, though still large pan situated to the north of Hoffman's Pan (Map 4). The Hoffman's Pan has a length of approximately 3.5 km with the pan to its north approximately 1 km in length. Their topography undoubtedly characterises them as depression wetland systems. The extensive shore portion along the pan's eastern border do not contain any wetland conditions but still form part of the pans and are therefore also included within the border of the delineated wetland systems. The hydrological regime of these pans are considered to be ephemeral and will only contain surface water after exceptional rainfall. These pans and their

shore is considered to be rather unique systems, largely as a result of their extensive size and are considered to be highly sensitive. It is recommended that as far as possible these be excluded from mining.

The northern portion of the study area consists of a relatively flat topography (refer to section 4.1.5) with the result that it contains few watercourses (Map 4). However, a few are still present, especially one large stream draining the interior of this portion. Due to the flat topography areas of ponding is easily formed. As a result of this, wetland areas have formed in and around the main channel of this stream system. Obligate wetland vegetation is prominent and soil samples also indicate clear wetland conditions occurring. These wetland areas are considered to have a seasonal regime and will contain surface water on a seasonal basis. These areas are also considered to be relatively unique, especially wetland areas adjacent to the quartzite outcrops along the western tributary of this large stream. Consequently, these wetland areas are considered to be highly sensitive and of high conservation value.

In close proximity to the above described wetland areas but considered a separate system is a very unique artesian fountain which seems to be entirely of natural origin (Table 6, Map 4). Systems such as this is exceptionally rare and considered highly unique. The extent of this entire fountain is no more than 1 hectare. Due to its perennial nature obligate wetland vegetation has become established around the fountain and clearly indicate the presence of wetland conditions. The fountain is considered a very unique system with a high conservation value. As a result it is recommended that it be excluded from mining operations. Furthermore, should mining within 500 meters of this fountain be desired the necessary geohydrological studies must be undertaken in order to determine a suitable buffer around it in order for its functioning to remain unaffected.

Impacts and condition of watercourses and wetlands

The determination of the condition of the watercourses and wetlands in the study area will be based on an overall determination of the Index of Habitat Integrity (IHI). The watercourses in the interior of the study area all drain into the Vaal River and therefore forms part of one system, located in close proximity to each other, are affected by the same impacts, situated in the same environmental setting and will all affect the same downstream section of the Vaal River. Therefore, one IHI will be conducted for these watercourses to represent the overall condition and a separate IHI conducted for the Vaal River in the study area. This is considered to give a good representation of the condition of the systems within the study area as all affected watercourses and wetlands drain into the Vaal River and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

The Vaal River and its associated floodplains are considered a fifth order watercourse. This is also due to the Vaal River being a large lowland river. The largest impact on the study area is the construction of large upstream containment dams in the Vaal River. These impacts alter flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix C). The results of the IHI indicated that the Vaal River has an Inseam IHI of category C: Moderately Modified and Riparian IHI of category C/D: Moderately to Largely Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Vaal River and associated wetlands and floodplains are considered to be somewhat altered and degraded by historical and current impacts.

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.

The watercourses and wetlands within the interior of the study area is considered to be affected by relatively few impacts and consequently still in a relatively natural condition. Current mining operations are however considered to have a significant impact. An Index of Habitat Integrity (IHI) was conducted for these watercourses within the study area (Appendix C). The results of the IHI indicated that the watercourses in the interior of the study area has an Instream IHI of category B: Largely Natural and Riparian IHI of category B: Largely Natural. This is considered accurate since they are located in their entirety in a natural area with few impacts. Current mining has not yet affected a large proportion of watercourses and is therefore not yet considered to have decreased the condition of watercourses significantly.

The EI&S of the floodplains associated with the watercourses and wetlands in the interior of the study area 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.

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 D). Assessment of the highly sensitive artesian fountain system has not been included as it is assumed to be excluded form mining activities.

Mining within the interior, main channel or banks of watercourses, the Vaal River or wetland areas as described will likely cause permanent modification of these systems. 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 watercourses, the Vaal River and 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 watercourses, Vaal River and 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 these systems.

Construction of roads and other infrastructure such as pipelines and canals through watercourses and wetland systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. Furthermore, watercourses being linear by nature is almost unavoidable although circular wetland systems are much more easily avoided.

8.3 Anticipated Impacts

The proposed alluvial diamond mining activities proposed for the study area will mostly take place in the western portion whilst the eastern portion (portions of Vogelstruis Pan 101 and almost the entire Vogelstruis Pan 98) will not be subjected to mining (Map 1). The remainder of the study area is anticipated to be subjected to extensive mining operations which will transform large portions of the vegetation and habitat. As can be expected this will result in numerous high impacts on the area.

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. Although the vegetation types in the study area is not considered to have a high conservation value they do form part of an area which is managed as private game reserve and contain smaller portions of unique habitat such as watercourses, wetlands, the central rocky portion of the study area and the low quartzite ridge (Map 2 & 3). These areas should be avoided as far as possible and where mining occurs, rehabilitation and monitoring measures should be increased. However, overall the vegetation seems to be rather uniform and the species diversity was not determined to be high. This may however increase during summer months and after sufficient rainfall and it should therefore be considered to conduct follow-up surveys to document the accurate species diversity in the study area.

As previously discussed, it has been shown that the site contains numerous protected species although when seen in context with the large size of the study area it is not considered to be high. However, mining activities will still clear vegetation and this will therefore require removal of protected species. The impact on these species will therefore still be considered to be relatively high. Tree species are easy to identify and they can therefore easily be avoided by mining activities or where this is not possible, permits be obtained to remove them. However, where they are removed, it is recommended that they be replaced by saplings grown in a nursery on the site from seed obtained in the study area. In contrast to these trees and shrubs the remaining protected species largely consist of succulent or geophytic species which are small and cryptic and therefore not easily identified. They are however easily transplanted and mining does not need to avoid them but they can easily be transplanted to adjacent or rehabilitated areas where they will remain unaffected. Permits should also be obtained to do this. Due to the difficulty in identifying these plants it is recommended that a walkthrough survey of each mining portion, i.e. M4, M5, be conducted prior to mining taking place. Protected species should then be identified and marked for easy transplanting. The walkthrough survey should preferably be conducted by ecologist or botanist with adequate knowledge of the vegetation in the area. Should the above mitigation be implemented the impact on protected species can be considerably decreased.

Mining within the study area will undoubtedly lead to high impacts on the watercourses in the study area. This is especially so for unique wetland systems or watercourses which are in a largely natural condition (Appendix C). As a result strict mitigation measures will have to be implemented to ensure that impacts are kept to a minimum. Predicted impacts include increased sedimentation of watercourses, increased establishment of weeds and invaders and increased erosion due to clearance of vegetation and disturbance of the soil profile. It is recommended that watercourses and wetlands as described in this report be excluded from mining as far as possible and where mining within watercourses or wetlands are desired the only mitigation can therefore be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations

within 100 meters or within the floodplain of watercourses and within 500 meters of wetland areas will require authorisation from DWS.

As was observed during the survey of the study area it contains relatively few exotic species, especially the terrestrial interior which is almost devoid of exotics. As a result proposed mining operations will create conditions highly susceptible to the establishment of exotic weeds and invaders. 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.

The most significant impacts that mining operations will have on the faunal population is primarily concerned with the loss and fragmentation of available habitat. This will also place pressure on the population and will ultimately lead to a decrease in the population size. Therefore, transformation of habitat by mining will lead to a decrease in the mammal population. This impact is considered to be relatively high but 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. 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.

The impact significance has been determined and it is clear that most impacts prior to mitigation will be moderate to high but can be decreased significantly with mitigation to low/moderate. The impact on natural vegetation and watercourses are not easily mitigated and is anticipated to remain moderate/high.

9. Recommendations

- Where mining activities occurs, it is important that comprehensive rehabilitation and monitoring of the rehabilitation takes place. It is therefore recommended that a comprehensive rehabilitation and monitoring plan be compiled and strictly adhered to.

- Recently mined and rehabilitated areas indicate that it is possible to re-instate a similar and comparable topography and vegetation layer. It is important that the rehabilitation succession and establishment of vegetation be continuously monitored to indicate the success of rehabilitation and the manner to which the original occurring natural vegetation can be re-established. This will also aid in improving or maintaining rehabilitation techniques.

- As discussed in the report, the study area contains numerous protected species. These consist of protected trees, succulents and geophytes. The following recommendations should be followed for protected species:

    - Where protected tree/shrub species occur in mining areas they should be avoided as far as possible.
    - Where this is not possible, permits should be obtained from the relevant authority to remove them. These trees should be replaced during rehabilitation by saplings sourced from seed in the study area.
    - Saplings should be cultivated in a small nursery area established on the site. This should also be established/overseen by a suitably qualified person.
    - Saplings may require protection and watering during the initial establishment phase.
    - The success of establishment should also be continuously monitored.
    - Where protected succulent/geophytic species will be affected by mining, permits should be obtained and these transplanted to adjacent or rehabilitated areas where they will remain unaffected.
    - These species are cryptic and inconspicuous and it is recommended that a walkthrough survey be conducted prior to an area being mined, i.e. M4, M5, etc. This should include identification and marking of all protected plants in such an area and should be performed by an ecologist or botanist.
    - The transplanting of these species should be overseen by an ecologist, botanist or other suitably qualified person.
    - Monitoring of the success of establishment should also be undertaken.

- The time of the survey was also not optimal in terms of species identification and it is therefore highly likely that recorded diversity will increase significantly during summer months and after sufficient rainfall. It is therefore recommended that follow-up surveys be conducted to accurately document the diversity in the study area.

- The mountainous central and south eastern portion of the study area contains a higher species diversity and a higher number of protected species. This gives the mountainous portion of the study area a high sensitivity (Map 3). As a result of this any mining taking place in this portion should be approached with the necessary caution, implementing comprehensive mitigation and a high level of rehabilitation.

- The low, quartzite ridge in the study area is a unique habitat which is considered to have a very high level of sensitivity (Map 3). It is accordingly recommended that this area be excluded from mining operations.

- The impact of habitat loss and fragmentation on the faunal population should be mitigated by amongst others:

    - Limit mining to set areas and not mine several areas at the same time, i.e. M4, M5, etc. Mining only one such an area at a time.
    - Limit the extent of each such mining area as far as possible.
    - Comprehensive and successful rehabilitation of mined areas.

- 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. This should include mammals, reptiles and amphibians.

- It has been determined that all watercourses and wetlands in the study area must be considered as highly sensitive and avoided by mining as far as possible (Map 3 & 4). Where mining within watercourses and wetland are desired a high level of rehabilitation will have to be implemented.

- Mining within watercourses should not be initiated without first determining that the diamond yield will justify this, i.e. all watercourses should not be mined but only those which have been determined to contain a high yield.

- A natural riparian vegetation should be re-instated where this was disturbed/removed. Only species sourced from the study area should be utilised for this and seed, seedlings, etc should not be brought in from outside areas. This should be done to ensure a gene pool remains in the study area and will prevent the establishment of “frankenflora”.

- When excavating in watercourses the upper 30 cm, or topsoil, should be removed together with the vegetation and stored as sods on the site. This will mostly be applicable to areas where wetland conditions are present These should then be replaced on top of the rehabilitated soil surface. Subsoil should be used as backfilling and not as top dressing. Only removed sods and topsoil should be utilised to rehabilitate the bed and bank surface. The soil surface and geomorphology should also be re-instated to its natural condition and shape.

- Watercourses and wetlands should constantly be monitored for erosion, especially where mining has occurred in the bed or banks. Where erosion is evident this must be remedied.

- The watercourse bed and bank geomorphology should also be re-instated as far as possible.

- Where steep banks occur and erosion is evidently problematic it is recommended that geotextiles be utilised to stabilise soils. Available options include contouring, berms, gabions and geotextile netting.

- Due to the susceptibility of mined areas, especially where watercourses are involved it is recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area and should be extended into the rehabilitation phase.

- Monitoring of mining operations and compliance with recommended mitigation and rehabilitation measures must be strictly implemented.

- The necessary authorisations must be acquired from Department of Water and Sanitation (DWS) for mining within watercourses and wetlands or within 100 meters or within the floodplain of watercourses and within 500 meters of wetland areas.

- Following completion of mining in specific areas and consequent rehabilitation it is recommended that an extended period of monitoring be initiated which should include monitoring of erosion, bank and bed stability, vegetation and weed establishment and remediating this.

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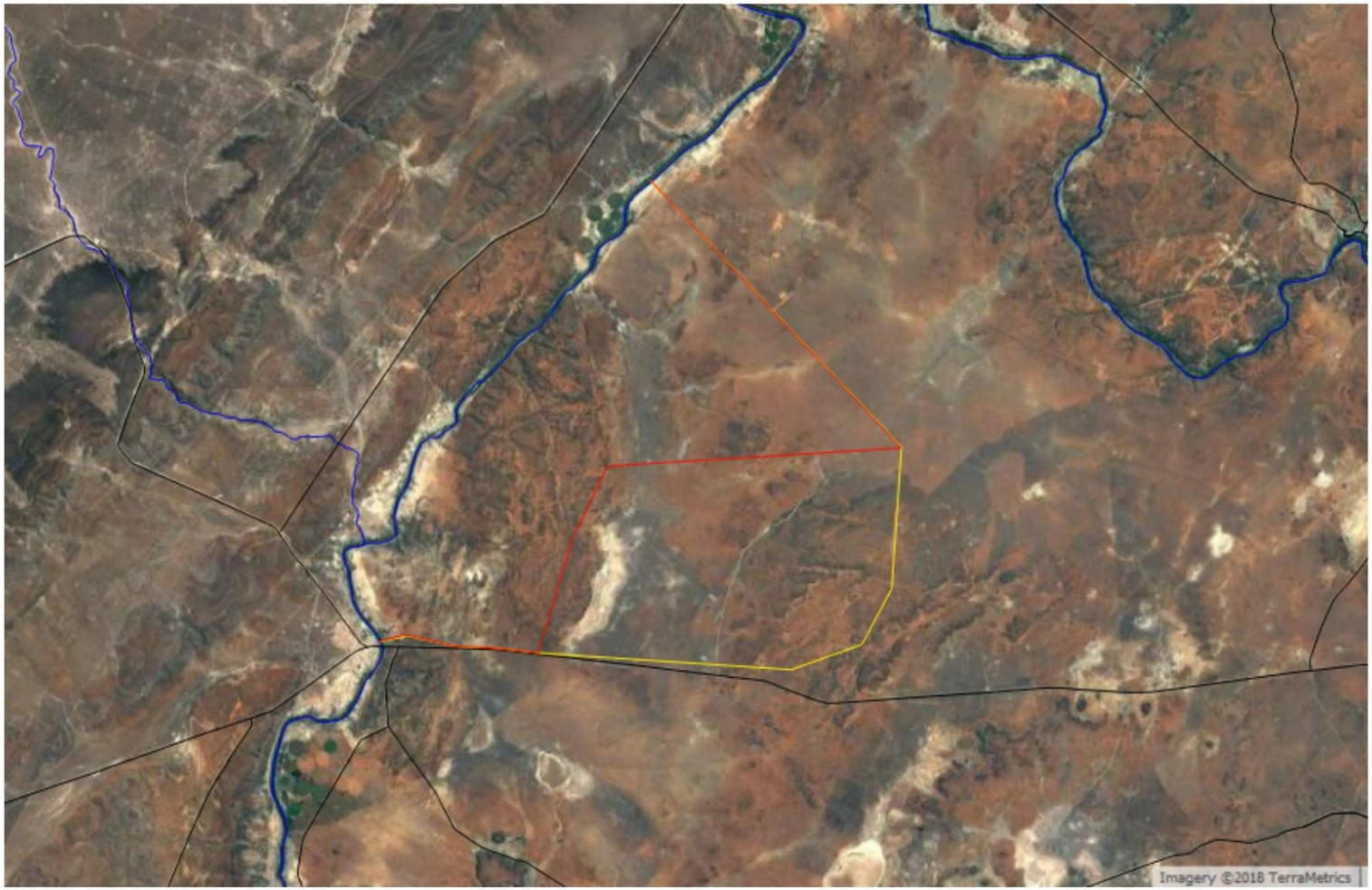
Annexure A: Maps

Locality of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Vaal River

Map Information

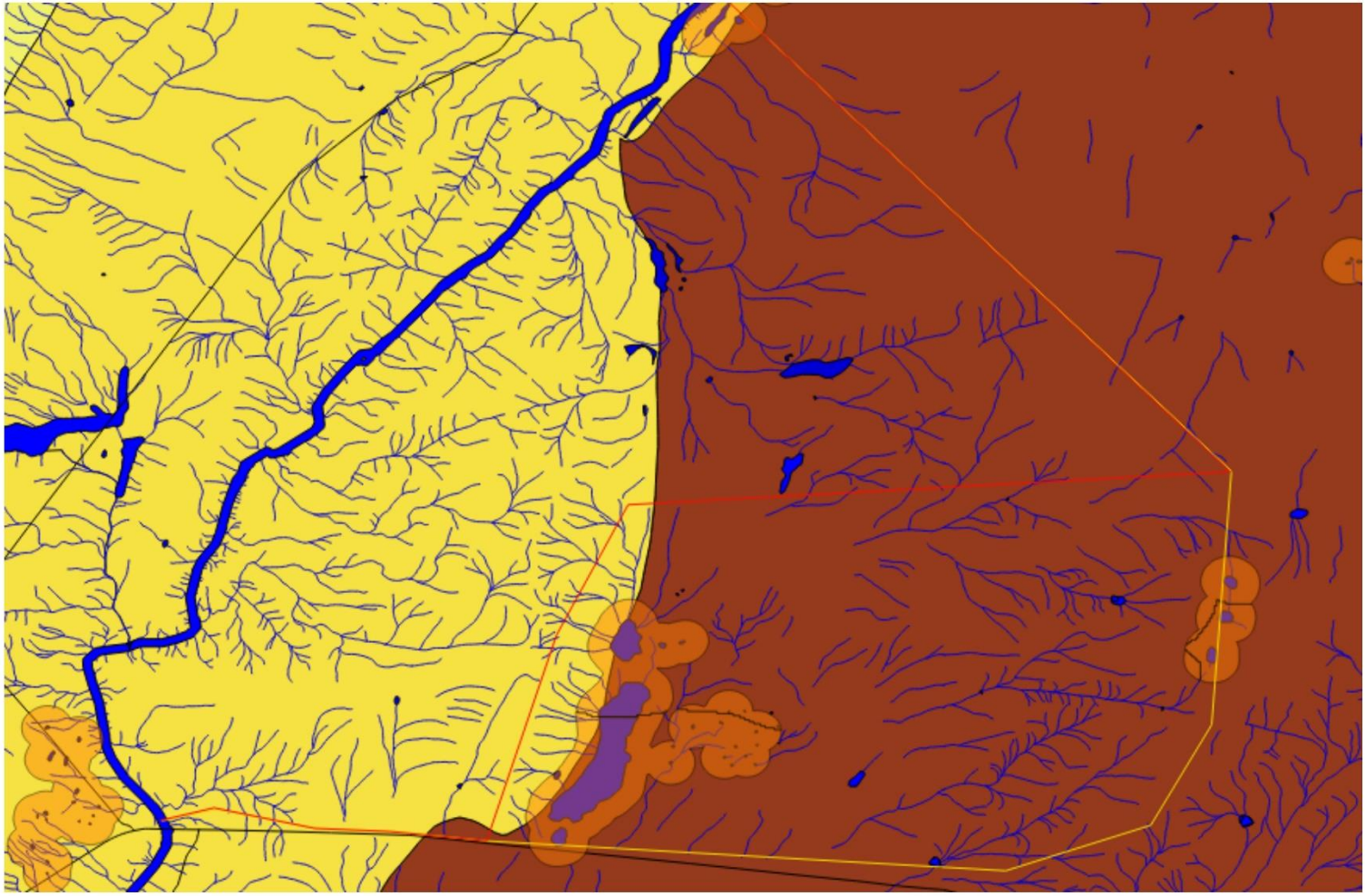
S 28.656145°
E 24.123029°

Spheroid: WGS 84
Scale: 1:200 000
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: Locality map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. The application area and the mining area has both been indicated. Note also that the Vaal River forms the western border of the mining area.

General ecology of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Preparred for:
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P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Watercourses
- Wetlands
- NFEPA Wetland Clusters
- Kimberley Thornveld
- Schmidtsdrif Thornveld

Map Information

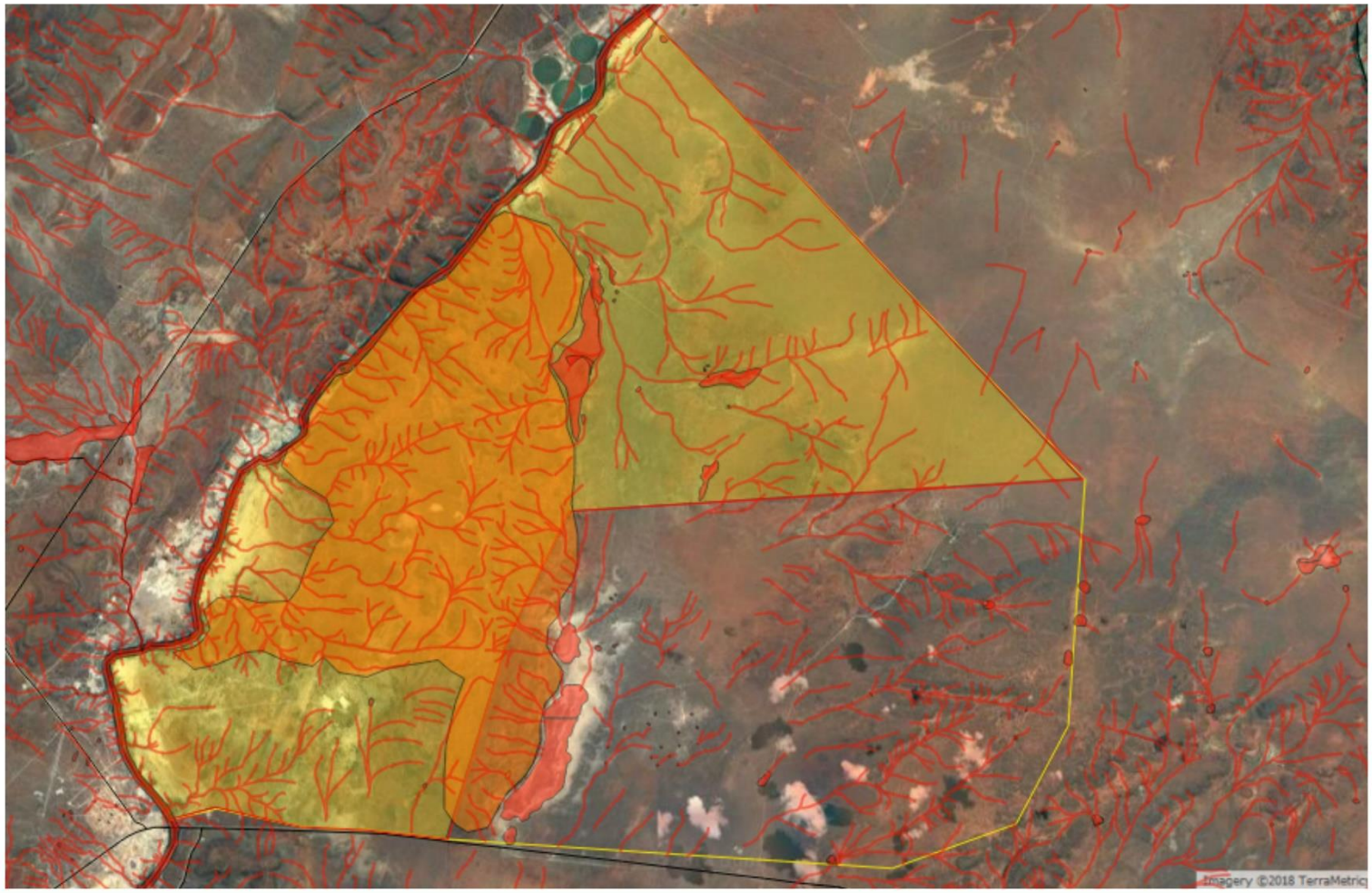
S 28.656145°
E 24.123029°

Spheroid: WGS 84
Scale: 1:100 000
Quantum GIS

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

Map 2: General ecology map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. The vegetation types in the study area is indicated as well as watercourses and wetlands. National Freshwater Ecosystem Priority Areas (NFEPA) Wetland Clusters indicate areas with a high abundance of wetlands and therefore higher sensitivity.

Sensitivity map of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Vaal River
- Very High Sensitivity
- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity

Map Information

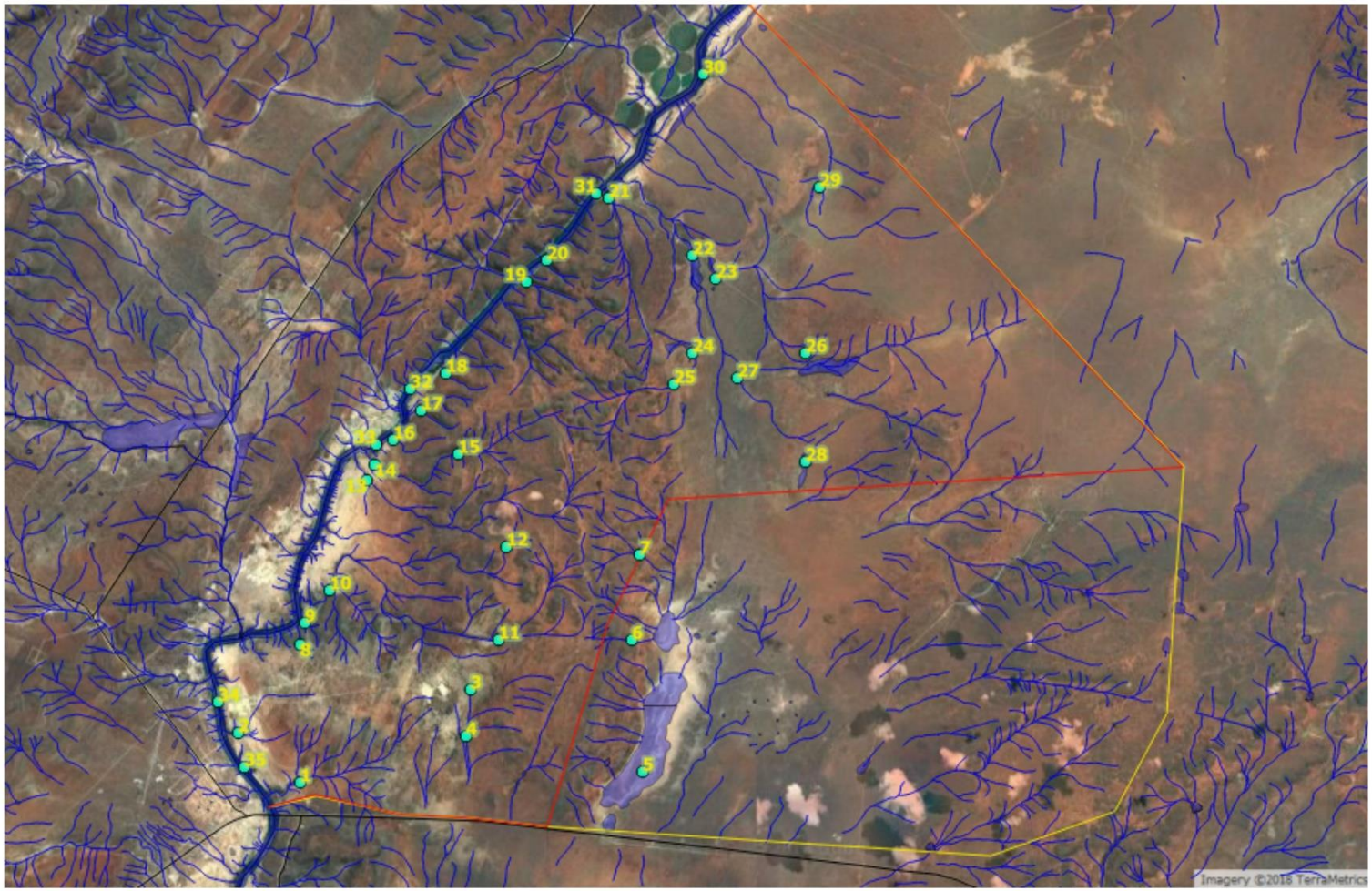
S 28.656145°
E 24.123029°

Spheroid: WGS 84
Scale: 1:100 000
Quantum GIS

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

Map 3: Sensitivity map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. The vegetation types in the study area is indicated as well as watercourses and wetlands. Areas of very high sensitivity include all watercourses and wetland areas as well as the low quartzite ridge. Areas of high sensitivity consist of the central and south eastern rocky, mountainous portion of the study area. The plains in the south western portion and northern and eastern portions are considered to be of moderate sensitivity.

Wetlands and surface water map of the alluvial diamond mining operations at Rooipoort on the farms Zandplaats 102/5, Vogelstruis Pan 101/0, Vogelstruis Pan 98/0, Bergplaats 100/0 and Klipfontein 99/0 near Schmidtsdrif, Northern Cape Province.



Map 4: Wetlands and surface water map for the proposed Rooipoort mining operations near Schmidstdrif, Northern Cape Province. All watercourses and wetlands in the study area is indicated and survey locations corresponding to Table 6 is also indicated.

Preparred for:
Rooipoort Developments (Pty) Ltd
P.O. Box 110471
Hadison Park
8306

Legend:

- Mining Area (Study Area)
- Application area
- Road network
- Watercourses
- Wetland areas
- Survey point

Map Information

S 28.656145°
E 24.123029°

Spheroid: WGS 84
Scale: 1:100 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
darius@dprecologists.co.za
P.O. Box 12726, Brandhof, 9324
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Appendix B: Soil Samples Methodology

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to confirm the wetland conditions in the study area. 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).

Appendix C: Index of Habitat Integrity (IHI) Summary

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

Vaal River IHI

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.517623
UPPER LONGITUDE	E 24.198120
UPPER ALTITUDE	1013
LOWER LATITUDE	S 28.703472
LOWER LONGITUDE	E 24.075298
LOWER ALTITUDE	1008
SURVEY SITE (if applicable)	Vaal River Rooipoort
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Low er Vaal
QUATERNARY	C92A & C92B
ECOREGION 2	29_2
DATE	19/06/2016
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	1.4	1.1
BED MODIFICATION	1.7	4.0
BANK MODIFICATION	2.0	3.0
CONNECTIVITTY MODIFICATION	2.0	4.0
INSTREAM IHI%	62.9	
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	1.75	4.00
CONNECTIVITY MODIFICATION	1.75	4.00
RIPARIAN HABITAT INTEGRITY (%)	57.69	
CATEGORY	C/D	
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	1.5
Salts	2.0
Nutrients	2.0
Water Temperature	1.0
Water clarity	2.0
Oxygen	1.0
Toxics	1.0
PC RATING	**1.4**
Sediment	2.0
Benthic Growth	1.5
BED RATING	**1.7**
Marginal	2.0
Non-marginal	2.0
BANK RATING	**2.0**
Longitudinal Connectivity	2.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**2.0**
INSTREAM IHI %	**62.9**
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)	2.0
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	2.0
BANK STRUCTURE RATING	**1.8**
Longitudinal Connectivity	1.5
Lateral Connectivity	2.0
CONNECTIVITY RATING	**1.8**
RIPARIAN IHI %	**57.7**
RIPARIAN IHI EC	**C/D**
RIPARIAN CONFIDENCE	**3.7**

Watercourses and wetlands in the interior of the study area IHI

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.517623
UPPER LONGITUDE	E 24.198120
UPPER ALTITUDE	1013
LOWER LATITUDE	S 28.703472
LOWER LONGITUDE	E 24.075298
LOWER ALTITUDE	1008
SURVEY SITE (if applicable)	Rooipoort Watercourses
SITE LATITUDE (if applicable)	S 28.656145
SITE LONGITUDE (if applicable)	E 24.123029
SITE ALTITUDE (if applicable)	1073
WMA	Low er Vaal
QUATERNARY	C92A & C92B
ECOREGION 2	29_2
DATE	22/11/2016
RIVER	Vaal River
TRIBUTARY	Watercourses w ithin Rooipoort
PERENNIAL (Y/N)	**N**
GEOMORPH ZONE	**MOUNTAIN STREAM**
WIDTH (m)	**>0-2**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	0.2	1.7
PHYSICO-CHEMICAL MODIFICATION	1.0	1.1
BED MODIFICATION	1.3	4.0
BANK MODIFICATION	1.0	3.0
CONNECTIVITTY MODIFICATION	1.0	4.0
INSTREAM IHI%	82.8	
CATEGORY	B	
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	0.16	3.00
BANK STRUCTURE MODIFICATION	1.00	4.00
CONNECTIVITY MODIFICATION	1.00	4.00
RIPARIAN HABITAT INTEGRITY (%)	85.61	
CATEGORY	B	
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	-0.5
Zero Flows	0.0
Floods	0.0
HYDROLOGY RATING	**0.2**
pH	0.0
Salts	2.0
Nutrients	1.5
Water Temperature	0.0
Water clarity	1.5
Oxygen	1.0
Toxics	1.0
PC RATING	**1.0**
Sediment	1.5
Benthic Growth	1.0
BED RATING	**1.3**
Marginal	1.0
Non-marginal	1.0
BANK RATING	**1.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.0**
INSTREAM IHI %	**82.8**
INSTREAM IHI EC	**B**
INSTREAM CONFIDENCE	**2.8**

	MRU
RIPARIAN IHI	
Base Flows	-0.5
Zero Flows	0.0
Moderate Floods	0.0
Large Floods	0.0
HYDROLOGY RATING	**0.2**
Substrate Exposure (marginal)	0.0
Substrate Exposure (non-marginal)	0.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	0.0
Erosion (marginal)	1.0
Erosion (non-marginal)	0.0
Physico-Chemical (marginal)	1.0
Physico-Chemical (non-marginal)	1.0
Marginal	1.0
Non-marginal	1.0
BANK STRUCTURE RATING	**1.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
RIPARIAN IHI %	**85.6**
RIPARIAN IHI EC	**B**
RIPARIAN CONFIDENCE	**3.7**

Appendix D: 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
1	Mostly Operational Phase but extending long after closure	Alluvial diamond mining operations	Mining within watercourses in the interior of the study area	Mining within the main channel of the ephemeral and seasonal watercourses in the interior of the study area will remove riparian vegetation, transform the soil profile and in so doing the hydrology, geomorphology, flow and flooding regime. Increased establishment of exotic weeds and invaders due to disturbance caused by mining is also probable.	5	4	5	3	4.25	4	4	12.25	4	4	5	2	15	183.75	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 affected watercourses. Due to the nature of this activity is likely to permanently affect the watercourses at least to some extent. Should this activity take place it is recommended that a comprehensive rehabilitation plan be compiled and monitoring be constantly applied. Despite this it is unlikely that the watercourses will be able to be rehabilitated to their condition prior to mining. Through a comprehensive rehabilitation program it is however likely to re-establish functioning watercourses.
	Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to watercourses in the study area	Mining will require removal of the vegetation layer in the catchment of the watercourses. This activity will most likely alter the flow- and flooding regime and sediment load to some extent. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	3	3	2	2	2.5	4	3	9.5	3	3	5	2	13	123.5	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 watercourses. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation

	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 higher larger volume of water transportation and general higher level of ecosystems services this rick 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.	2	4	4	3	3.25	4	4	11.25	4	4	5	4	17	191.25	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 and especially the floodplain. 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	4	2	2	2.5	2	3	7.5	3	3	5	3	14	105	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.

Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to wetland areas in the study area	Mining will require removal of the vegetation layer in the catchment of wetland area. This includes pans, wetland areas associated with streams and backwaters. This activity will most likely alter the flow- and flooding regime and sediment load to some extent. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	3	3	2	3	2.75	2	4	8.75	3	3	5	4	15	131.25	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 wetland areas. Comprehensive rehabilitation should be applied and should aim to re-instate the natural topography and establish an indigenous vegetation layer. Alteration of the topography and flow patterns may alter the inflow and therefore hydrology and it is therefore important that the natural topography be accurately re-instated.
Mostly Operational Phase but extending long after closure		Mining within wetland areas in the study area.	Mining within the wetland areas as described in the study area will entail a high risk and will include removal of the vegetation layer, transform the soil profile and in so doing the hydrology, geomorphology, flow and flooding regime. Increased establishment of exotic weeds and invaders due to disturbance caused by mining is also probable.	5	4	5	4	4.5	3	5	12.5	4	4	5	3	16	200	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 affected wetlands. Due to the nature of this activity is likely to permanently affect the wetland systems to a large extent. The hydrological functioning of wetlands is complex and often associated with a saturated or impenetrable layer which will be irreversibly transformed by mining and its therefore unlikely to restore the functioning of these systems. Consequently mining within wetlands should be avoided as far as possible. Comprehensive rehabilitation and monitoring may establish a natural vegetation layer but is unlikely to re-establish a naturally functioning wetland system.

	Mostly Operational Phase		Construction of roads and infrastructure through watercourses and wetlands	Construction of roads and infrastructure over watercourses and wetlands will also cause disturbance although on a local scale. These structures will act as flow barriers and will alter the hydrology of these systems. Increased erosion, sediment load and exotic weed establishment is also likely.	3	2	3	2	**2.5**	2	4	8.5	2	2	5	2	**11**	**93.5**	**M**	4	The impact will be largely confined to the operational phase as long as roads and infrastructure are removed and rehabilitated. This is likely reversible impacts and therefore only has a moderate risk. It is still of paramount importance that adequate rehabilitation and monitoring thereof takes place. Mitigation should include the correct design of roads and structures so that they not act as flow barriers and minimise disturbance to the flow regime. Rehabilitation and monitoring should be comprehensive and should aim to remove all structures, re-instate the watercourse or wetland morphology and establish an indigenous vegetation layer. Watercourses being linear by nature is almost unavoidable although circular wetland systems are much more easily avoided.

Appendix E: 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.