Report on the ecological and wetland assessment for the proposed alluvial diamond mining operations on various portions of the farms Vanaswegenshoek 493 and Greylingslyn 355 along the Vaal River near the town of Christiana, Free State Province.

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DECLARATION OF INDEPENDENCE

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

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Executive Summary

The study area is situated along the southern banks of the Vaal River and situated adjacent to the small town of Christiana though just inside the borders of the Free State Province (Appendix A: Map 1). The study area is quite extensive and includes large terrestrial plains, various wetlands and watercourses and also the floodplain and banks of the Vaal River and has an approximate extent of 4 000 hectares.

From the description of the study area it is clear that the majority of the site has been transformed by agricultural and mining operations (Appendix A: Map 1). This would therefore increase the conservation value of those portions of remaining natural vegetation, i.e. the less habitat remains, the rarer it will be, the higher the conservation value will become. However, when looking at available resources it is evident that the vegetation types on the site, Kimberley Thornveld and Highveld Alluvial Vegetation is not currently regarded as rare or endangered and still covers large areas of the region (Appendix A: Map 1). This will therefore not contribute toward their conservation value. Furthermore, the Free State Province Biodiversity Management Plan (2015) regards the site as being of Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other categories and do not contain Critical Biodiversity Area (CBA) which would be of high conservation value (Appendix A: Map 2). Despite this, natural areas do still contain some elements of conservation value such as a range of protected succulent and geophytic species and large and old specimens of the protected *Vachellia erioloba* (Camel Thorn) (Appendix B).

Given the fairly low conservation value of remaining natural areas on the site, this will decrease the impact that mining operations will have on the loss of habitat and species diversity. However, from previous mining operations it is also clear that mining operations cause significant impacts and result in the transformation of natural areas. By the nature of alluvial diamond mining, i.e. removal of the vegetation and modification of the soils profile, it results in the irreversible transformation of the ecosystem. However, given the fairly uniform soil conditions and habitats on the site and provided that comprehensive rehabilitation is undertaken, it may be possible to re-instate a somewhat similar vegetation composition after mining has ceased. This will also entail the re-instatement of the natural topography as far as possible as well as the correct management of topsoil. Mining also results in high levels of disturbance and consequently, the establishment of exotic weeds and invasive species and the eradication and monitoring of these should also form an important part of the management of mining and rehabilitation operations.

Mammal species identified on the site indicate a significant diversity, which although dominated by widespread and generalist species, also contain species of higher conservation value. Evidence of the Cape Clawless Otter (a Red Listed species regarded as being Near Threatened) was also confirmed along the Vaal River. This also indicates that although the mammal population will be somewhat modified, it remains likely that other species of high conservation value will still be present.

The Vaal River flows from north east to south west along the border of the site (Appendix A: Map 3). It is a perennial system and flows throughout the year but has been heavily modified in terms of its flow and flooding regime by upstream containment dams. The floodplain has also been affected and modified by agricultural and mining operations. A few small drainage lines occur in the western portion of the site where the slope increases slightly toward the Vaal River (Appendix A: Map 3). As indicated, the terrestrial portion of the site has a flat topography and

as a result watercourses are absent. However, this flat topography also promotes the formation of a few small pans or depressions (Appendix A: Map 3). All of these pans have been quite heavily affected by the surrounding agricultural operations.

The determination of the presence of wetland condition in the study are was undertaken by using surface topography soil wetness indicators as well as obligate wetland vegetation. This indicated that the Vaal River banks clearly contains wetland conditions, while the floodplain is devoid of wetland conditions but still forms part of the riparian zone of the river (Appendix A: Map 3). Where small drainage lines or impoundments occur near the river, wetland conditions have also formed. The upper portions of these drainage lines are largely devoid of wetland conditions though they must be regarded as forming watercourses over their entire length. A few small pans systems all contain clear wetland conditions despite being heavily degraded.

The largest impact on the Vaal River at the site is considered agricultural transformation and irrigation followed by previous alluvial diamond mining which has had a high impact on the site. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are centre-pivot irrigation, alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified (Appendix D). The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate.

The largest impact on the pan system on the site is undoubtedly several large centre-pivot irrigation fields in close proximity to it. This clearly results in an increase in the nutrient input of the pan which causes a significant modification in the vegetation composition of the pan. In addition, surface runoff and groundwater seepage from the centre-pivots will also alter the hydrology of the pan in that this will increase the inflow into it. The results of the WET-Health indicated an overall Present Ecological State of Category D: Largely modified (Appendix D). The EI&S of the pan system has been rated as being Moderate.

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's (DWS) requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS. Where the risk assessment refers to mining operations in close proximity to watercourses and wetland this refers to the regulated area as stipulated by DWS, i.e. within the floodplain or riparian zone or within 100 meters of the edge of a watercourse. This is also applicable to the small depressions occurring in the study area.

Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible. The current mine plan also indicates that mining operations will exclude the main channel and banks of the Vaal River from mining operations. Should mining occur within any of the lateral drainage lines or depressions (pans), this will also entail a high risk and should therefore be avoided.

Mining in close proximity to the Vaal River or within the floodplain and riparian zone will still result in significant impacts. This is also applicable to the lateral drainage lines and small depressions or pans occurring in the study area. Mining operations in close proximity to any of these systems are 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 impacts can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of these systems.

Mining operations will also include haul roads and other infrastructure such as pipelines and powerlines and where these occur within the floodplain or riparian zone of the river, or across any of the lateral drainage lines or pan systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. The design of these structures should be such that they minimise the obstruction of flow and disturbance of the floodplain, watercourses and pan systems.

The impact significance has been determined and should mining take place without mitigation it is anticipated that several moderate-high to high impacts will occur. The impact on the Vaal River will also result in a high impact. However, should adequate mitigation be implemented as described these can all be reduced to moderate and low-moderate impacts. This is however subject to mining operations limiting the extent of disturbance, not being implemented indiscriminately over the entire area, excluding the river and its floodplain, retaining and transplanting of protected plant species, implementing a monitoring and eradication programme for invasive species and implementing comprehensive rehabilitation.

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Ecological and wetland assessment.

1. INTRODUCTION

1.1 Background

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

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

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

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

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

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

The study area is situated along the southern banks of the Vaal River and situated adjacent to the small town of Christiana though just inside the borders of the Free State Province (Appendix A: Map 1). The study area is quite extensive and includes large terrestrial plains, various wetlands and watercourses and also the floodplain and banks of the Vaal River and has an approximate extent of 4 000 hectares. The majority of this area has however already been transformed by agricultural irrigation with centre-pivots and orchards dominating the landscape. However, significant portions of natural vegetation are also still present and will form the focus of this study.

A site visit was conducted on 08 November 2021. The entire footprint of the proposed mining area, including terrestrial and riparian areas, was surveyed over the period of one day. The site survey was conducted during late spring after heavy rains and consequently vegetation identification was adequate and an active hydrological regime was present. This ensured accurate identification of watercourses and wetlands.

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

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

1.2 The value of biodiversity

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

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

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

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

1.3 Details and expertise of specialist

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South African Council for Natural Scientific Professions No. (400284/13) (Ecological Science).

Membership with relevant societies and associations:

- South African Society of Aquatic Scientists (SASAQS0091)
- South African Association of Botanists
- South African Wetlands Society (3SLY4IG4)

Expertise:

- Qualifications: B.Sc. (Hons) Botany (2008), M.Sc. in Vegetation Ecology (2012) with focus on ephemeral watercourses.
- Vegetation ecologist with over 10 years experience of conducting ecological assessments.
- Founded DPR Ecologists & Environmental Services (Pty) Ltd in 2016.
- Has conducted over 200 ecological and wetland assessments for various developments.
- Regularly attend conferences and courses in order to stay up to date with current methods and trends:

  2017: Kimberley Biodiversity Symposium.
  2018: South African Association of Botanists annual conference.
  2018: National Wetland Indaba Conference.
  2019: SASS5 Aquatic Biomonitoring Training.
  2019: Society for Ecological Restoration World Congress 2019.
  2019: Wetland rehabilitation: SER 2019 training course.
  2020: Tools For Wetlands (TFW) training course.

2. SCOPE AND LIMITATIONS

- To evaluate the present state of the vegetation and ecological functioning of the area proposed for the mining development.
- To identify possible negative impacts that could be caused by the proposed clearing of vegetation and establishment of mining operations.
- To provide a description of watercourses, wetlands and riparian vegetation included within the study area.
- Identify watercourses including rivers, streams, pans and wetlands and determine the presence of wetland conditions within these systems.
- Where wetland conditions have been identified the classification of the wetland system will be given.
- To evaluate the present state of the wetlands and riparian vegetation in close proximity to the site. The importance of the ecological function and condition will also be assessed.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the watercourses in close proximity to operations.
- 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 proposed site.
- The overall status of the vegetation on site.
- Species composition with the emphasis on dominant-, rare- and endangered species.

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

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

2.2 Fauna

Aspects of the fauna that will be assessed include:

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

2.3 Wetlands and watercourses

Aspects of the wetlands that will be assessed include:

- Identification and delineation of watercourses including rivers, streams, pans and wetlands.

- Determine the presence of wetland conditions and riparian vegetation using obligate wetland and riparian species.
- Describe watercourses and wetlands and importance relative to the larger system.
- Conduct habitat integrity assessment of perennial systems to inform the condition and status of watercourses.

2.4 Limitations

- Due to the season of the survey several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to their seasonal or deciduous nature.
- Although a comprehensive survey of the site was done it is still likely that several species were overlooked.
- Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
- Due to previous mining activities this may have altered soil layers and the morphology of the river banks which would complicate the delineation of wetland and riparian areas.
- Due to time constraints only limited surveys of watercourses were done.
- Some animal species may not have been observed as a result of their nocturnal and/or shy habits.
- Access could not be obtained to a few fenced game areas and could therefore not be assessed.

3. METHODOLOGY

3.1 Several literature works were used for additional information.

General ecology:

- Red Data List (Raymondo *et al.* 2009).
- Vegetation types (Mucina & Rutherford 2006).
- NBA 2018: South African Inventory of Inland Aquatic Ecosystems (SAIIAE).
- NBA 2018 Technical Report: Inland Aquatic (Freshwater) Realm.
- NBA 2018 Technical Report Volume 1: Terrestrial Realm.
- NEM:BA: List of threatened ecosystems and Threatened Or Protected Species (TOPS).
- National Freshwater Ecosystem Priority Areas 2011 (NFEPA).
- Strategic Water Source Areas 2018 (SWSA).
- SANBI (2011): List of threatened ecosystems.
- Biodiversity Plan Free State Province (2018).

Vegetation:

- Red Data List (Raymondo *et al.* 2009)
- Vegetation types (Mucina & Rutherford 2006)
- Field guides used for species identification (Adams 1976, Bromilow 1995, 2010, Coates-Palgrave 2002, Fish *et al* 2015, Gerber *et al* 2004, Gibbs-Russell *et al* 1990, Griffiths & Picker 2015, Manning 2009, Pooley 1998, Retief & Meyer 2017, Roberts & Fourie 1975, Van Ginkel & Cilliers 2020, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Wyk & Malan 1998, Van Wyk & Van Wyk 1997, Venter & Joubert 1985).

Terrestrial fauna:

- Field guides for species identification (Smithers 1983, Child *et al* 2016, Cillié 2018).

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, Macfarlane, Ollis & Kotze 2020, Ollis *et al* 2013, Nel *et al* 2011, SANBI 2009.

3.2 Survey

The site was assessed by means of transects and sample plots. Observation w.r.t. the general ecology of the area includes:

- 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 site according to their distribution areas and habitat requirements.
The state of the habitat was also assessed.

All rivers, streams, pans and wetlands were identified and surveyed where they occurred in the study area. These systems were determined by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix B & C). The following outlines the process applied during the on-site survey in order to obtain all required data:

- Perform desktop overview of the study area utilising available resources (Section 3.1). From the desktop overview identify the different landscape forms, possible wetland areas, watercourses and their relative flow patterns. Using this information, identify transects and sample plots for possible on-site survey. This should be both representative of the wetland or watercourse as a whole but should also include any prominent or significantly unique features.
- Possible sites identified during the desktop overview should be surveyed on-site. Where access is not possible or where desktop features are considered poor representatives of the wetland or watercourse the survey site or transect should be moved to another location, without compromising a comprehensive overview of the system.
- Where a lateral transect is taken of a watercourse this is done from the water's edge, across the marginal, lower and upper zones and extended across the floodplain until the edge of the riparian zone is reached.
- Where a transect is taken of a wetland system, this should preferably be taken across the entire wetland at its widest part or where it is most relevant to the proposed development, from the terrestrial surroundings, across the temporary, seasonal and perennial zones across the wetland.
- Soil samples are taken at 10 meter intervals along the survey transect, or where a distinct transition into a different zone is observed.
- A survey of the plant species within each distinct riparian or wetland zone is undertaken and includes the identification of obligate wetland species, riparian species, terrestrial species, exotic species and the general species composition and vegetation structure which allows for an accurate description of the watercourse or wetland.
- Visual survey of the general topography which substantiates the presence of riparian zones and wetland forms.
- Other general observations include any impacts observed, the overall ecosystem function, presence of fauna, surrounding land uses and the overall condition of the watercourse or wetland.
- Data is recorded by means of photographs with GPS coordinates taken at all relevant soil sampling sites and borders of riparian and wetland zones.

Data obtained during the on-site survey is utilised to provide the following information on the system:

- Desktop overview and assimilation of information on the likely impacts and functioning of the wetland system.
  - Review all available spatial data and resources in order to provide an estimate of the likely impacts and condition of the wetland or watercourse system.
- Confirm the presence of the wetland or watercourse system and provide an estimate of its borders.
  - The border of wetland conditions or the edge of the riparian zone will be confirmed by using soil sampling, obligate wetland vegetation and topography. This will also include the delineation of any temporary, seasonal or perennial

zones of wetness along wetlands and the marginal, lower, upper and riparian zones along watercourses.

- Provide a description of the wetland or watercourse.
  - Provide the hydrogeomorphic setting of the wetland, a longitudinal profile which will aid in determining the erodibility of the wetland and provide an overall description of the wetland and impacts affecting it.
  - Provide a general description of the lateral zonation of the watercourse banks including the marginal, lower, upper and riparian zones and a description of the riparian vegetation along the banks of the watercourse. This will also include the description of any impacts or modification of the watercourse.
- Assess the current condition of the wetland or watercourse.
  - Utilising information obtained from the assessments listed above, determine the condition of this portion of the wetland by applying the WET-Health 2 tool.
  - Utilising information obtained from the assessments listed above, determine the condition of the relevant section of the watercourse by applying the Index of Habitat Integrity (IHI) tool.
- Utilising all of the information obtained from the assessment, provide recommendations to mitigate anticipated impacts that the development will have.

The following guidelines and frameworks were also used to determine the presence of 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 or wetlands 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.

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

- Macfarlane, D.M., Ollis, D.J. & Kotze, D.C. 2020. WET-Health (Version 2.0): a refined suite of tools for assessing the present ecological state of wetland ecosystems. WRC Report No. TT 820/20.

A Risk Assessment will be conducted for the proposed development 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 site 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 OVERVIEW OF THE SITE

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

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

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

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4) and Highveld Alluvial Vegetation (Aza 5) (Appendix A: Map 1). The Kimberley Thornveld dominates the study area and covers all the terrestrial plains while the Highveld Alluvial Vegetation covers portions of the floodplain of the Vaal River. Both these vegetation types are currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). They are not currently subjected to any pronounced transformation pressures. Within the study area, both of these have been transformed to a significant extent by agricultural irrigation both in the terrestrial plains as well as the floodplain of the Vaal River.

The Free State Province Biodiversity Management Plan (2015) has recently been published and has identified areas which are essential to meeting conservation targets for specific vegetation types, i.e. Critical Biodiversity Areas. The site in question is listed as being an Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other (Appendix A: Map 2). Areas identified as ESA 1 and 2 are associated with the immediate catchment of the Vaal River and functions in support of this large watercourse. This functioning and support should therefore be retained as far as possible. Degraded areas are associated with areas transformed by agricultural irrigation and centre-pivots. Those areas regarded as Other, indicate areas still consisting of natural vegetation but which area not regarded as being critical within the conservation plan. This would seem to indicate that, in general, the study area does not contain extensive areas of high conservation value. The site survey may however still indicate smaller portions or elements of high sensitivity.

The study area is situated along the southern banks of the Vaal River and situated adjacent to the small town of Christiana though just inside the borders of the Free State Province (Appendix A: Map 1). The study area is quite extensive and includes large terrestrial plains, various wetlands and watercourses and also the floodplain and banks of the Vaal River and has an approximate extent of 4 000 hectares. The majority of this area has however already been transformed by agricultural irrigation with centre-pivots and orchards dominating the landscape. However, significant portions of natural vegetation are also still present and will form the focus of this study. These portions of natural vegetation range from open grassland to relatively closed savannah.

As previously stated, the majority of the study area has already been transformed by agricultural land use. This is also confirmed by the National Biodiversity Assessment (2018) (Appendix A: Map 1). Where pecan nut orchards or centre-pivots occur, this has completely transformed the natural vegetation. These areas are therefore no longer relevant to the ecology of the area and has not been included in this assessment. A few centre-pivots have been left fallow or have been planted with pasture and in both instances, these have no significant remaining ecological function left. Any residual natural vegetation will be of secondary establishment and will not contribute in any significant manner toward the ecology of the area and will therefore not be included in this assessment. These areas will be utilised by a few mammals as foraging areas but will not contribute toward a natural ecological population. The study will focus on all of the remaining natural areas in the study area which will still contain a naturally functioning ecosystem and will contribute towards important ecological functions. These areas are also quite fragmented in this area although a substantial natural area still occurs in the southern portion of the site.

Figure 1: The study area is largely transformed by centre-pivot irrigation.

Figure 2: Centre-pivots which are not currently irrigated are either fallow or has been planted with pasture.

The remaining terrestrial areas occurring on the site, and forming the focus of it, can be further divided into distinct vegetation communities, based on the vegetation structure, dominant species and the topography and soils. The large remaining natural area in the south of the site consists of a well-developed grass layer with few scattered trees and is a consequence of sandy soils but which are shallow and underlain by a calcrete bedrock. Toward the west of the site areas occur with a slight elevation and where a short shrub/tree layer becomes prominent and can be quite dense and which is a consequence of rocky soils dominated by gravels. A few isolated fragments occur in between centre-pivots in the central and northern portion of the site. Here large trees dominate with a well-developed grass layer interspersed and is a consequence of deep sandy soils. These areas were also most heavily affected by agriculture since these deep sandy soils are most beneficial to crop production. The study will also discuss the terrestrial ecology of the area separately for these three distinct areas.

Figure 3: Southern portion of the study area contains a well-developed grass layer with scattered trees.

Figure 4: Towards the west of the site, remaining natural vegetation consist of a well-developed grass layer but with a quite dense shrub layer also being present.

Figure 5: Fragmented central portions of the site is dominated by a well-developed woodland.

The Vaal River adjacent to the site, including the riparian zone or floodplain and banks of the river has been quite heavily modified by historical agricultural land use. The riverbanks themselves are heavily modified, especially the riparian vegetation which is now dominated by the reed, *Phragmites australis* and the invasive Bluegum tree, *Eucalyptus camaldulensis*. The dominating reedbeds are a consequence of elevated nutrient levels caused by fertiliser runoff and other upstream impacts. The riparian zone or floodplain of the river is also heavily modified and transformed by historical agriculture and alluvial diamond mining. In addition, increased runoff and groundwater seepage from the surrounding irrigation also modifies the surface flow patterns and occurrence of wetland areas. This has also made assessment and delineation of the riparian zone difficult.

Figure 6: The riparian zone along the Vaal River is dominated in many areas by exotic Bluegum trees (*Eucalyptus camaldulensis*).

Figure 7: The banks of the Vaal River are largely quite degraded and dominated by reeds (*Phragmites australis*), an indicator of elevated nutrient levels.

Figure 8: Several pecan nut orchards encroach into the riparian zone and cause transformation of this area.

Figure 9: Previous mining operations within the riparian zone has also resulted in significant modification.

As indicated, agricultural irrigation in the form of centre-pivots and orchards and the activities associated with this is considered the main impact in this area (Appendix A: Map 1). This causes the direct loss of surface vegetation, modification of runoff patterns and the transformation of the ecosystem. In addition, the indirect impacts are also quite substantial where fertiliser causes the enrichment of downslope areas and the consequent modification of the vegetation composition. Continuous irrigation also increases surface flow and groundwater seepage and this clearly contributes to the modification of wetland and drainage areas. Previous alluvial diamond mining operations has also caused extensive disturbance in a few areas. This has also caused the clearance of vegetation but also the transformation of the natural soil profile and topography which results in the complete transformation of the natural ecosystem in these areas. In these areas a pioneer vegetation layer has been able to re-establish but is not a good representation of the natural vegetation in this area. It will be important for proposed mining operations to remove and retain the topsoil layer as this will aid in adequate rehabilitation of the area. The inadequate rehabilitation resulting from previous mining clearly indicate the high impact this has and the need for post mining rehabilitation and adequate management of topsoil. Other smaller but still significant impacts include numerous dirt tracks and gravel roads as well as buildings, structures and infrastructure.

Large portions of the topography of the study area has been altered to a significant degree. The terrestrial portion of the site consists of a relatively flat plain with slight slope to the west and toward the Vaal River. Due to this flat topography, the centre-pivots and agricultural fields would only have resulted in a moderate modification of the surface topography but would nonetheless have caused some modification of surface runoff patterns. Where previous mining has occurred, this has however had a more pronounced impact on the surface topography modification. Tailings, excavations and slimes dams modify the surface topography to a large degree. The topography of the banks of the Vaal River is considered still intact to a large degree although agriculture and mining has evidently affected the floodplain in several areas, also causing modification of the surface topography there. The interior, terrestrial portion of the study area contains very few wetlands and watercourses. Only a few small pans or depressions occur here. Toward the western portion of the study area as the slope gradient increases toward the Vaal River, a few drainage lines has formed (Appendix A: Map 3). These are natural watercourses but has been heavily modified by runoff from irrigation areas.

The mining area is situated in a semi-arid region with cold, dry winters and hot, semi-dry summers. The town of Christiana, adjacent to the site, receives between 400 and 500 mm of rain annually, with 458 mm being measured for the nearest weather station (C9E003).

Precipitation occurs mainly during summer and autumn, with most rainfall received during January (76 mm), February (73 mm) and March (74 mm), although the months of November (53 mm) and December (60 mm) also yield significant rainfall. Winters are very dry with the period between June to August only yielding an average of 7 to 8 mm per month. This is considered a relatively low rainfall, though still adequate to enable the establishment of a significant vegetation cover. It is however considered to form part of a semi-arid region of South Africa. The mean annual evaporation for the area is between 2200 mm to 2600 mm per annum which is considered relatively high. This considerably decreases the likelihood of wetland conditions forming as soils are unable to retain saturated conditions due to high evaporation. However, the site is also situated adjacent to an endoreic area which means that it is inward draining and coupled with the high evaporation promotes the formation of large pan wetlands. From the above it should be clear that the climate in the area is semi-arid which will limit the amount of storm water generated. The surface water runoff in the area does not occur frequently and is quite erratic and results in an estimated mean annual runoff for the area between 2.5 – 5 mm according to a study by the Water Research Commission (WRC REPORT NO. TT 685/16, 2016).

Midday temperatures in the area can range from lows of 18°C to as high as 32°C dependent upon the time of year and season. Alternatively, nightly temperatures can drop to lows of 0.1°C on average during colder months. Humidity (atmospheric moisture) in the area is calculated to an amount of 30% on average

The underlying geology consists of andesitc lavas of the Allanridge Formation (Ra) at the top of the Ventersburg Supergroup. The Late Archaean succession is almost entirely composed of resistant-weathering, dark grey-green lavas and associated pyroclastic rocks.

As previously indicated, the terrestrial component of the study area, and those portions that still consist of natural vegetation, can roughly be divided into three distinct areas, based on the vegetation composition and soil characteristics. These are the southern portion with well-developed grass layer, shallow sandy soils overlying calcrete bedrock, the western portion with a dense shrub/tree layer and shallow rocky soils and the central portions with a tall, well-developed tree layer and deep sandy soils. These will be discussed separately in the below paragraphs and elements of conservation value indicated where these were observed.

Southern Plains (Grass layer on shallow sands over calcrete bedrock)

The southern portion of the site contains the largest remaining natural area (Appendix A: Map 1 & 4). This is most probably as it is not well suited for crop cultivation. This area contains sandy soils but with a shallow calcrete bedrock underlying it. The depth of the calcrete layer has been observed to be about 30 cm but may also outcrop in a few areas. This is the main ecological driver which differentiates this area from the surrounding natural areas. Here the vegetation is dominated by a well-developed grass layer while trees are only scattered and absent in many areas. Trees require deeper soils and are therefore not well suited to this habitat type. They area however able to utilise cracks within the calcrete layer and are represented here by scattered specimens. Grasses do not require deep soils and are consequently dominant in this habitat.

This area, at least the portion that remains intact, seems to still be in a relatively natural condition. It is however a fairly uniform habitat and also in terms of species diversity was not noted to contain a wide variety of species and growth forms. Several grass species dominate the area and include *Themeda triandra, Cymbopogon pospischillii, Schmidtia pappophoroides, Eragrostis lehmanniana, Stipagrostis uniplumis, Anthephora pubescens* and *Eragrostis superba.* The majority of these are also climax species indicating a grass layer in good condition. Dwarf karroid shrubs are also abundant but considered a natural component of the vegetation and also confirms a grass layer in good condition. Where these dwarf shrubs become dominant this may indicate high levels of overgrazing, but on the site is still present in low numbers and therefore indicate a healthy grass layer. These dwarf karroid shrubs include *Hertia pallens, Nolletia ciliaris, Gnidia podocephala, Amphiglossa triflora* and *Felicia muricata*. A high abundance of herbaceous species are also interspersed within the grass layer. These include *Berkheya onopordifolia, Senna italica, Dicoma macrocephala, Gazania krebsiana, Heliotropium ovalifolium, Heliotropium ciliatum, Chascanum pinatifidum, Helichrysum argyrosphaerum* and *Trichodesma angustifolium.* These are but a few and many others have not been listed here (Appendix B). Of note is also substantial abundances of the pioneer herbs, *Salvia disermas, Salvia verbenaca, Nidorella resedifolia* and *Geigeria pectidea*. These do indicate some level of disturbance and is likely coupled with at least a moderate level of overgrazing by domestic livestock. Spreading or creeping plants were also noted to be quite abundant, a natural component of this vegetation type, and include *Hermannia quartiniana, Acanthosicyos naudinianus, Rhynschosia totta* and *Elephantorrhiza elephantina*. Geophytic species are present but not abundant and include *Albuca sp., Boophone distichia, Bulbine abyssinica, Bulbine narcissifolia, Ledebouria luteola* and *Chlorophytum sp.* These are all rather widespread although *B. distichia* is a protected species and will still retain a significant conservation value. As previously indicated, the area also contains scattered trees which consist almost exclusively of *Vachellia erioloba* (Camel Thorn) which is also a listed protected species and will have a significant conservation value. Underneath these trees a sparse understorey is present consisting of low shrubs such as *Lycium hirsutum, Searsia pyroides* and *Asparagus larcinus*. It is was also noticeable that this area also did not contain any exotic weeds or invasive species and also indicates the relatively good condition of this area.

In conclusion, the southern plains portion is still natural and in a fairly good condition. It is however rather uniform with only a moderate species diversity and does not contain any endangered or rare species (Appendix A: Map 4). A few protected species were noted but are also not abundant. This area therefore does not seem to contain elements of high conservation value which is also confirmed to some degree by the Free State Biodiversity Management Plan which regards this area as falling within the Other category (Appendix A: Map 2). Despite this, the area does still have some conservation value as it is one of the remaining natural areas still in a good condition in the study area.

Figure 10: The southern plain has a rather flat topography, dominated by a well-developed grass layer and with trees being scattered.

Figure 11: The area is underlain by calcrete which may as shallow as 30 cm and does outcrop in some areas.

Western Rocky areas (dominated by low shrub layer)

Fragmented natural areas remain in the western portion of the site (Appendix A: Map 4). These areas have also been most affected by previous mining operations. They can be mostly differentiated in terms of the soil conditions which are dominated by rocky soils with a mixture of calcrete and alluvial gravel. This is the main ecological driver which differentiates this area from the surrounding natural areas. Here the vegetation is dominated by a well-developed grass layer but with a fairly dense shrub layer being prominent. This shrub layer varies from 1 to 2 meters with a few scattered taller trees also being present. Rocky soils promote the establishment of shrubs while deeper soils are more beneficial for taller trees.

These areas have become rather fragmented and consequently are somewhat degraded in general. Those portions to the west have been affected by the proximity of farming operations and contain a prominent component of exotic weeds while the eastern and central portions have been affected by previous mining operations. Where mining has affected the vegetation this has resulted in its transformation. The habitat contains a somewhat more varied vegetation composition with more growth forms and consequently more protected species of conservation importance. The grass layer is dominated by a few species which include *Eragrostis pallens, Eragrostis lehmanniana, Cymbopogon pospischillii* and *Eragrostis rigidior.* This illustrates a less well-developed grass layer with sub-climax grasses dominating. This may be a result of the habitat though disturbances in this area will at least have some impact on the grass layer as well. As indicated, a shrub layer dominates this habitat and is also clearly evident in the species composition which includes *Grewia flava, Ziziphus mucronata, Gymnosporia buxifolia, Tarchonanthus camphoratus, Senegalia melifera* subsp. *detinens, Vachellia hebeclada* and *Ehretia rigida*. This clearly illustrates a diversity of shrubs occurring in this area. It was also evident that dwarf karroid shrubs are abundant in this habitat. Though these are a natural component, where they dominate it indicates disturbance of the vegetation. This does occur in this habitat but is not the norm. Such dwarf karroid shrubs include *Pentzia quinquifida, Pentzia calcarea* and *Amphiglossa triflora*. It was also notable that in this habitat, succulent species were more abundant, probably as a consequence of the rocky soils. These species included *Orbea lutea* subsp. *lutea, Aloe grandidentata* and *Delosperma herbeum*. Of these, *A. grandidentata* and *O. lutea* are also protected species but are widespread and fairly common and therefore only of moderate conservation value. Geophytic species were also quite abundant and includes *Boophone distichia, Cyphostemma hereroensis, Ledebouria luteola, Raphionacme hirsuta, Bulbine narcissifolia* and *Pterodiscus speciosus*. Several of these are also protected species and are of significant conservation value. As noted, this habitat also contains an abundance of exotic weeds including *Conyza bonariensis, Argemone ochroleuca* and *Opuntia ficus-indica*. This is a further indication of significant disturbance in this habitat.

In conclusion, the western rocky areas still contain natural areas, but which are clearly fragmented by agricultural and mining operations and consequently, overall, this habitat is considered somewhat degraded (Appendix A: Map 4). This also serves as an indication that where mining has taken place, the impact on the natural habitat is high. The habitat is also relatively uniform, though less so than the southern plains, but still has only a moderate species diversity. Despite the somewhat degraded condition, several protected plant species occur in this habitat, with some also being regarded as less common and also of significant conservation value. According to the Free State Biodiversity Management Plan this habitat is also listed as an Ecological Support Area 1 (ESA 1) which also indicates a somewhat higher conservation value (Appendix A: Map 2). This habitat would therefore overall, not be regarded as having a very high level of sensitivity, but would still have at least a moderate conservation value (Appendix A: Map 4).

Figure 12: The habitat contains a well-developed shrub layer which can be quite dense in many areas.

Figure 13: Dwarf karroid shrubs can also be abundant in some areas and is an indicator of disturbance.

Figure 14: Portions of this habitat contain an abundance of exotic weeds, also an indicator of disturbance.

Figure 15: Soils contain a high degree of calcrete and alluvial gravel which is considered the main ecological driver for this habitat.

Central woodland areas (consisting of deep sandy soils)

The central and northern portions of the site consist of deep sandy soils and these areas had also been most affected by transformation for crop irrigation. A few fragmented portions remain within the central portion of the site (Appendix A: Map 4). They are currently utilised as game breeding areas and should therefore also remain unaffected by the proposed mining operations. This habitat can be differentiated in terms of the soil conditions which consists of deep, sandy soils and which allows for a well-developed tree layer with fairly dense canopy to establish. This results in a quite tall and dense woodland habitat. A fairly well-developed grass layer also remains present.

These areas are fragmented and are no longer subjected to landscape ecological processes such as large herbivores, fire regime and migratory patterns. This causes some modification of these areas though they are still in a fairly good condition. The exception being a small remnant in the north eastern corner of the site which is small, isolated and clearly quite degraded. The habitat is fairly uniform but does contain many large and old trees which contributes towards its conservation value. The tree layer is dominated by *Vachellia erioloba* (Camel Thorn) which is also a protected species and many large and old specimens being present which have a high conservation value. Other trees and shrubs include *Ziziphus mucronata* and *Ehretia rigida*. The grass layer is dominated by species adapted to sandy soils such as *Eragrostis palles* and *Schmidtia pappophoroides*. Herbaceous species are abundant and include *Delosperma herbeum, Clematis brachiata, Menodora africana, Solanum supinum* and *Plinthus sericeus*. The protected geophyte, *Ammocharis coranica* also occurs in these deep sandy habitats and has a significant conservation value. Exotic weeds are largely absent, indicating a fairly good condition. The exception being the small remnant in the north eastern corner of the site which contains an abundance of weeds such as *Bidens bipinnata* and *Opuntia humifusa*, also a confirmation of the degraded condition of this remnant. Since these woodland areas will be excluded from mining operations only limited surveys were undertaken here and it is likely that the actual species diversity will be much higher. Species diversity is however regarded as still moderate.

In conclusion, the central woodland remnants are still natural and in fairly good condition. The habitat is relatively uniform but does contain elements of high conservation value, i.e. large and old specimens of the protected *Vachellia erioloba* as well as other protected plant species (Appendix A: Map 4). The habitat is regarded as having a moderate species diversity. According to the Free State Biodiversity Management Plan this habitat is also listed as an Other category which indicates that it is regarded as being only of moderate conservation value (Appendix A: Map 2). These areas will however be excluded from mining operations and should therefore remain unaffected.

Conclusions

From the description of the area given above it is clear that the majority of the site has been transformed by agricultural and mining operations (Appendix A: Map 1). This would therefore increase the conservation value of those portions of remaining natural vegetation, i.e. the less habitat remains, the rarer it will be, the higher the conservation value will become. However, when looking at available resources it is evident that the vegetation types on the site, Kimberley Thornveld and Highveld Alluvial Vegetation is not currently regarded as rare or endangered and still covers large areas of the region. This will therefore not contribute toward their conservation value. Furthermore, the Free State Province Biodiversity Management Plan (2015) regards the site as being of Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other categories and do not contain Critical Biodiversity Areas (CBA) which would be of high conservation value (Appendix A: Map 2). Despite this, natural areas do still contain some elements of conservation value such as a range of protected succulent and geophytic species and large and old specimens of the protected *Vachellia erioloba* (Camel Thorn).

From aerial imagery it is also evident how the area has progressively been transformed (Google Earth 2021, National Geo-Spatial Information 1957). This also indicates that those portions of remaining natural vegetation are still fairly similar in terms of vegetation composition although the woodlands areas has experienced a significant increase in tree canopy cover.

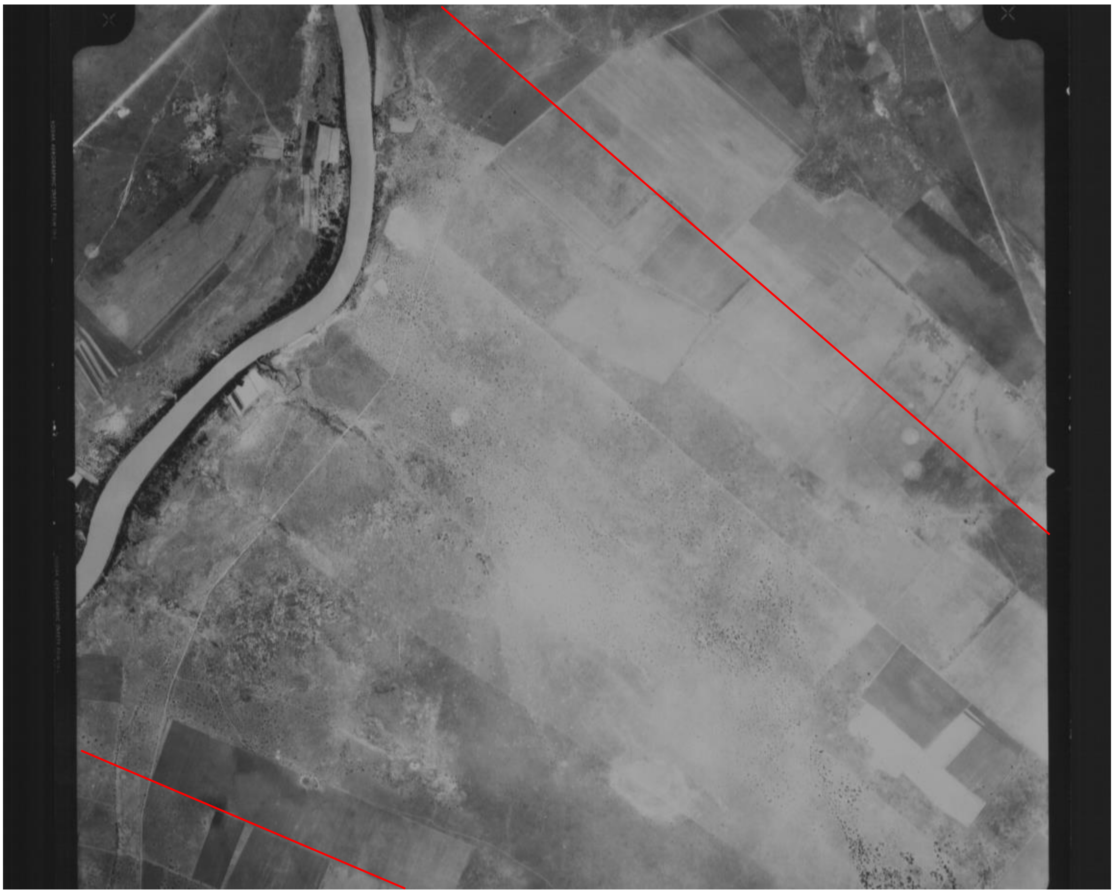


Figure 16: Historical imagery dating from 1957 (National Geo-Spatial Information) indicate a largely natural area though agricultural transformation is already evident. The southern portion contains a grass dominated vegetation cover while woodland is evident in the central and northern portions.

Figure 17: Aerial view of the recent condition of the study area (Google Earth 2021) which clearly indicates the large scale transformation of the area. The approximate extent of natural areas are indicated: Yellow – southern plains, Blue – western rocky areas, Green – central woodland areas.

Given the fairly low conservation value of remaining natural areas on the site, this will decease the impact that mining operations will have on the loss of habitat and species diversity. However, from previous mining operations it is also clear that mining operations cause significant impacts and result in the transformation of natural areas. By the nature of alluvial diamond mining, i.e. removal of the vegetation and modification of the soils profile, it results in the irreversible transformation of the ecosystem. However, given the fairly uniform soil conditions and habitats on the site and provided that comprehensive rehabilitation is undertaken, it may be possible to re-instate a somewhat similar vegetation composition after mining has ceased. This will also entail the re-instatement of the natural topography as far as possible as well as the correct management of topsoil. Mining also results in high levels of disturbance and consequently, the establishment of exotic weeds and invasive species and the eradication and monitoring of these should also form an important part of the management of mining and rehabilitation operations. The Vaal River, associated floodplain, watercourses and wetlands, also forming part of the study area, is however highly sensitive but will be discussed in detail in the following sections (Appendix A: Map 3 & 4).

Since it is clear that the impact of mining operations on natural areas will be high and will lead to irreversible transformation, mining should be confined to selected and limited areas and should not be implemented indiscriminately over the entire area. Furthermore, numerous protected plant species has been identified in remaining natural areas (Appendix B). These include the protected succulent and geophytic species, *Boophone distichia, Orbea lutea* subsp. *lutea, Aloe grandidentata, Raphionacme hirsuta* and *Ammocharis coranica*. Where mining will affect these species, the necessary permits should be obtained and a significant proportion of these transplanted to adjacent areas where they will remain unaffected. In addition, there is a high abundance of the protected *Vachellia erioloba* (Camel Thorn) in most of the remaining natural areas and these should be retained and excluded from mining as far as possible. Where any of these will require removal, the necessary permits should be obtained and replaced during the rehabilitation phase by means of saplings.

4.2 Overview of terrestrial fauna (actual & possible)

Signs and tracks of mammals are fairly abundant on the site though the mammal population will be quite modified from the natural condition. Natural vegetation has a high carrying capacity for mammals which decreases significantly where agriculture transforms this natural vegetation and in such agricultural areas the mammal population is normally represented by a generalist mammal population. Those portions of remaining natural areas on the site will still contain a natural mammal population but is also likely to be somewhat modified by the proximity of agricultural operations (Appendix A: Map 1). Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are also dependant on habitat in pristine condition. Though such habitats are largely absent from the site, there is still a likelihood that remaining natural areas may harbour species of high conservation value.

Wetland and riparian habitats associated with rivers generally provide higher abundance of resources and subsequently are also able to sustain a diverse and large mammal population (Appendix A: Map 3). This will also be the case for the Vaal River and associated riparian zone. Surrounding vegetation transformation by agriculture and mining as well as disturbance of the riparian zone will influence the mammal population along the river to some extent. Nonetheless, watercourses are able to sustain a higher bio-load which in turn supports a larger mammal population and it is likely that the mammal population along the river will be substantial. Should mining take place along the banks or main channel of the river the impact on mammals will be significant.

The mammal survey of the site was conducted by means of active searching and recording any tracks or signs of mammals and actual observations of mammals. From the survey the following actual observations of mammals were recorded:

- Soil mounds of the Common Molerat (*Cryptomys hottentotus*) were common in most areas of the study area. This is a widespread species which has even become adapted to urban areas. It is a generalist species anticipated to occur in this area.

- Scat most likely associated with Porcupines (*Hystrix africaeaustralis*) were noted along the Vaal River. This is also a generalist species, widespread and common in peri-urban areas. It is also able to inhabit disturbed habitats as occurs on the site.

- Scat of a small carnivore was observed on the site. Judging by the size and proximity to the Vaal River, it is most likely a Water Mongoose (*Atilax paludinosus*). This is a widespread species but is dependant on a watersource and therefore associated with the Vaal River.

- Several burrows of small mammals were noted which could not be identified but do indicate a significant mammal population in the area.

- Several burrows and excavation of Aardvark (*Oryteropus afer*) occur in the study area. This is also a fairly widespread and common species but is highly reclusive and is also listed as a protected species and is therefore of significant conservation value.

- Extensive colonies of Ground Squirrel (*Xerus inauris*) and Yellow Mongoose (*Cynictis penicillata*) occur in the study area. These are companion species which are widespread and common and found in most natural or disturbed habitats.

- Dung heaps of small antelope, most probably Steenbok (*Raphicerus campestris*) or Common Duiker (*Sylvicapra grimmia*), are also common. These species are both widespread but confined to fairly natural or agricultural areas and generally avoid urban areas.

- Scat of a Cape Clawless Otter (*Aonyx capensis*) was also found along the Vaal River. This is a rare and elusive species which is dependant on a perennial watersource and also requires an abundant prey base. It is also Red Listed as a Near Threatened (NT) species due to the decline in suitable habitat. Large numbers of the African Porcelain Mussel (*Corbicula fluminalis*), an uncommon species, also indicates a prey base for the Cape Clawless Otter.

- Several Warthog (*Phacochoerus africanus*) were noted, especially around agricultural fields. This species is considered invasive in this region and do not naturally occur here, having been brought in by game farms. They naturally occur only in northern bushveld regions of the country. They are known to cause significant damage to natural ecosystems where they have invaded the semi-arid regions of the country.

These species identified on the site indicate a significant diversity, which although dominated by widespread and generalist species, also contain species of higher conservation value. This also indicates that although the mammal population will be somewhat modified, it remains likely that other species of high conservation value will still be present.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. This will only be applicable where mining will affect the remaining natural areas on the site. In these instances the impact will however be at least moderate. Additional measures which will significantly mitigate this include 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, exclude the Vaal River and riparian zone from mining operations and comprehensive and successful rehabilitation of mined areas.

It is also considered likely that several mammal species were overlooked during the survey and it may also be likely that rare and endangered species may be present on the site.

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.

Mammals species likely to occur on the site has been determined by means of FitzPatrick Institute of African Ornithology (2021) as well as the species list for the nearby Sandveld Nature Reserve (Avenant & Watson 2002).

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

Common name	**Scientific name**	**Status**
Ground Pangolin	*Smutsia temminckii*	**Vulnerable (VU)**
Hedgehog	*Atelerix frontalis*	**Near Threatened (NT)**
Swamp Musk Shrew	*Crocidura mariquensis*	**Near Threatened (NT)**
African White-tailed Rat	*Mystromys albicaudatus*	**Vulnerable (VU)**
Southern African Vlei Rat	*Otomys auratus*	**Near Threatened (NT)**
African Clawless Otter	*Aonyx capensis*	**Near Threatened (NT)**
Black-footed Cat	*Felis nigripes*	**Vulnerable (VU)**
Brown Hyena	*Hyaena brunnea*	**Near Threatened (NT)**
Serval	*Leptailurus serval*	**Near Threatened (NT)**
African Striped Weasel	*Poecilogale albinucha*	**Near Threatened (NT)**

The survey has indicated that though the mammal population will consist largely of widespread, generalist species, it remains possible that some of these Red Listed species may occur in the area. Evidence of the Cape Clawless Otter was also confirmed along the Vaal River.

Table 3: Likely mammal species in the region.

Order	Common name	Scientific name	Status
Macroscelidea	Eastern Rock Elephant Shrew	*Elephantulus myurus*	
Chiroptera	African Straw-colored Fruit Bat	*Eidolon helvum*	
	Cape Serotine	*Neoromicia capensis*	
	Egyptian Slit-Faced Bat	*Nycteris thebaica*	
	Egyptian Free-tailed Bat	*Tadarida aegyptiaca*	
Primates	Vervet Monkey	*Chlorocebus pygerythrus*	
Pholidota	Ground Pangolin	*Smutsia temminckii*	**Vulnerable (VU)**
Lagomorpha	Cape Hare	*Lepus capensis*	
	Scrub Hare	*Lepus saxatilis*	
Insectivora	Hedgehog	*Atelerix frontalis*	**Near Threatened (NT)**
	Swamp Musk Shrew	*Crocidura mariquensis*	**Near Threatened (NT)**
	Lesser Dwarf Shrew	*Suncus vailla*	
Rodentia	Namaqua Rock Mouse	*Aethomys namaquensis*	
	Cape Molerat	*Cryptomys hottentotus*	
	Gray African Climbing Mouse	*Dendromus melanotis*	
	Highveld Gerbil	*Gerbilliscus brantsii*	
	Bushveld Gerbil	*Gerbilliscus leucogaster*	
	Paeba Hairy-footed Gerbil	*Gerbilliscus paeba*	
	African Dormouse	*Graphiurus murinus*	
	Porcupine	*Hystrix aficaeaustralis*	
	Southern African Mastomys	*Mastomys coucha*	
	Desert Pygmy Mouse	*Mus (Nannomys) indutus*	
	Southern African Pygmy Mouse	*Mus minutoides*	
	Large-eared African Desert Mouse	*Malacothrix typica*	
	African White-tailed Rat	*Mystromys albicaudatus*	**Vulnerable (VU)**
	Southern African Vlei Rat	*Otomys auratus*	**Near Threatened (NT)**
	Springhare	*Pedetes capensis*	
	Xeric Four-striped Grass Rat	*Rhabdomys pumilio*	

	Southern African Pouched Mouse	*Saccostomus campestis*	
	Ground Squirrel	*Xeris inauris*	
Carnivora	African Clawless Otter	*Aonyx capensis*	**Near Threatened (NT)**
	Marsh Mongoose	*Atilax paludinosus*	
	Black-backed Jackal	*Canis mesomelas*	
	Caracal	*Caracal caracal*	
	Yellow Mongoose	*Cynictis penicillata*	
	Wildcat	*Felis silvestris*	
	Black-footed Cat	*Felis nigripes*	**Vulnerable (VU)**
	Common Genet	*Genetta genetta*	
	Cape Genet	*Genetta tigrina*	
	Slender Mongoose	*Herpestes sanguineus*	
	Brown Hyena	*Hyaena brunnea*	**Near Threatened (NT)**
	Striped Polecat	*Ictonyx striatus*	
	Serval	*Leptailurus serval*	**Near Threatened (NT)**
	Honey Badger	*Mellivora capensis*	
	Bat-eared Fox	*Otocyon megalotis*	
	African Striped Weasel	*Poecilogale albinucha*	**Near Threatened (NT)**
	Aardwolf	*Proteles cistatus*	
	Meerkat	*Suicata silicatta*	
	Cape Fox	*Vulpes chama*	
Tubulidentata	Aardvark	*Orycteropus afer*	
Hyracoidea	Rock Hyrax	*Procavia capensis*	
Artiodactyla	Impala	*Aepyceros melampus*	
	Springbok	*Antidorcas marsupialis*	
	Gemsbok	*Oryx gazella*	
	Warthog	*Phacochoerus aethiopicus*	
	Steenbok	*Raphicerus campestris*	
	Southern Reedbuck	*Redunca arundinum*	
	Duiker	*Sylvicapra grimmia*	
	Eland	*Tragelaphus oryx*	
	Koedoe	*Tragelaphus strepsiceros*	

From historical records (Table 3) it is evident that the area contains a large amount of mammals and numerous Red Listed mammals. Many of the larger mammals are however historical records and would only be found within conservation areas, they are not of consequence to the development. The smaller Red Listed mammal species may still occur in the area, including the Black-footed Cat (*Felis nigripes*), Serval (*Leptailurus serval*), Southern African Vlei Rat (*Otomys auratus*), African Striped Weasel (*Poecilogale albinucha*), Ground

Pangolin (*Smutsia temminckii*), Hedgehog (*Atelerix frontalis*), Swamp Musk Shrew (*Crocidura ariquensis*), Brown Hyena (*Hyaena brunnea*) and African White-tailed Rat (*Mystromys albicaudatus*). As indicated, the Cape Clawless Otter listed as Near Threatened has already been confirmed to occur along the Vaal River. It therefore remains likely some of the other Red Listed mammals may also occur in the area.

Figure 18: Tracks and signs of mammals on the site include clockwise from top left; Burrow of an Aardvark (*Orycteropus afer*), Ground squirrels (*Xerus inauris*), burrow of an unidentified small mammal, scat along the Vaal River probably of a Water Mongoose (*Atilax paludinosus*), scat of Porcupine (*Hystrix africaeaustralis*), scat with a high shell content being that of a Cape Clawless Otter (*Aonyx capensis*), dungheap of a small antelope and a soil mound of the Common molerat (*Cryptomys hottentotus*).

4.3 Wetland Assessment

4.3.1 Introduction

The surface water of the area is dominated by the Vaal River which forms the western border of the proposed mining area (Appendix A: Map 3). The river will therefore form the main focus of the wetland assessment. A few small drainage lines are also present as well as a few small pan systems and these will also be included in the assessment.

The Vaal River flows from north east to south west along the border of the site (Appendix A: Map 3). It is a perennial system and flows throughout the year but has been heavily modified in terms of its flow and flooding regime by upstream containment dams. The river is also being used for extensive irrigation and water abstraction will also have a significant impact on it. The river contains a significant floodplain or riparian zone but varies in width along the section on the site. Generally the insides of bends have the widest floodplain while the outsides of bends have the narrowest floodplain. The floodplain has also been affected and modified by agricultural and mining operations.

A few small drainage lines occur in the western portion of the site where the slope increases slightly toward the Vaal River (Appendix A: Map 3). These drainage lines are quite small and generally without a defined main channel. However, due to the increase in surface runoff and seepage generated by irrigated areas and coupled with the construction of artificial berms and impoundments, these drainage lines do form wetland areas where they feed into the Vaal River. These drainage lines are however quite clearly seasonal and only flow for short periods during the rainy season.

As indicated, the terrestrial portion of the site has a flat topography and as a result watercourses are absent. However, this flat topography also promotes the formation of a few small pans or depressions (Appendix A: Map 3). They are quite small and vary between 70 and 120 meters in diameter. There is however one pan that is quite prominent and has an approximate diameter of 600 meters. All of these pans have been quite heavily affected by the surrounding agricultural operations.

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

Watercourse means:

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

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

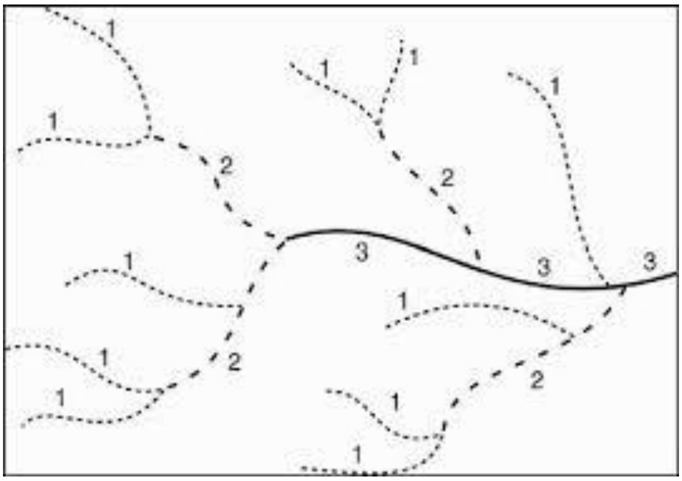


Figure 19: The classification of stream orders from 1 to 3 (Strahler 1952)

4.3.2 Wetland indicators

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

The Vaal River and its associated wetland conditions were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix C). Due to time constraints and the extent of the study area soil samples were only taken within sample points within the watercourses and wetlands to confirm the presence of wetland conditions. The following guidelines and frameworks were used to determine and delineate the watercourses and wetlands in the study area:

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

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River as well as associated drainage lines and pan systems (Appendix C). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils.

The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Appendix A: Map 3). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators with the Marginal Zone showing soil characters of a permanent zone of wetness. The upper zone contains a minimal grey matrix, no mottles and is not considered as being a wetland area. However, the marginal and lower zone of the Vaal River contains distinctive wetland soil indicators. The banks (Lower Zone) shows indications of a seasonal zone of wetness whilst the Marginal Zone shows soil characters of a permanent zone of wetness. The Vaal River and its banks are clearly defined and easily identifiable. The boundary of the floodplain is not easily identified due to previous transformation by agriculture and mining operations which makes accurate delineation of the riparian zone difficult. However, a few reference points could be determined and here the soils within the riparian zone or floodplain consists of fine, silty sediments with a lighter colour being deposited by large flooding events and can be differentiated from the adjacent terrestrial areas which contain reddish coloured sandy soils. Furthermore, where the riparian vegetation is still intact it can also be used to differentiate between the riparian zone and adjacent terrestrial areas. Where orchards, agricultural operations or previous mining activities has transformed the riparian zone a fairly accurate estimate of the natural extent of the riparian zone can still be made and when using historical imagery this also improves the accuracy of the delineation.

Three very small drainage lines area present on the site which drain from the terrestrial interior and into the Vaal River. These drainage lines range in length from approximately 800 meters to 1 500 meters. They generally do not contain a well defined main channel and wetland conditions are also absent along portions of their course. However, where impoundments occur in these systems and also the section located within the riparian zone of the Vaal River, wetland conditions become prominent. This may be coupled with the floodplain of the river but is also likely influenced by seepage and runoff from the surrounding irrigated areas.

A few small depressions or pans also occur in the terrestrial portion of the site. The five smaller pans are all heavily modified and degraded by the historical agricultural operations in the area. The larger pan is still largely intact though it is also clear that agricultural impacts cause significant degradation of this pan. In spite of the degraded condition of these pans, they all contain clear wetland conditions, albeit only on a seasonal basis. This was confirmed by both soil samples and obligate wetland vegetation.

In conclusion, the Vaal River banks clearly contains wetland conditions, while the floodplain is devoid of wetland conditions but still forms part of the riparian zone of the river (Appendix A: Map 3). However, where small drainage lines or impoundments occur near the river, wetland conditions have also formed. The upper portions of these drainage lines are largely devoid of wetland conditions though they must be regarded as forming watercourses over their entire length. A few small pans systems all contain clear wetland conditions despite being heavily degraded.

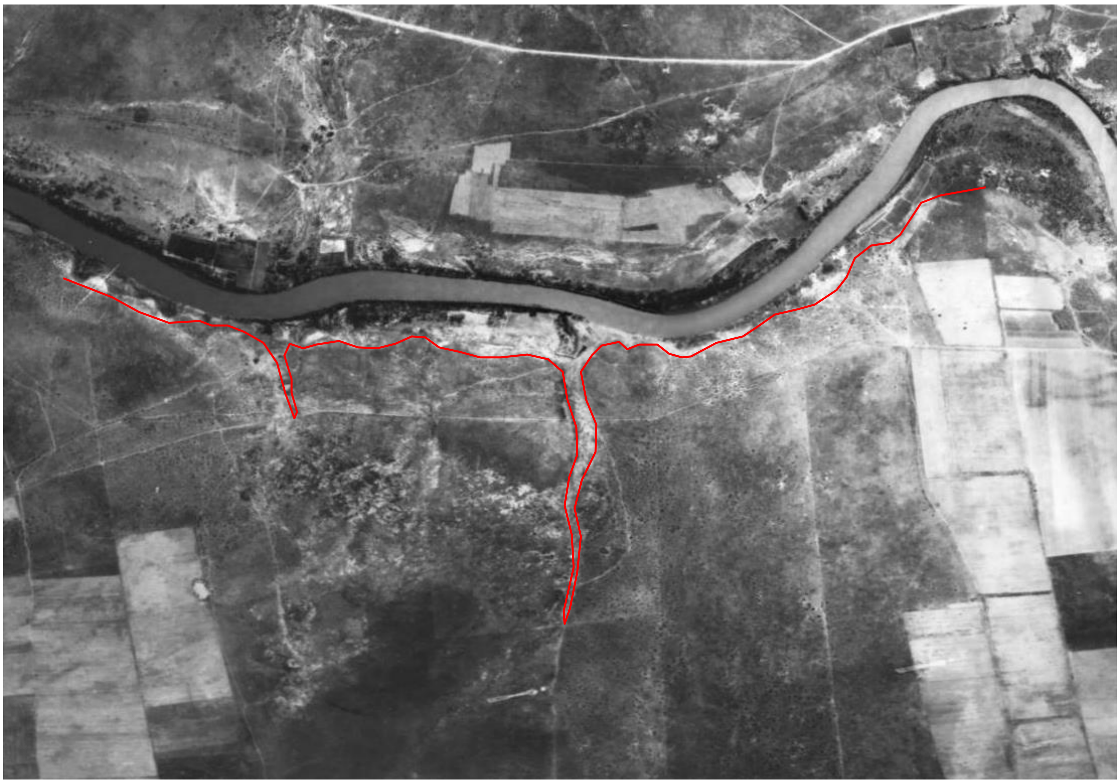


Figure 20: Delineation of wetland and watercourses and especially the riparian zone of the Vaal River was improved by combining it with historical imagery (National Geo-Spatial Information 1957).

4.3.3 Classification of wetland systems

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

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

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

This accurately describes the wetland conditions along the Vaal River (Appendix A: Map 3). Here the wetland conditions are most prominent along the main channel and decrease in distance from the channel.

Where wetland conditions occur in the floodplain of the Vaal River, including where drainage lines flow into the river the wetland conditions can be regarded as forming a floodplain wetland (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 described the wetland conditions which occur within the floodplain of the Vaal River (Appendix A: Map 3). These wetland conditions may also have been influenced by agricultural and mining modifications in the floodplain where excavations and modification of the surface topography now cause the accumulation of runoff and consequently wetland conditions form.

The small pan systems in the study area can be categorised as 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 is an accurate description of these pans and their functioning. They are all circular forming a very shallow but discernible depression in the landscape (Appendix A: Map 3). The survey indicated that the most likely reasons for the formation of these pans are the flat topography of the terrestrial interior of the site and underlying calcrete bedrock which prevents infiltration. These pans are all endorheic (without outflow).

4.3.4 Description of the Vaal River

The Vaal River was surveyed by four separate locations along the section adjacent to the site (Appendix A: Map 3). The length of river included in the study area is relatively long, approximately 6.5 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 river in the study area, especially the floodplain, is quite variable in terms of geomorphology though the main channel, vegetation structure and species composition remain relatively similar.

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 31). The marginal zone of the river is considered to be largely intact in terms of the geomorphology although the vegetation structure is modified to a large degree. The geomorphology of the marginal zone consists of a very narrow strip along the main channel, uniform along the study area, which does not contain any extensive rocky, braided or marshy areas. As a result extensive wetland areas are also absent and at least in this stretch no significant wetland habitat is present and the purification functioning of the river is relatively low. The stretch at the site as well as upstream contain extensive centre-pivot irrigation areas and these are associated with high nutrient values originating from fertiliser runoff. The high nutrient levels in the river promote the proliferation of reedbeds (*Phragmites australis*). These are indigenous reeds but where high nutrient values and slow flow occurs they proliferate greatly to the point where they exclude most other vegetation and this has also occurred on the site which is considered a significant modification of the vegetation in the marginal zone and to some extent also the lower zone. Vegetation in the marginal zone is therefore dominated almost exclusively by the reed, *Phragmites australis*. Scattered specimens of exotic weeds are also present and include *Argemone ochroleuca* and *Oenothera rosea*. It is evident that the marginal zone is very low in species diversity, uniform and quite significantly affected by upstream impacts.

Figure 21: View of the banks of the Vaal River in the study area with the different zonation clearly visible: Marginal (red), Lower (yellow) and Upper Zones (blue).

Figure 22: The marginal zone of the river is almost exclusively dominated by reedbeds of the indigenous reed, *Phragmites australis*. This indicates a regulated flow regime and high levels of nutrients.

Figure 23: View of the marginal zone (red) in the north eastern portion of the study area. Note dense reedbeds and very narrow 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 31). The lower zone is also quite narrow, though somewhat broader than the marginal zone. Its borders are also well defined and it is an easily distinguished zone. It is quite steep and narrow and has a clear border with the upper zone where the slope levels off into a more gradual slope. Its geomorphology is also considered to still be mostly intact though the riparian vegetation is also considered modified to some degree by upstream impacts on the river, though somewhat less so than the marginal zone. The lower zone is inundated less frequently though still annually during flooding. As a result, reedbeds (*Phragmites* australis) are also able to establish at the lower border of the lower zone. Its density and extent is however lower than in the marginal zone and consequently a few other species also occur and the vegetation becomes dominated by pioneer, riparian grasses toward the upper border of the zone. This riparian grass layer is dominated by *Cynodon dactylon*, a pioneer grass often dominant along riverbanks. The cosmopolitan weeds, *Phyla nodiflora* is also abundant in the lower zone, it often forms thick mats along riverbanks and dams. Along the upper border of the lower zone a few shrubs such as *Asparagus larcinus* and riparian trees such as *Vachellia karroo* have become established. A few specimens of the protected geophyte, *Crinum bulbisepermum* were also noted. Exotic weeds are present though not abundant and also include *Argemone ochroleuca*.

Figure 24: The lower zone is dominated by the pioneer grass, *Cynodon dactylon*.

Figure 25: The lower zone (red) is also quite narrow though steep and is dominated in the lower portion by reeds (*Phragmites australis*) and riparian grass (*Cynodon dactylon*). Note also how it clearly levels off into the upper zone.

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 31). The upper zone is extensive and very broad in the majority of the study area. A few sections also occur where it becomes quite narrow. The zone is dominated by riparian thicket. The border between the upper- and lower zones are clearly visible as a drastic decease in slope gradient with the upper zone having a much more gradual slope. The border between the upper zone and surrounding terrestrial areas are much less clear, especially where mining and agriculture has transformed the topography but can still be distinguished by soils and riparian vegetation and combining this with historical aerial imagery. Soils within the riparian zone or floodplain consists of fine, silty sediments with a lighter colour being deposited by large flooding events and can be differentiated from the adjacent terrestrial areas which contain fine but more sandy soils with a light but more reddish colouration. The upper zone is also synonymous with the floodplain of the river and therefore also represents the riparian zone (Map 1). In general, the upper zone has been degraded to a significant degree. Large portions of the upper zone has been transformed by orchards of pecan nut trees, while significant portions have also been modified by previous mining activities, especially the north eastern corner of the site. Other impacts include a range of surface disturbances such as small excavations, impoundments, buildings, tracks and activities associated with the agricultural operations in the area. Where the riparian thicket is still intact it is also quite heavily degraded and dominated in many areas by the exotic Red River Gum (*Eucalyptus camaldulensis*) which is well known to have allelopathic and shading effects on natural vegetation and consequently the species diversity in these areas are quite low, further degrading the condition of the upper zone. The riparian tree species within the upper zone is dominated by *Searsia lancea, Vachellia karroo, Ziziphus mucronata, Diospyros lycioides, Lycium arenicola* and *Lycium hirsutum*. Other common shrubs also include *Grewia flava, Asparagus larcinus* and *Gymnosporia buxiifolia*. Several of these are considered riparian species in this region. The understorey is quite sparse and dominated by a few grass and herbaceous species. Grasses include *Cynodon dactylon, Eragrostis trichophora, Aristida congesta, Setaria certicillata* and *Chloris virgata*. A range of pioneer herbaceous species are also present and include *Gomphocarpus fruticosus, Pavonia burchellii* and *Arctotis arctotoides*. As mentioned, exotic and invasive tree species may be dominant in some areas, especially the Red River Gum (*Eucalyptus camaldulensis*) though several others are also prominent and include *Gleditsia triacanthos.* Exotic weeds are also quite abundant in most areas, especially in close proximity to irrigation areas. These include *Bidens bipinnata, Verbena bonariensis* and *Tagetes minuta*.

The upper zone forms part of the floodplain of the river but does not contain wetland conditions. However, several areas occur where wetland conditions has formed in the floodplain, mostly associated with areas where lateral drainage lines flow into the Vaal River. These wetland conditions may also have been influenced by agricultural and mining modifications in the floodplain where excavations and modification of the surface topography now cause the accumulation of runoff and consequently wetland conditions form. Here, clear wetland conditions has manifested, forming floodplain wetland areas. Both the soil samples and vegetation also confirm these wetland conditions. Wetland vegetation include reedbeds, *Phragmites australis,* dense stands of Bulrush, *Typha capensis,* rushes, *Juncus rigidus*, wetland grasses, *Paspalum distichum* and semi-aquatic ferns, *Marsilea sp.* In addition, and especially where disturbance is significant, a variety of exotic weeds are also abundant. These include *Polypogon mospeliensis, Calbrochoa parvifolia, Oenothera rosea, Plantago lanceolata, Cirsium vulgare, Tamarix ramosissimum* and *Veronica anagalis-aquatica*.

Figure 26: The upper zone is most obviously discernible as a decrease in the slope gradient and a significant increase in the riparian thicket component.

Figure 27: The riparian thicket can also become quite thick in many parts of the upper zone or floodplain.

Figure 28: The upper zone along large portions of the site the riparian thicket is dominated by exotic *Eucalyptus camaldulensis* trees.

Figure 29: Large portions of the riparian zone or floodplain has also been transformed by orchards of pecan nut trees.

Figure 30: Within the floodplain, especially where lateral drainage lines flow into the Vaal River, prominent wetland areas has formed.

Habitat and species diversity is considered quite low which is normally not the case along large watercourses. This is in part a result of upstream impacts on the river but also due to agriculture, irrigation and previous mining operations in the floodplain and in close proximity of the river. The habitat and banks of the river is rather uniform and species diversity is very low in many areas. However, the functioning and habitat provided by the river and its floodplain should still be regarded as important and highly sensitive.

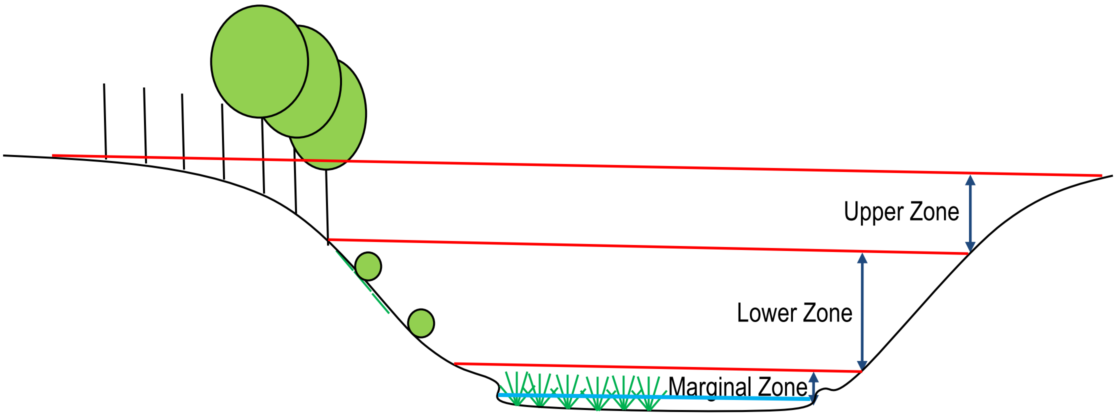


Figure 31: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation along the entire river section and also illustrates its rather uniform nature in this section.

4.3.5 Condition and importance of the affected watercourses

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section forming part of the study area (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system. The Vaal River will form the main recipient of impacts caused by the proposed mining operations with all other drainage lines flowing into it and will also affect the same downstream section of the Vaal River. Therefore, one IHI will be conducted for the Vaal River to represent the overall condition of the river and associated drainage lines on the site. This is considered to give a good representation of the condition of the Vaal River system within the study area. The IHI will be taken as representative of the Present Ecological State (PES) of this system.

In addition, the pans or depressions on the site form isolated wetland systems which are not associated with the Vaal River. In order to provide an indication of the condition of these pans, a WET-Health determination will be done for the large pan occurring in the central portion of the site. The WET-Health will be taken as representative of the Present Ecological State (PES) of this system (Appendix D).

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).

Ecological 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/wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains/wetlands are 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 Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains/wetlands 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/wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains/wetlands 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.	>1 and <=2	C

Low/marginal Floodplains/wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains/wetlands are ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

According to Kleynhans (2000) a desktop assessment of the Vaal River in the study area and which will be affected by mining operations is considered to have a PES of Category D: Largely Modified. More recent desktop assessments (Van Deventer *et al* 2018) also confirm this assessment. On-site observation indicate that this is relatively accurate, as this study has also calculated the river as having a PES of Category D: Largely Modified. A large loss of natural habitat, biota and basic ecosystem function has occurred. 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 (Appendix A: Map 4).

The section of the Vaal River within the study area is considered to be largely 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. The magnitude of floods is also controlled and much diminished from the natural condition and are no longer able to clear reedbeds which essentially start to choke the flow of the river and cause a significant decrease in species diversity. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site as well as previous mining which had taken place in the study area. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. 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 several portions of the site also having been affected by previous mining. These areas area clearly quite degraded and transformed. This has also caused the clearance of vegetation but also the transformation of the natural soil profile and topography which results in the complete transformation of the natural ecosystem in these areas. In these areas a pioneer vegetation layer has been able to re-establish but is not a good representation of the natural vegetation in this area. Centre-pivot irrigation is the main land use on the site and is also abundant upstream and downstream as well. This has visibly had a high impact on the river as a result of fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. Algae blooms are evident within the main channel of the river and will have a high impact on the aquatic component of the river. The terrestrial portion of the study area has also been transformed to a large extent by centre-pivot irrigation. This causes the direct loss of surface vegetation, modification of runoff patterns and the transformation of the ecosystem. In addition, the indirect impacts are also quite substantial where fertiliser causes the enrichment of downslope areas and the consequent modification of the vegetation composition. Continuous irrigation also increases surface flow and groundwater seepage and this clearly contributes to the modification of wetland and drainage areas.

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix D). This is also due to the river being a large lowland river. The quaternary catchment of this area is C91D. The largest impact on the site itself is considered agricultural transformation and irrigation followed by previous alluvial diamond mining which has had a high impact on the site. Consequently the majority of the site has been transformed from the natural vegetation typ. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are centre-pivot irrigation, alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified. This is largely due to the change in flooding regime and other significant impacts such as centre-pivot irrigation and previous alluvial diamond mining within the study area.

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.

According to previous desktop assessments (Kleynhans 2000, Van Deventer *et al* 2018) the large pan situated in the central portion of the site is considered to have a PES of Category A/B: Natural to Largely Natural. The current survey has however determined that this is significantly overestimated. The pan itself is largely still natural though a large gravel road transects the central portion of the pan and will result in several significant impacts. The largest impact on the pan is however undoubtedly several large centre-pivot irrigation fields in close proximity to it. This clearly results in an increase in the nutrient input of the pan which causes a significant modification in the vegetation composition of the pan. The natural vegetation within and around the pan consists of riparian grasses and a variety of small dwarf shrubs adapted to the higher salt concentrations around the pan. The increase in nutrients now result in the establishment of reedbeds and other wetland vegetation such as rushes along the periphery of the pan, especially along that side bordering the centre-pivots. These centre-pivots has also removed the natural vegetation which promotes runoff while decreasing infiltration and in so doing increases surface erosion. This mainly increase the sediment load being deposited within the pan and may, to some degree, also increases erosion around the periphery of the pan. Coupled with the crop cultivation will also be fertiliser, pesticide and herbicide runoff. This will mainly have an impact on nutrient load which may influence the riparian vegetation composition around the pan. In addition, surface runoff and groundwater seepage from the centre-pivots will also alter the hydrology of the pan in that this will increase the inflow into it.

From the above described impacts it should be clear that the pan system is subjected to significant impacts associated with the irrigation in the catchment. A WET-Health determination was undertaken for the pan which forms part of the study area to determine its current condition given the impacts affecting it (Appendix D). The results of the WET-Health indicated an overall Present Ecological State of Category C: Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged. This is considered relatively accurate given the significant impacts affecting it.

The EI&S of the pan system has been rated as being Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands 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. This is a result of the relatively unique habitats the pan supports and a moderate species diversity but which does not exceed moderate EI&S as it has been modified to a significant degree.

4.2.6 Description of watercourses and wetlands

A comprehensive description has been provided for the Vaal River and its associated floodplain/riparian zone in previous sections. However, as indicated, a few small drainage lines with associated wetland conditions and a few small pan systems also form part of the study areas. A short description of each of these will be provided below (Table 6). Note that where several drainage lines or small pans occur in close proximity that only one is included in the discussion to serve as representative of the surrounding similar systems.

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

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

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

- Van Ginkel, C.E. & Cilliers, C.J. 2020. Aquatic and wetland plants of Southern Africa. Briza Publications, Pretoria.

Table 6: Description of the individual watercourses and wetlands which forms part of the study area (Appendix A: Map 1 & 3) (FW – Facultative wetland species, OW – Obligate wetland species, * - Exotic species).

Watercourse name: #1 Seasonal drainage line – small southern tributary of the Vaal River	**Coordinates of sampling:** S 27.972185°, E 25.112935° S 27.971276°, E 25.112209°	**Flow regime:** Seasonal drainage line
Description of watercourse: This is a small drainage lines located in the southern portion of the study area and which drains into the Vaal River (Appendix A: Map 3). It is taken here as representative of two adjacent drainage lines of similar size and in close proximity to each other. These three drainage lines vary in length from 250 meters to 800 meters and they all drain across the riparian zone or floodplain of the river. The drainage lines are therefore fed by runoff generated in the terrestrial portion of the study area. Any impacts that will affect these drainage lines will affect the Vaal River into which they feed. All three drainage lines are surrounded by irrigated centre-pivots		

and pecan nut orchards and these clearly cause significant modification of these drainage lines. Increased runoff from this irrigation clearly increase the establishment of wetland conditions and higher nutrient load and disturbance caused by agriculture also contribute to the establishment of exotic weeds in these drainage lines. These drainage lines will function on a seasonal basis and will contain wetland conditions during the rainy season while continuous flow will only take place during large rainfall events which will flush these drainage lines. Flow will also only occur for short periods, whereafter saturated soils and pools will be maintained, at least during the rainy season. Soil within these drainage lines clearly contain seasonal wetland conditions with a grey matrix and prominent mottling. These wetland condition however clearly decrease upstream and at their origin wetland conditions may not be clearly visible. This is also substantiated by the vegetation along these drainage lines where the upstream sections contain riparian trees but no wetland grasses and sedges. As these drainage lines flow downstream toward the Vaal River, the occurrence of wetland plants steadily increase and those portions occurring within the floodplain or riparian zone of the Vaal River contain clear and quite extensive wetland conditions. The main channel is not clear over the entire course of the drainage lines and is also influenced in some areas by agricultural operations, including roads, impoundments and associated activities. Where a main channel is discernible it is fairly broad, but shallow, with the main channel containing hygrophilous grasses and sedges, while the banks are dominated by riparian trees. As indicated, due to relatively high levels of disturbance the drainage lines contain a large amount of exotic weeds.
Dominant plant species: Bank – *Ziziphus mucronata, Gymnosporia buxiifolia, Eragrostis trichophora, Salix mucronata, Diospyros lycioides.* Main channel: *Ranunculus multifidus, Juncus rigidus* (OW), *Marsilea sp.* (OW), *Paspalum distichum* (OW), *Phragmites australis* (OW). Exotic weeds: *Oenothera rosea, Plantago lanceolata, Cirsium vulgare, Polypogon monspeliensis, Calibrochoa parvifolia*.
Protected plant species: None observed.
Soil sample:

The upper reaches of the drainage line contains a defined main channel although wetland conditions are not prominent.

As drainage lines near the riparian zone of the Vaal River, wetland conditions become much more prominent.

The downstream sections of the drainage lines, occurring in the floodplain of the Vaal River, contain clear wetland conditions though a main channel is shallow and not distinct.

Watercourse name:	**Coordinates of sampling:**	**Flow regime:**
#2 Seasonal drainage line – small central tributary of the Vaal River	S 27.960901°, E 25.135397° S 27.949621°, E 25.133513° S 27.950796°, E 25.132575°	Seasonal drainage line

Description of watercourse:

This is a small drainage line located in the central portion of the study area and which drains into the Vaal River (Appendix A: Map 3). It is taken here as representative of two drainage lines located adjacent to each other, are similar in size and in close proximity to each other. These two drainage lines vary in length from 700 meters to 1 400 meters and both drain across the riparian zone or floodplain of the river. The drainage lines are therefore fed by runoff generated in the terrestrial portion of the study area. Any impacts that will affect these drainage lines will affect the Vaal River into which they feed. Both drainage lines are surrounded by irrigated centre-pivots and pecan nut orchards and these clearly cause significant modification of these drainage lines. Increased runoff from this irrigation clearly increase the establishment of wetland conditions and higher nutrient load and disturbance caused by agriculture also contribute to the establishment of exotic weeds in these drainage lines. Previous mining operations around the southern drainage line will also contribute additional impacts.

These drainage lines will function on a seasonal basis and will contain wetland conditions during the rainy season while continuous flow will only take place during large rainfall events which will flush these drainage lines. Flow will also only occur for short periods, whereafter saturated soils and pools will be maintained, at least during the rainy season.

Soil within these drainage lines clearly contain seasonal wetland conditions with a grey matrix and prominent mottling. These wetland condition however clearly decrease upstream and at their origin wetland conditions may not be clearly visible. This is also substantiated by the vegetation along these drainage lines where the upstream sections contain riparian trees but no wetland grasses and sedges. As these drainage lines flow downstream toward the Vaal River, the occurrence of wetland plants steadily increase and those portions occurring within the floodplain or riparian zone of the Vaal River contain clear and quite extensive wetland conditions. The main channel is not clear over the entire course of the drainage lines and is also influenced in some areas by agricultural operations, including roads, impoundments and

associated activities. Where a main channel is discernible it is fairly broad, but shallow, with the main channel containing hygrophilous grasses and sedges, while the banks are dominated by riparian trees. As indicated, due to relatively high levels of disturbance the drainage lines contain a large amount of exotic weeds.
Dominant plant species: Bank – *Vachellia karroo, Diospyros lycioides, Pentzia globosa, Tarchonanthus camphoratus, Aloe grandidentata.* Main channel: *Ranunculus multifidus, Juncus rigidus* (OW), *Phragmites australis* (OW), *Typha capensis* (OW), *Sonchus oleraceus, Breula erecta* (OW). Exotic weeds: *Oenothera rosea, Plantago lanceolata, Cirsium vulgare, Polypogon monspeliensis, Calibrochoa parvifolia, Tamarix ramosissimum, Eucalyptus camaldulensis*
Protected plant species: *Aloe grandidentata*.
Soil sample: 
 The upstream sections of the drainage lines are not well defined but are visible as low points in the landscape.

The downstream sections of the drainage lines contain clearer wetland conditions with riparian trees along the banks.

The sections of the drainage lines occurring in the floodplain of the Vaal River contain quite extensive wetland conditions.

Over the course of the drainage lines they are affected by a range of agricultural operations.

Watercourse name: #3 Large pan – Central depression wetland	**Coordinates of sampling:** S 27.981719°, E 25.152055°	**Flow regime:** Seasonal depression wetland
Description of watercourse: The terrestrial interior of the study areas is relatively flat and consequently several areas have		

a low surface flow and are inward draining which leads to the formation of small pans or depressions (Appendix A: Map 3). These are circular in shape and are readily identifiable as depressions. The underlying calcrete also likely contributes to the accumulation of surface water. None of the pans surveyed contained any visible surface water or inundation though signs are present that indicate they may become inundated for short periods after heavy rainfall. The large pan located in the central portion of the site is however clearly saturated on a seasonal basis. The functioning of these pans and the climate of the region also promote evaporation and high salt concentrations in these pans which sustain the presence of several salt loving plants or halophytes. The larger central pan also still provide important ecosystem functions including unique habitat, groundwater recharge and higher biomass when compared to the surrounding habitats. The large central pan is however quite visibly degraded. The pan itself is largely still natural though a large gravel road transects the central portion of the site and will result in several significant impacts. The largest impact on the pan is however undoubtedly several large centre-pivot irrigation fields in close proximity to it. This clearly results in an increase in the nutrient input of the pan which causes a significant modification in the vegetation composition of the pan. The increase in nutrients now result in the establishment of reedbeds and other wetland vegetation such as rushes along the periphery of the pan, especially along that side bordering the centre-pivots. These centre-pivots has also removed the natural vegetation which promotes runoff while decreasing infiltration and in so doing increases surface erosion. This mainly increase the sediment load being deposited within the pan and may, to some degree, also increases erosion around the periphery of the pan. Coupled with the crop cultivation will also be fertiliser, pesticide and herbicide runoff. This will mainly have an impact on nutrient load which may influence the riparian vegetation composition around the pan. In addition, surface runoff and groundwater seepage from the centre-pivots will also alter the hydrology of the pan in that this will increase the inflow into it. The pan has an approximate diameter of 560 meters. This large pan forms a depositional feature whereby surface flow is contained and sediment deposition takes place. Soils within the pan consist of fine silty clays, with a prominent grey matrix and feint mottling which indicate the presence of at least seasonal wetland conditions. The pan also contains a quite significant species diversity and indicates that it provides relatively unique habitat. Vegetation largely consists of riparian grasses and a variety of small dwarf shrubs adapted to the higher salt concentrations around the pan. However, on the side bordering adjacent irrigation areas it was notable that vegetation consists of wetland reeds and rushes and is clearly a consequence of increased seepage resulting from the irrigation as well as a higher nutrient load. This also gives an indication of the significant modification that the irrigation causes. A few exotic weeds and invasive plants also confirm a somewhat degraded condition.
Dominant plant species: *Panicum coromandelianus, Eragrostis bicolor, Phragmites australis* (OW), *Cynodon dactylon, Berkheya macrocephala, Juncus rigidus* (OW), *Geigeria filifolia, Pentzia calcarea, Albuca sp., Ledebouria sp., Fingerhuthia africana, Commicarpus pentandrus, Pegolettia retrofracta, Hermannia linearifolia, Leucas capensis, Stipagrostis uniplumis, Litogyne gariepina, Ziziphus mucronata, Hypertelis cerviana, Chrysocoma ciliata, Hermbstaedtia odorata, Lophiocarpus polystachyus, Diospyros lycioides.* Exotic weeds: *Cylindropuntia imbricata, Datura ferox*.
Protected plant species:

None observed.

Soil sample:

The pan is farily large and within the interior basin dominated by hygrophilous grasses.

The pan has a well defined edge or shore.

The side of the pan bordering on irrigation areas has a much more defined wetland component, a consequence of runoff and seepage from ittigation areas.

Watercourse name: #4 Small pan – Southern depression wetland	**Coordinates of sampling:** S 29.177429°, E 23.320270°	**Flow regime:** Seasonal depression wetland

Description of watercourse:

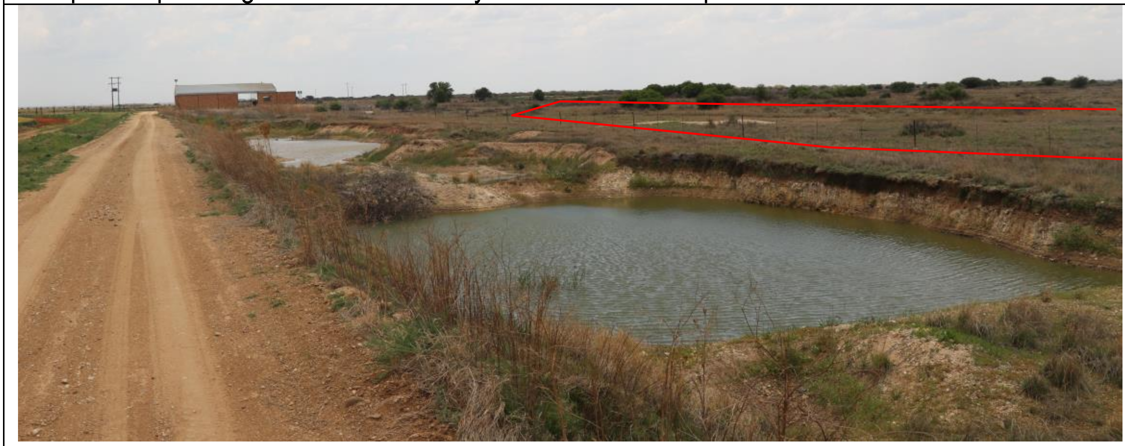
The terrestrial interior of the study areas is relatively flat and consequently several areas have a low surface flow and are inward draining which leads to the formation of small pans or depressions (Appendix A: Map 3). These are circular in shape and are readily identifiable as depressions. The underlying calcrete also likely contributes to the accumulation of surface water. None of the pans surveyed contained any visible surface water or inundation though signs are present that indicate they may become inundated for short periods after heavy rainfall. A small pan occurs in the south of the study area which is regarded to become saturated on a seasonal basis. The pan is quite small and has been quite heavily modified by surrounding agricultural operations. This also decreases its conservation value since the ecosystem function will be modified, degradation of the available habitat and ability to sustain a significant biomass will be compromised. However, it will still function in terms of groundwater recharge which should be preserved. The specific pan is situated near the southern border of the study area and is taken as representative of several similar small pans in the surroundings but which could not be accessed as they form part of a fenced game area. They are assumed to be similar in shape, condition and function as this pan. These small pans are all similar in size at approximately 150 meters in diameter.

These small pans form depositional features whereby surface flow is contained and sediment deposition takes place. Consequently, soils contain a higher degree of fine sediments, sand, loam and gravel. Despite their small size the soils still contain indicators of wetland conditions. The topography and shape of the depression, vegetation composition and functioning also serve as further confirmation that it forms a small pan or depression wetland. The vegetation composition is still representative of such a pan system, containing many hygrophilous grasses, but also quite visibly degraded from the anticipated natural condition.

Dominant plant species:

Platycarphella parvifolia, Leptochloa fusca (OW), *Amaranthus sp., Cullen tomentosum, Cynodon dactylon* (FW), *Stachys spatulata, Gomphocarpus fruticosus.*

Exotic weeds: None observed.

Protected plant species: None observed.
Soil sample: 
 The pan is quite degraded but still easily discirnible as a depression wetland.
 Large excavations adjacent to the pan (red) will result in large impacts, especially in terms of the hydrology of the pan.

Watercourse name:	**Coordinates of sampling:**	**Flow regime:**
#5 Two small pans – North eastern depression wetland	S 27.980491°, E 25.197254° S 27.982354°, E 25.197713°	Seasonal depression wetland
Description of watercourse: The terrestrial interior of the study areas is relatively flat and consequently several areas have a low surface flow and are inward draining which leads to the formation of small pans or depressions (Appendix A: Map 3). These are circular in shape and are readily identifiable as		

depressions. The underlying calcrete also likely contributes to the accumulation of surface water. None of the pans surveyed contained any visible surface water or inundation though signs are present that indicate they may become inundated for short periods after heavy rainfall. Two very small pans occur adjacent to each other in the north eastern corner of the study area. They are clearly saturated on a seasonal basis. Both these pans are quite heavily degraded and modified by surrounding agricultural operations. This also decreases their conservation value since the ecosystem function will be modified, degradation of the available habitat and ability to sustain a significant biomass will be compromised. However, they will still function in terms of groundwater recharge which should be preserved. These small pans are all similar in size at approximately 100 meters in diameter. These small pans form depositional features whereby surface flow is contained and sediment deposition takes place. Consequently, soils contain a higher degree of fine sediments, sand, loam and gravel. Despite their small size the soils still contain indicators of wetland conditions. The topography and shape of the depression, vegetation composition and functioning also serve as further confirmation that it forms a small pan or depression wetland. The vegetation composition is still representative of such a pan system, containing many hygrophilous grasses, but also quite visibly degraded from the anticipated natural condition.
Dominant plant species: *Paspalum distichum* (OW), *Cynodon dactylon* (FW), *Cotula anthemoides, Nidorella resedifolia.* Exotic weeds: *Polygonum aviculare, Nidens bipinnata.*
Protected plant species: None observed.
Soil sample:  

The pan is clearly quite small but forms well-defined depression wetland.

The adjacent pan is also clearly visible though heavily degraded by the artificial building of the surrounding pan edge.

It is highly likely that the more degraded of the two pans was previously used as containment dam.

4.3.7 Risk Assessment

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's (DWS) requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Activities likely to be associated with the mining operations and which will likely affect the Vaal River and associated wetlands include mining in close proximity to the river (floodplain/riparian zone) and mining within the main channel or banks of the river (Appendix A: Map 3). There is also a likelihood that infrastructure such as roads, pipelines and powerlines may be placed within the floodplain of the river. These activities may also affect the small lateral drainage lines and depression areas. Should a Section 21 (c) & (i) Water Use License Application (WULA) indicate additional activities these should be assessed and added to the Risk Assessment. Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS

Where the risk assessment refers to mining operations in close proximity to watercourses and wetland this refers to the regulated area as stipulated by DWS, i.e. within the floodplain or riparian zone or within 100 meters of the edge of a watercourse. This is also applicable to the small depressions occurring in the study area.

Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Although a comprehensive rehabilitation and monitoring regime may decrease this risk it is still unlikely to ensure the re-establishment of current natural functioning. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible. The current mine plan also indicates that mining operations will exclude the main channel and banks of the Vaal River from mining operations.

As in the previous paragraph, should mining occur within any of the lateral drainage lines, this will also entail a high risk and should therefore be avoided. These drainage lines feed into the Vaal River and clearly also contains extensive wetland conditions and any direct impacts on these drainage lines will also have a large impact on the Vaal River itself.

Although the small pan systems in the study area are not connected to the Vaal River, they still have important functions in terms of unique habitat, groundwater recharge and higher biomass when compared to the surrounding habitats. Should any mining take place within these pans this will also entail a high risk and consequently should also be excluded from mining operations.

Mining in close proximity to the Vaal River or within the floodplain and riparian zone will still result in significant impacts. This is also applicable to the lateral drainage lines and small depressions or pans occurring in the study area. Mining operations in close proximity to any of these systems are 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 impacts can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of these systems is likely.

Mining operations will also include haul roads and other infrastructure such as pipelines and powerlines and where these occur within the floodplain or riparian zone of the river, or across any of the lateral drainage lines or pan systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. The design of these structures should be such that they minimise the obstruction of flow and disturbance of the floodplain, watercourses and pan systems.

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

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

Mitigation as recommended should be implemented as far as possible which should considerably alleviate the risks on the Vaal River and associated floodplain, lateral drainage lines and pan systems in the study area.

For the complete risk assessment please refer to Appendix E.

No.	Phases	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	Mostly Operational Phase but extending long after closure	Mining within or on the banks of the Vaal River	Mining within the main channel or the banks of the Vaal River will remove riparian vegetation, transform the soils profile and in so doing the hydrology, geomorphology, flow and flooding regime. Due to the larger volume of water transportation and general higher level of ecosystems services of the Vaal River this risk is anticipated to be higher. It is however less probable to influence the larger hydrological functioning and will impact higher at a localised scale. Increased establishment of exotic weeds and invaders due to disturbance caused by mining is also probable.	H	80	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, the Vaal River and associated floodplain will be excluded from mining operations as far as possible.
	Mostly Operational Phase but extending long after closure	Mining within lateral drainage lines or pan systems in the study area.	Mining within the lateral drainage lines or pan systems 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	80	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 and wetlands. Due to the nature of this activity is likely to permanently affect the drainage lines and pan systems to a large extent. The hydrological functioning of these systems are 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 drainage lines or pans 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 watercourse or wetland system.

	Mostly Operational Phase but also extending to a degree beyond the closure phase	Mining in close proximity to the Vaal River, floodplain or riparian zone of the river.	Mining will require removal of the vegetation layer in the riparian zone of the Vaal River. Due to the large scale of this lowland river it is unlikely to significantly alter the flow- and flooding regime and will most likely have the highest impact on sediment load. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	**M**	80	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 lateral drainage lines and pan systems in the study area	Mining will require removal of the vegetation layer in the catchment of drainage lines and pan systems. Where this occurs within 100 meters of these watercourses and wetland the 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**	80	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 drainage lines and pan systems. 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	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**	80	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 pan systems are much more easily avoided.

5. ANTICIPATED IMPACTS

Anticipated impacts that the development will have is primarily concerned with the loss of habitat and species diversity but will also include impacts on the Vaal River, associated floodplain, lateral drainage lines and pan system forming part of the study area (Appendix A: Map 1 - 4).

The following ecological principles were also taken into consideration in order to provide an indication of the anticipated impacts caused by mining operations:

- Ecological integrity refers the integrity or condition of the ecosystem and ecological processes. The current ecological integrity of the study area was estimated by comparing the reference or pristine condition against the current impacts affecting it. Since alluvial diamond mining is done by removing the vegetation layer and excavating the underlying soils and gravel this results in an extensive degradation of the ecological integrity of an area. The current ecological integrity is then compared to the anticipated ecological integrity caused by mining operations.
- Alluvial diamond mining removes the vegetation layer and underlying soils and gravel which in turn leads to the extensive loss of ecosystem function, habitat and diversity. Where mining occurs in natural areas the impact would therefore be high.
- The biophysical environment refers to the physical environment which drives an ecosystem, i.e. soil, geology, climate, etc. Since alluvial diamond mining requires the excavation of large volumes of soil and underlying gravel, it leads to the transformation of the biophysical environment of the natural ecosystem which in turn results in high impacts.
- Ecological integrity objectives refer to the preservation of an area in its natural condition. This is also often coupled with the biodiversity management plan of an area. The study area does not fall within a Critical Biodiversity Area which does reduce the impact on the ecological integrity objective for the area. However, Ecological Support Areas are still present and through the transformation of natural areas for mining operations this will decrease the percentage of intact areas of the vegetation types in the area and will therefore also increase the importance of the preservation of remaining natural areas in the surroundings.

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. As indicated from the discussion of the study area, the majority of the area has already been transformed by agricultural and mining operations (Appendix A: Map 1). Portions of natural vegetation do however still remain and where mining will affect these areas, it will still result in significant impacts. These areas do however not have a high conservation value, which will decrease the anticipated impact to some degree. The vegetation types on the site, Kimberley Thornveld and Highveld Alluvial Vegetation is not currently regarded as rare or endangered and still covers large areas of the region (Appendix A: Map 1). This will therefore not contribute toward their conservation value (Appendix A: Map 4). Furthermore, the Free State Province Biodiversity Management Plan (2015) regards the site as being of Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other categories and do not contain Critical Biodiversity Areas (CBA) which would be of high conservation value (Appendix A: Map 2). Given the fairly low conservation value of remaining natural areas on the site, this will decrease the impact that mining operations will have on the loss of habitat and species diversity. However, from previous mining operations it is also clear that mining operations cause significant impacts and result in the transformation of natural areas. By the nature of alluvial diamond mining, i.e. removal of the vegetation and modification of the soils profile, it results in the irreversible transformation of the ecosystem. However, given the fairly uniform soil conditions and habitats on the site and provided that comprehensive rehabilitation is undertaken, it may be possible to re-instate a somewhat similar vegetation composition after mining has ceased. This will also entail the re-instatement of the natural topography as far as possible as well as the correct management of topsoil. Since it is clear that the impact of mining operations on natural areas will be high and will lead to irreversible transformation, mining should be confined to selected and limited areas and should not be implemented indiscriminately over the entire area. Despite these mitigation measures, the loss of habitat and diversity is still anticipated to be a moderate impact.

Given the relative uniformity of remaining natural areas and the moderate species diversity, protected plant species are not abundant though several are present (Appendix B). No Red Listed plant species could be identified and though it is unlikely that such species would occur, there is still a low likelihood of this. However, numerous protected plant species has been identified in remaining natural areas. These include the protected succulent and geophytic species, *Boophone distichia, Orbea lutea* subsp. *lutea, Aloe grandidentata, Raphionacme hirsuta* and *Ammocharis coranica*. Where mining will affect these species, the necessary permits should be obtained and a significant proportion of these transplanted to adjacent areas where they will remain unaffected. In addition, there is a high abundance of the protected *Vachellia erioloba* (Camel Thorn) in most of the remaining natural areas and these should be retained and excluded from mining as far as possible. Where any of these will require removal, the necessary permits should be obtained and replaced during the rehabilitation phase by means of saplings. Provided that this mitigation is successfully implemented, the anticipated impact should remain moderate.

The Vaal River forms part of the study area and it is therefore likely to be directly affected by the mining operations (Appendix A: Map 3).

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

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

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Furthermore, many areas along the Vaal- and Orange Rivers were mined a century ago and the environmental footprints are still prevalent. It is important that rehabilitation is comprehensive and successful and that the impacts as listed be managed and mitigated adequately. As indicated, the mining operations will mostly be excluded from the river and floodplain (Appendix A: Map 3). This should considerably decrease the anticipated impacts. However, sedimentation will remain a likely significant impact and comprehensive rehabilitation and monitoring should still be implemented. Where mining along the riverbanks or floodplain is desired the only mitigation can be strict adherence to a comprehensive rehabilitation and monitoring plan. Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS. Refer to the risk assessment (Section 4.3.4) for a more detailed discussion on the likely risks and impacts that mining will have on the Vaal River, associated floodplain/riparian zone, lateral drainage lines and pan systems.

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

As was observed during the survey of the study area it contains several exotic weed and invader species (Appendix B). In addition, mining operations will increase disturbance and exacerbate conditions susceptible to the establishment of exotic weeds and invaders. Without mitigation this will significantly increase the establishment of exotics and is likely to spread into the floodplain and along the riverbanks. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the mining area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. This will only be applicable where mining will affect the remaining natural areas on the site. In these instances the impact will however be at least moderate. Additional measures which will significantly mitigate this include 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, exclude the Vaal River and riparian zone from mining operations and comprehensive and successful rehabilitation of mined areas. In addition, provided that adequate rehabilitation is undertaken the area will again be available to most generalist species as suitable habitat. 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 should mining take place without mitigation it is anticipated that several moderate-high to high impacts will occur. The impact on the Vaal River will also result in a high impact. However, should adequate mitigation be implemented as described these can all be reduced to moderate and low-moderate impacts. This is however subject to mining operations limiting the extent of disturbance, not being implemented indiscriminately over the entire area, excluding the river and its floodplain, retaining and transplanting of protected plant species, implementing a monitoring and eradication programme for invasive species and implementing comprehensive rehabilitation.

Please refer to Appendix F for the impact methodology.

Significance of the impact:

Impact	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Before Mitigation								
Loss of vegetation type and clearing of vegetation	4	4	4	4	5	4	4.5	18
Loss of protected species	4	5	3	4	5	3	4	16
Impact on watercourses	5	5	4	4.6	5	4	4.5	20.7
Infestation with weeds and invaders	4	4	4	4	5	3	4.5	18
Impact on Terrestrial fauna	4	4	4	4	3	4	3.5	15.3
After Mitigation								
Loss of vegetation type and clearing of vegetation	3	4	3	3.3	5	4	4.5	14.8
Loss of protected species	2	5	2	3	3	3	3	9
Impact on watercourses	4	4	3	3.6	4	3	3.5	12.6
Infestation with weeds and invaders	3	3	3	3	3	3	3	9
Impact on Terrestrial fauna	3	4	3	3.3	3	3	3	10

6. BIODIVERSITY SENSITIVITY RATING (BSR)

Habitat diversity and species richness:
The natural vegetation types in the study area has been extensively transformed by agricultural and mining operations. In addition, remaining natural areas are fairly uniform with a low diversity of habitats (Appendix A: Map 4). As a consequence of this, the study area only has a moderate species diversity as well (Appendix B)

Presence of rare and endangered species:
Given the relative uniformity of remaining natural areas and the moderate species diversity, protected plant species are not abundant though several are present (Appendix B). No Red Listed plant species could be identified and though it is unlikely that such species would occur, there is still a low likelihood of this. However, numerous protected plant species has been identified in remaining natural areas. These include the protected succulent and geophytic species, *Boophone distichia, Orbea lutea* subsp. *lutea, Aloe grandidentata, Raphionacme hirsuta* and *Ammocharis coranica*.

Ecological function:
The ecological function of the site has been altered to a significant degree. The site functions as habitat for a variety of fauna, supports specific vegetation types and the Vaal River, floodplain, lateral drainage lines and pan systems forming part of the site also provides vital functions in terms of water transportation, wetland and aquatic habitats and bio-remediation. The vegetation type on the site has been transformed to a large degree and the resultant habitat provided to fauna is also altered and unable to sustain the natural population (Appendix A: Map 1). The functioning of the Vaal River has been shown to be largely modified but is still considered a highly sensitive system. Overall the ecological function of the study is therefore regarded as moderately modified.

Degree of rarity/conservation value:
According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4) and Highveld Alluvial Vegetation (Aza 5). Both these vegetation types are currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Appendix A: Map 1). They are not currently subjected to any pronounced transformation pressures. Within the study area, both of these have been transformed to a significant extent by agricultural irrigation both in the terrestrial plains as well as the floodplain of the Vaal River.

The Free State Province Biodiversity Management Plan (2015) has recently been published and has identified areas which are essential to meeting conservation targets for specific vegetation types, i.e. Critical Biodiversity Areas. The site in question is listed as being an Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other (Appendix A: Map 2). Areas identified as ESA 1 and 2 are associated with the immediate catchment of the Vaal River and functions in support of this large watercourse. This functioning and support should therefore be retained as far as possible. Degraded areas are associated with areas transformed by agricultural irrigation and centre-pivots. Those areas regarded as Other, indicate areas still consisting of natural vegetation but which area not regarded as being critical within the conservation plan. This would seem to indicate that, in general, the study area does not contain extensive areas of high conservation value.

Although degraded the Vaal River still plays a vital role in water transport and is therefore considered to have a high conservation value (Appendix A: Map 4).

Percentage ground cover:
Overall, the percentage vegetation cover is regarded as moderately modified. Those portions transformed by agricultural and mining operations contain very low percentage vegetation cover while those areas still consisting of natural vegetation contain a moderate cover of grasses, shrubs and trees which is regarded as close to the natural condition.

Vegetation structure:
The area forms part of the Savannah Biome and should naturally therefore contain a well-developed grass layer with open to close tree/shrub canopy. In those portions of natural vegetation still is still very much the case. However, areas transformed or degraded by agricultural and mining operations considerably modify this vegetation structure and overall, the vegetation structure on the site is regarded as moderately modified.

Infestation with exotic weeds and invader plants:
Numerous exotic weeds and invasive tree species are present on the site (Appendix B). Although abundant they do not yet dominate and are still considered eradicable. These include *Opuntia ficus-indica, Argemone ochroleuca, Opuntia humifusa, Bidens bipinnata, Verbena bonariensis, Gleditsia triacanthos, Eucalyptus camaldulensis, Cirsium vulgare, Datua ferox, Cylindropuntia imbricata, Tamarix ramosissimum* and *Tagetes minuta*. Several of these are considered serious invasive species and it is important that a comprehensive eradication and monitoring programme be implemented.

Degree of grazing/browsing impact:
The area is being utilised as grazing and browsing for domestic livestock introduced game but does not seem to be grossly overstocked and overgrazing, -browsing and trampling is still regarded as moderate.

Signs of erosion:
Signs of erosion is common, though not yet extensive and gulley formation is not yet prominent.

Terrestrial animals:
Signs and tracks of mammals are fairly abundant on the site though the mammal population will be quite modified from the natural condition. Natural vegetation has a high carrying capacity for mammals which decreases significantly where agriculture transforms this natural vegetation and in such agricultural areas the mammal population is normally represented by a generalist mammal population. Those portions of remaining natural areas on the site will still contain a natural mammal population but is also likely to be somewhat modified by the proximity of agricultural operations (Appendix A: Map 1). Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are also dependant on habitat in pristine condition. Though such habitats are largely absent from the site, there is still a likelihood that remaining natural areas may harbour species of high conservation value.

Wetland and riparian habitats associated with rivers generally provide higher abundance of resources and subsequently are also able to sustain a diverse and large mammal population. This will also be the case for the Vaal River and associated riparian zone (Appendix A: Map 3). Surrounding vegetation transformation by agriculture and mining as well as disturbance of the riparian zone will influence the mammal population along the river to some extent. Nonetheless, watercourses are able to sustain a higher bio-load which in turn supports a larger mammal population and it is likely that the mammal population along the river will be substantial. Should mining take place along the banks or main channel of the river the impact on mammals will be significant.

Table 7: Biodiversity Sensitivity Rating for the proposed mining development.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness		2	
Presence of rare and endangered species		2	
Ecological function		2	
Uniqueness/conservation value		2	
Vegetation condition			
Percentage ground cover		2	
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers	3		
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species		2	
Sub total	3	18	0
Total		21	

7. BIODIVERSITY SENSITIVITY RATING (BSR) INTERPRETATION

Table 8: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
IIP 84 Mining Operations	21	Degraded	3

8. DISCUSSION AND CONCLUSION (Appendix A: Map 1 - 4)

The site proposed for mining operations has been rated as being degraded. This is mostly a result of the extensive areas of the site that has been transformed by agricultural and mining operations as well the general uniformity and moderate species diversity of remaining natural areas (Appendix A: Map 1 & 4). However, elements of high sensitivity is still present and these should be avoided by the proposed mining operations (Appendix A: Map 4). Such areas include the Vaal River, associated drainage lines and pan systems.

The study area is situated along the southern banks of the Vaal River and situated adjacent to the small town of Christiana though just inside the borders of the Free State Province (Appendix A: Map 1). The study area is quite extensive and includes large terrestrial plains, various wetlands and watercourses and also the floodplain and banks of the Vaal River and has an approximate extent of 4 000 hectares. The majority of this area has however already been transformed by agricultural irrigation with centre-pivots and orchards dominating the landscape. However, significant portions of natural vegetation are also still present and will form the focus of this study. These portions of natural vegetation range from open grassland to relatively closed savannah.

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4) and Highveld Alluvial Vegetation (Aza 5). The Kimberley Thornveld dominates the study area and covers all the terrestrial plains while the Highveld Alluvial Vegetation covers portions of the floodplain of the Vaal River. Both these vegetation types are currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Appendix A: Map 1). They are not currently subjected to any pronounced transformation pressures. Within the study area, both of these have been transformed to a significant extent by agricultural irrigation both in the terrestrial plains as well as the floodplain of the Vaal River.

The Free State Province Biodiversity Management Plan (2015) has recently been published and has identified areas which are essential to meeting conservation targets for specific vegetation types, i.e. Critical Biodiversity Areas. The site in question is listed as being an Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other (Appendix A: Map 2). Areas identified as ESA 1 and 2 are associated with the immediate catchment of the Vaal River and functions in support of this large watercourse. This functioning and support should therefore be retained as far as possible. Degraded areas are associated with areas transformed by agricultural irrigation and centre-pivots. Those areas regarded as Other, indicate areas still consisting of natural vegetation but which area not regarded as being critical within the conservation plan. This would seem to indicate that, in general, the study area does not contain extensive areas of high conservation value.

As previously stated, the majority of the study area has already been transformed by agricultural land use. This is also confirmed by the National Biodiversity Assessment (2018) (Appendix A: Map 1). Where pecan nut orchards or centre-pivots occur, this has completely transformed the natural vegetation. These areas are therefore no longer relevant to the ecology of the area and has not been included in this assessment. The remaining terrestrial areas occurring on the site, and forming the focus of it, can be further divided into distinct vegetation communities, based on the vegetation structure, dominant species and the topography and soils. The large remaining natural area in the south of the site consists of a well-developed grass layer with few scattered trees and is a consequence of sandy soils but which area shallow and underlain by a calcrete bedrock. Toward the west of the site areas occur with a slight elevation and where a short shrub/tree layer becomes prominent and can be quite dense and which is a consequence of rocky soils dominated by gravels. A few isolated fragments occur in between centre-pivots in the central and northern portion of the site. Here large trees dominate with a well-developed grass layer interspersed and is a consequence of deep sandy soils. These areas were also most heavily affected by agriculture since these deep sandy soils are most beneficial to crop production.

From the description of the study area it is clear that the majority of the site has been transformed by agricultural and mining operations (Appendix A: Map 1). This would therefore increase the conservation value of those portions of remaining natural vegetation, i.e. the less habitat remains, the rarer it will be, the higher the conservation value will become. However, when looking at available resources it is evident that the vegetation types on the site, Kimberley Thornveld and Highveld Alluvial Vegetation is not currently regarded as rare or endangered and still covers large areas of the region (Appendix A: Map 1). This will therefore not contribute toward their conservation value. Furthermore, the Free State Province Biodiversity Management Plan (2015) regards the site as being of Ecological Support Area (ESA) 1 and 2 as well as Degraded and Other categories and do not contain Critical Biodiversity Area (CBA) which would be of high conservation value (Appendix A: Map 2). Despite this, natural areas do still contain some elements of conservation value such as a range of protected succulent and geophytic species and large and old specimens of the protected *Vachellia erioloba* (Camel Thorn) (Appendix B).

Given the fairly low conservation value of remaining natural areas on the site, this will decrease the impact that mining operations will have on the loss of habitat and species diversity. However, from previous mining operations it is also clear that mining operations cause significant impacts and result in the transformation of natural areas. By the nature of alluvial diamond mining, i.e. removal of the vegetation and modification of the soils profile, it results in the irreversible transformation of the ecosystem. However, given the fairly uniform soil conditions and habitats on the site and provided that comprehensive rehabilitation is undertaken, it may be possible to re-instate a somewhat similar vegetation composition after mining has ceased. This will also entail the re-instatement of the natural topography as far as possible as well as the correct management of topsoil. Mining also results in high levels of disturbance and consequently, the establishment of exotic weeds and invasive species and the eradication and monitoring of these should also form an important part of the management of mining and rehabilitation operations.

Since it is clear that the impact of mining operations on natural areas will be high and will lead to irreversible transformation, mining should be confined to selected and limited areas and should not be implemented indiscriminately over the entire area. Furthermore, numerous protected plant species has been identified in remaining natural areas (Appendix B). These include the protected succulent and geophytic species, *Boophone distichia, Orbea lutea* subsp. *lutea, Aloe grandidentata, Raphionacme hirsuta* and *Ammocharis coranica*. Where mining will affect these species, the necessary permits should be obtained and a significant proportion of these transplanted to adjacent areas where they will remain unaffected. In addition, there is a high abundance of the protected *Vachellia erioloba* (Camel Thorn) in most of the remaining natural areas and these should be retained and excluded from mining as far as possible. Where any of these will require removal, the necessary permits should be obtained and replaced during the rehabilitation phase by means of saplings.

Mammal species identified on the site indicate a significant diversity, which although dominated by widespread and generalist species, also contain species of higher conservation value. Evidence of the Cape Clawless Otter (a Red Listed species regarded as being Near Threatened) was also confirmed along the Vaal River. This also indicates that although the mammal population will be somewhat modified, it remains likely that other species of high conservation value will still be present.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. This will only be applicable where mining will affect the remaining natural areas on the site (Appendix A: Map 1). In these instances the impact will however be at least moderate. Additional measures which will significantly mitigate this include 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, exclude the Vaal River and riparian zone from mining operations and comprehensive and successful rehabilitation of mined areas. In addition, provided that adequate rehabilitation is undertaken the area will again be available to most generalist species as suitable habitat. 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 Vaal River flows from north east to south west along the border of the site (Appendix A: Map 3). It is a perennial system and flows throughout the year but has been heavily modified in terms of its flow and flooding regime by upstream containment dams. The river is also being used for extensive irrigation and water abstraction will also have a significant impact on it. The river contains a significant floodplain or riparian zone but varies in width along the section on the site. Generally the insides of bends have the widest floodplain while the outsides of bends have the narrowest floodplain. The floodplain has also been affected and modified by agricultural and mining operations.

A few small drainage lines occur in the western portion of the site where the slope increases slightly toward the Vaal River (Appendix A: Map 3). These drainage lines are quite small and generally without a defined main channel. However, due to the increase in surface runoff and seepage generated by irrigated areas and coupled with the construction of artificial berms and impoundments, these drainage lines do form wetland areas where they flow into the Vaal River.

As indicated, the terrestrial portion of the site has a flat topography and as a result watercourses are absent. However, this flat topography also promotes the formation of a few small pans or depressions (Appendix A: Map 3). They are quite small and vary between 70 and 120 meters in diameter. There is however one pan that is quite prominent and has an approximate diameter of 600 meters. All of these pans have been quite heavily affected by the surrounding agricultural operations.

The determination of the presence of wetland condition in the study are was undertaken by using surface topography soil wetness indicators as well as obligate wetland vegetation. This indicated that the Vaal River banks clearly contains wetland conditions, while the floodplain is devoid of wetland conditions but still forms part of the riparian zone of the river (Appendix A: Map 3). Where small drainage lines or impoundments occur near the river, wetland conditions have also formed. The upper portions of these drainage lines are largely devoid of wetland conditions though they must be regarded as forming watercourses over their entire length. A few small pans systems all contain clear wetland conditions despite being heavily degraded.

The Vaal River was surveyed by four separate locations along the section adjacent to the site (Appendix A: Map 1 & 3). The length of river included in the study area is relatively long, approximately 6.5 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 river in the study area, especially the floodplain, is quite variable in terms of geomorphology though the main channel, vegetation structure and species composition remain relatively similar.

Habitat and species diversity is considered quite low which is normally not the case along large watercourses. This is in part a result of upstream impacts on the river but also due to agriculture, irrigation and previous mining operations in the floodplain and in close proximity of the river. The habitat and banks of the river is rather uniform and species diversity is very low in many areas. However, the functioning and habitat provided by the river and its floodplain should still be regarded as important and highly sensitive (Appendix A: Map 4).

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section forming part of the study area (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system. One IHI was conducted for the Vaal River to represent the overall condition of the river and associated drainage lines on the site. In addition, the pans or depressions on the site form isolated wetland systems which are not associated with the Vaal River. In order to provide an indication of the condition of these pans, a WET-Health determination will be done for the large pan occurring in the central portion of the site.

The largest impact on the Vaal River at the site is considered agricultural transformation and irrigation followed by previous alluvial diamond mining which has had a high impact on the site. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are centre-pivot irrigation, alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified (Appendix D). The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate.

The largest impact on the pan system on the site is undoubtedly several large centre-pivot irrigation fields in close proximity to it. This clearly results in an increase in the nutrient input of the pan which causes a significant modification in the vegetation composition of the pan. In addition, surface runoff and groundwater seepage from the centre-pivots will also alter the hydrology of the pan in that this will increase the inflow into it. The results of the WET-Health indicated an overall Present Ecological State of Category D: Largely modified (Appendix D). The EI&S of the pan system has been rated as being Moderate.

A Risk Assessment for the proposed mining area has been undertaken according to the Department of Water & Sanitation's (DWS) requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS. Where the risk assessment refers to mining operations in close proximity to watercourses and wetland this refers to the regulated area as stipulated by DWS, i.e. within the floodplain or riparian zone or within 100 meters of the edge of a watercourse. This is also applicable to the small depressions occurring in the study area.

Mining within the main channel or banks of the Vaal River or wetland areas as described will likely cause permanent modification of this system. Although a comprehensive rehabilitation and monitoring regime may decrease this risk it is still unlikely to ensure the re-establishment of current natural functioning. Consequently this is considered as a high risk for the Vaal River and associated wetland areas. This activity is therefore recommended to be excluded as far as possible. The current mine plan also indicates that mining operations will exclude the main channel and banks of the Vaal River from mining operations.

As in the previous paragraph, should mining occur within any of the lateral drainage lines, this will also entail a high risk and should therefore be avoided. These drainage lines feed into the Vaal River and clearly also contains extensive wetland conditions and any direct impacts on these drainage lines will also have a large impact on the Vaal River itself.

Although the small pan systems in the study area are not connected to the Vaal River, they still have important functions in terms of unique habitat, groundwater recharge and higher biomass when compared to the surrounding habitats. Should any mining take place within these pans this will also entail a high risk and consequently should also be excluded from mining operations.

Mining in close proximity to the Vaal River or within the floodplain and riparian zone will still result in significant impacts. This is also applicable to the lateral drainage lines and small depressions or pans occurring in the study area. Mining operations in close proximity to any of these systems are 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 impacts can be minimised and provided adequate rehabilitation is undertaken no additional and other permanent modification to the functioning of these systems.

Mining operations will also include haul roads and other infrastructure such as pipelines and powerlines and where these occur within the floodplain or riparian zone of the river, or across any of the lateral drainage lines or pan systems is anticipated to still have a moderate risk and will still have impacts on these although at a local scale. The design of these structures should be such that they minimise the obstruction of flow and disturbance of the floodplain, watercourses and pan systems.

The impact significance has been determined and should mining take place without mitigation it is anticipated that several moderate-high to high impacts will occur. The impact on the Vaal River will also result in a high impact. However, should adequate mitigation be implemented as described these can all be reduced to moderate and low-moderate impacts. This is however subject to mining operations limiting the extent of disturbance, not being implemented indiscriminately over the entire area, excluding the river and its floodplain, retaining and transplanting of protected plant species, implementing a monitoring and eradication programme for invasive species and implementing comprehensive rehabilitation.

9. RECOMMENDATIONS

- Where mining operations occur, 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.

- 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.

- Correct topsoil and seedbank management will be paramount to rehabilitation. Where disturbance or excavation will occur upper 30 cm, or topsoil, should be removed together with the vegetation and stored on the site. The topsoil together with the seedbank and any vegetation material should then be replaced on top of the rehabilitated soil surface. Subsoil should be used as backfilling and not as top dressing. Only removed topsoil should be utilised to rehabilitate the disturbed surface. The soil surface and geomorphology should also be re-instated to its natural condition and shape.

- The survey has indicated several areas that are considered highly sensitive and with a high conservation value and should be excluded from mining operations as far as possible (Appendix A: Map 4):

    - The Vaal River, including the main channel and banks as well as the riparian zone or floodplain.
    - All of the lateral drainage lines which flow into the Vaal River.
    - The pan systems occurring on the site, including small and degraded pans.
    - Portions of Camel Thorn (*Vachellia erioloba*) woodland that remain on the site. These are utilised as game areas and are unlikely to be affected by mining.

- Although remaining natural areas have been shown to be fairly uniform, the mining operations should still aim to minimise the anticipated impact on these areas by confining mining operations to selected and limited areas and should not be implemented indiscriminately over the entire area.

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

    - Where protected tree species (*Vachellia erioloba* – Camel Thorn) 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. 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 impact of habitat loss and fragmentation on the faunal population should be mitigated by amongst others:

  - Limiting mining operations to set areas and not mine several areas at the same time.
  - Limit the extent of each such mining area.
  - Comprehensive and successful rehabilitation of mined areas.
  - Exclusion of areas with high sensitivity.

- Mining operations may 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 is recommended that mining activities be excluded from the watercourses and wetlands as described in this report (Appendix A: Map 1 - 4) as far as possible.

- A natural riparian vegetation should be re-instated where this was disturbed/removed.

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

- 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 disturbed 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 areas and should be extended into the rehabilitation phase.

- The necessary authorisations must be acquired from Department of Water and Sanitation (DWS) for prospecting within 100 meters or within the floodplain of watercourses and within 500 meters of wetland areas (Appendix A: Map 3).

- Where roads, haul roads and other infrastructure such as conveyors are required by mining operations, the following should be considered:

    - Where infrastructure cross over watercourses or wetlands, this will require additional authorisation.
    - Roads crossing over watercourses should be done with adequate designs which should allow for sufficient flow within these watercourses.
    - The minimum of roads and infrastructure should be retained after closure, if any, and roads and infrastructure should be removed and rehabilitated to as natural condition as possible.

- 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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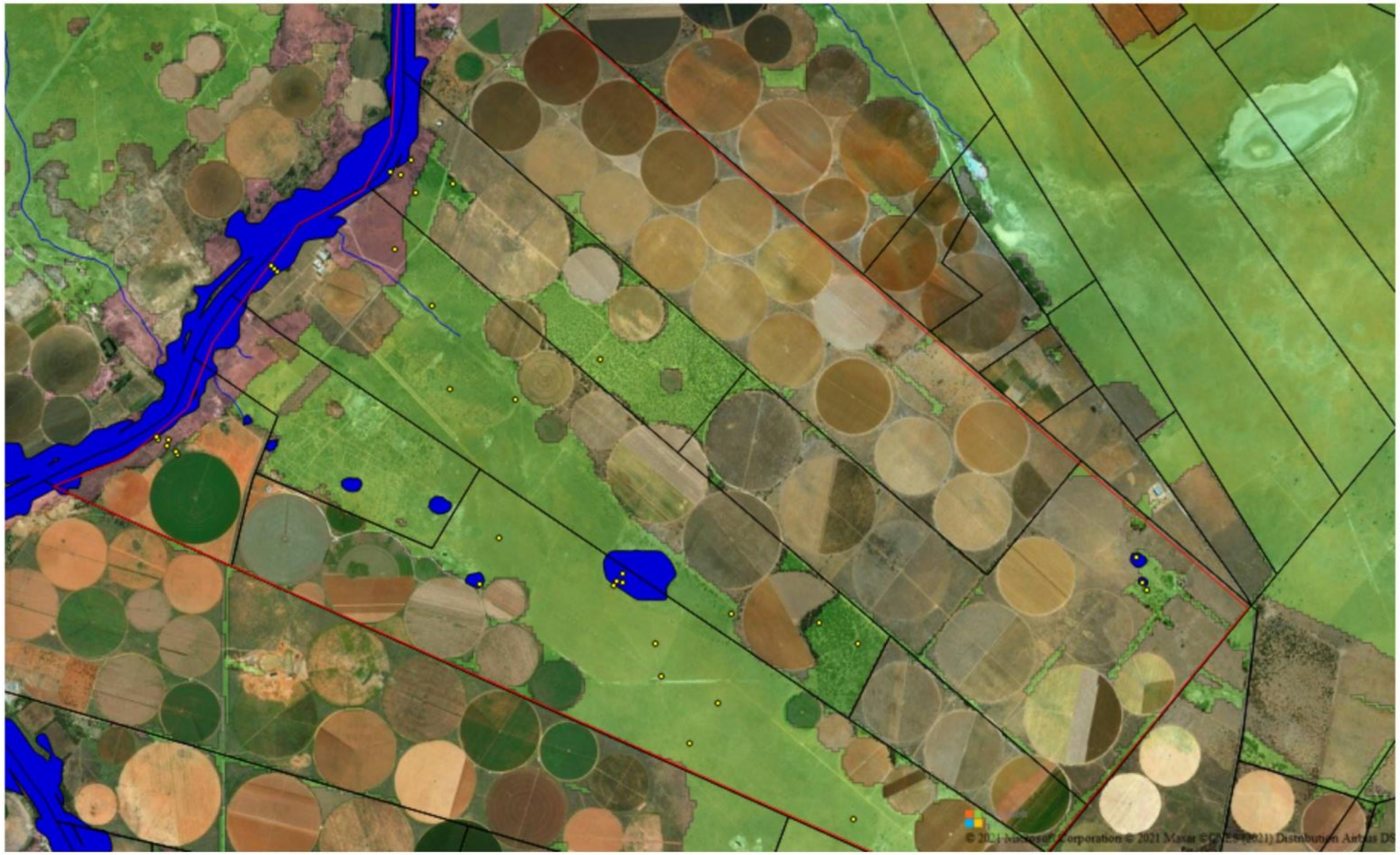
Annexure A: Maps

Sensitivity map for the proposed diamond mining operations on various portions of the farms Vanaswegenshoek 493 and Greylingslyn 355 along the Vaal River near the town of Christiana, Free State Province.



Preparred for:
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Somerset West
7130

Legend:

- Property Boundaries
- Study area
- Watercourses
- NFEPA Wetlands
- Highveld Alluvial Vegetation
- Kimberley Thornveld
- Sampling points

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:55 000

DPR Ecologists
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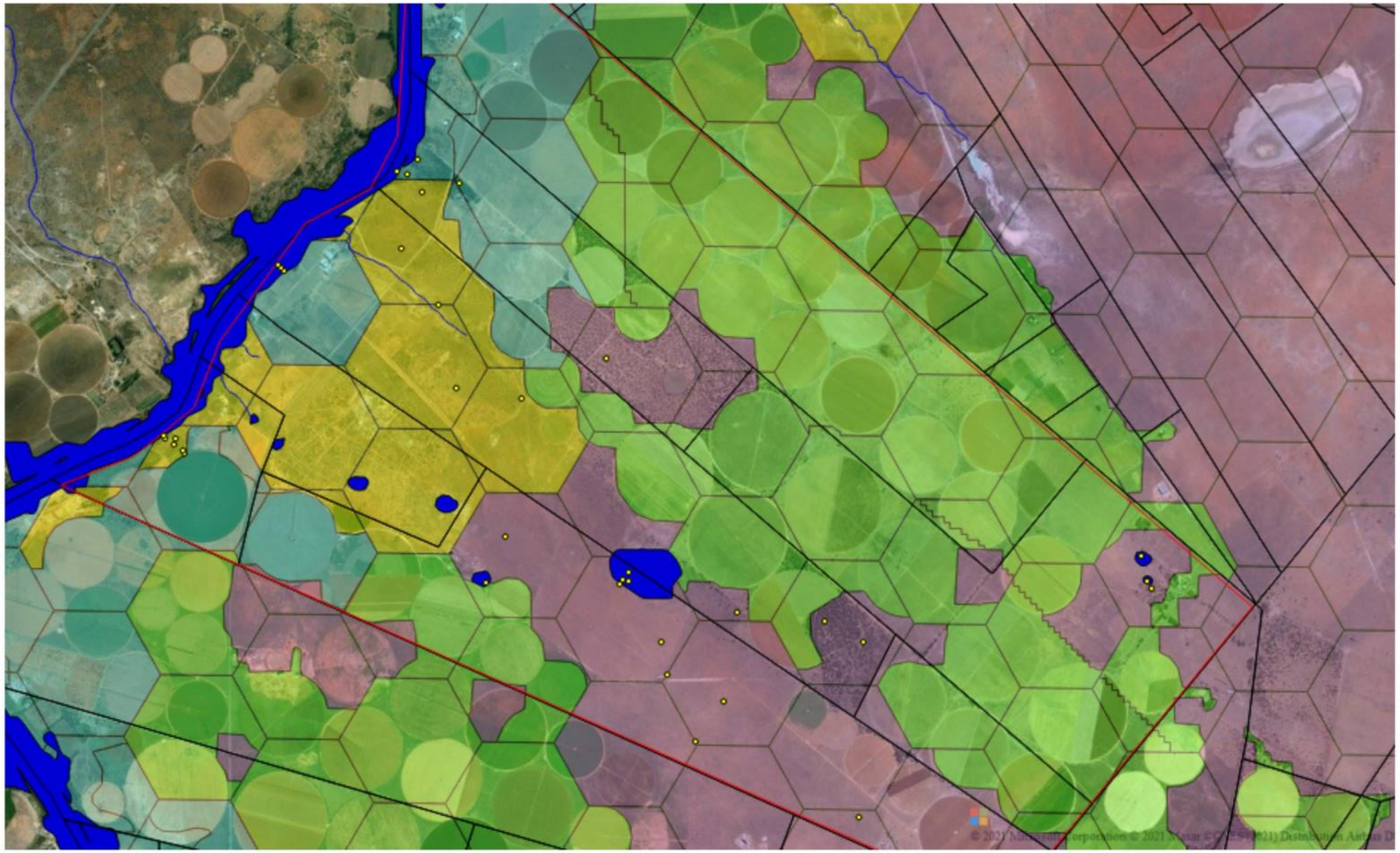
Map 1: Locality map of the proposed mining operations on the Farms Vanaswegenshoek 493 and Greylingslyn 355 near the town of Christiana. Those portions of remaining natural vegetation are indicated and it is clear that the majority of the study area has been transformed by agriculture. Remaining natural areas can also be divided into the southern plains, the central woodland areas and western rocky areas. Locations of NFEPA identified wetland areas are also indicated. Note hover that these may not be accurate and on-site delineation should be used for the location of wetlands (Map 3).The location of sample survey site are also indicated.

Free State Biodiversity Plan map for the proposed diamond mining operations on various portions of the farms Vanaswegenshoek 493 and Greylingslyn 355 along the Vaal River near the town of Christiana, Free State Province.



Map 2: Free State Biodiversity Plan map of the proposed mining operations on the Farms Vanaswegenshoek 493 and Greylingslyn 355 near the town of Christiana. The area does not contain Critical Biodiversity Areas. Those areas contributing to the functioning of the Vaal River has been listed as Ecological Support Areas. Areas of remaining natural vegetation but which is not regarded as essential to meet conservation targets are indicted as Other. Large portions of the site which has been transformed by agriculture and mining are listed as Degraded areas.

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Legend:

- Property Boundaries
- Study area
- Watercourses
- NFEPA Wetlands
- Critical Biodiversity Area 1
- Critical Biodiversity Area 2
- Ecological Support Area 1
- Ecological Support Area 2
- Degraded
- Other
- Sampling sites

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:55 000

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Wetland and riparian delineation map for the proposed diamond mining operations on various portions of the farms Vanaswegenshoek 493 and Greylingslyn 355 along the Vaal River near the town of Christiana, Free State Province.

Map 3: Wetland and riparian delineation map of the proposed mining operations on the Farms Vanaswegenshoek 493 and Greylingslyn 355 near the town of Christiana. The banks of the Vaal River as well as several areas in the floodplain contain clear wetland conditions. This also includes the lateral drainage lines flowing into it. The floodplain is devoid of wetland conditions but still forms part of the riparian zone of the river. The interior of the study area contains five small and degraded pan system and one larger, more natural pan. The map may contain minor errors in delineation of wetland and riparian areas.

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Legend:

- **Property Boundaries**
- **Study area**
- **Delineated Wetlands Areas**
- **Riparian Zone**
- **Sampling sites**

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:55 000

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Sensitivity map for the proposed diamond mining operations on various portions of the farm Vanaswegenshoek 493 and Greylingslyn 355 along the Vaal River near the town of Christiana, Free State Province.

Map 4: Sensitivity map of the proposed mining operations on the Farms Vanaswegenshoek 493 and Greylingslyn 355 near the town of Christiana. Those portions of the site being transformed by agriculture and mining has not been delineated but would be considered to be of Low Sensitivity. Areas of Moderate Sensitivity consist of remaining natural areas but which are fairly uniform and not regarded to be of high conservation value. Areas of High Sensitivity include significant portions of intact woodland, degraded small pan systems and the floodplain or riparian zone of the Vaal River. The banks of the Vaal River, associated wetland areas and all the lateral drainage lines as well as the large pan system in the centre of the site are regarded to be of Very High Sensitivity.

Preparred for:
Greenmined Environmental
Baker Square
Somerset West
7130

Legend:

- Property Boundaries
- Study area
- Very High
- High
- Moderate
- Low
- Sampling points

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:55 000

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Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Argemone ochroleuca*	Herb
**Bidens bipinnata*	Herb
**Calibrochoa parvifolia*	Herb
**Cirsium vulgare*	Herb
**Conyza bonariensis*	Herb
**Cylindropuntia imbricata*	Succulent
**Datura ferox*	Herb
**Eucalyptus camaldulensis*	Tree
**Gleditsia triacanthos*	Tree
**Oenothera rosea*	Herb
**Opuntia ficus-indica*	Succulent
**Opuntia humifusa*	Succulent
**Phyla nodiflora*	Herb
**Plantago lanceolata*	Herb
**Polygonum aviculare*	Herb
**Polypogon monspeliensis*	Grass
**Tagetes minuta*	Herb
**Tamarix ramosissimum*	Shrub
**Verbena bonariensis*	Herb
**Veronica anagalis-aquatica*	Herb
Acanthosicyos naudinianus	Creeper
Albuca sp.	Geophyte
Aloe grandidentata	Succulent
Amaranthus sp.	Herb
Ammocharis coranica	Geophyte
Amphiglossa triflora	Dwarf shrub
Anthephora pubescens	Grass
Arctotis arctotoides	Herb
Asparagus larcinus	Shrub
Barleria macrostegia	Herb
Berkheya macrocephala	Herb
Berkheya onopordifolia	Herb
Berula erecta	Herb
Boophone distichia	Geophyte
Bulbine abyssinica	Geophyte
Bulbine narcissifolia	Geophyte
Cadaba aphylla	Shrub
Chascanum hederaceum	Herb
Chascanum pinnatifidum	Herb
Chlorophytum sp.	Geophyte

Chrysocoma ciliata	Dwarf shrub
Clematis brachiata	Climber
Commicarpus pentandrus	Herb
Convolvulus oculatus	Herb
Cotula anthemoides	Herb
Crinum bulbispermum	Geophyte
Cullen tomentosum	Herb
Cymbopogon pospischillii	Grass
Cynodon dactylon	Grass
Cyphosetmma hereroensis	Geophyte
Delosperma herbeum	Succulent
Dicoma macrocephala	Herb
Diospyros lycioides	Shrub
Ehretia rigida	Shrub
Elephantorrhiza elephantina	Suffrutex
Eragrostis bicolor	Grass
Eragrostis lehmanniana	Grass
Eragrostis pallens	Grass
Eragrostis rigidior	Grass
Eragrostis superba	Grass
Eragrostis trichophora	Grass
Euphorbia inaequilatera	Herb
Felicia muricata	Dwarf shrub
Fingerhuthia africana	Grass
Gazania krebsiana	Herb
Geigeria filifolia	Herb
Geigeria pectidea	Herb
Gnidia podocephala	Dwarf shrub
Gomphocarpus fruticosus	Herb
Grewia flava	Shrub
Gymosporia buxiifolia	Shrub
Helichrysum argyrosphaerum	Herb
Helichrysum zeyheri	Dwarf shrub
Heliotropium ciliatum	Herb
Heliotropium ovalifolia	Herb
Hermannia comosa	Herb
Hermannia linearifolia	Herb
Hermannia quartiniana	Herb
Hermbstaedtia odorata	Herb
Hertia pallens	Dwarf shrub
Heteropogon contortus	Grass
Hibiscus pusillus	Herb
Hibiscus trionum	Herb
Hilliardiella elaeagnioides	Herb
Hypertelis cerviana	Herb
Jamesbrittenia atropurpurea	Dwarf shrub

Juncus rigidus	Rush
Kyllinga alba	Sedge
Lantana rugosa	Herb
Ledebouria luteola	Geophyte
Ledebouria sp.	Geophyte
Leptochloa fusca	Grass
Leucas capensis	Herb
Litogyne gariepina	Herb
Lophiocarpus polystachyus	Dwarf shrub
Lotononis sp.	Herb
Lycium hirsutum	Shrub
Marsilea sp.	Fern
Menodora africana	Herb
Microloma armatum	Dwarf shrub
Nidorella resedifolia	Herb
Nolletia ciliaris	Dwarf shrub
Orbea lutea subsp. *lutea*	Succulent
Paspalum distichum	Grass
Pavonia burchellii	Herb
Pegolettia retrofracta	Dwarf shrub
Peliostomum leucorrhizum	Herb
Pentzia calcarea	Dwarf shrub
Pentzia globosa	Dwarf shrub
Pentzia quinquifida	Dwarf shrub
Phragmites australis	Reed
Platycarphella parvifolia	Herb
Plinthus sericeus	Dwarf shrub
Pterodiscus speciosus	Geophyte
Ranunculus multifidus	Herb
Raphionacme hirsuta	Geophyte
Rhynchosia totta	Herb
Ruschia hamata	Dwarf shrub
Salix mucronata	Tree
Salvia disermas	Herb
Salvia verbenaca	Herb
Schmidtia pappophoroides	Grass
Searsia lancea	Tree
Searsia pyroides	Shrub
Senegalia melifera subsp. *detinens*	Tree
Senna italica	Herb
Setaria verticillata	Grass
Sida sp.	Herb
Sochus oleraceus	Herb
Solanum incanum	Herb
Solanum supinum	Herb
Sporobolus coromandelianus	Grass

Stachys spathulata	Herb
Stipagrostis uniplumis	Grass
Tarchonanthus camphoratus	Shrub
Themeda triandra	Grass
Trichodesma angustifolium	Herb
Typha capensis	Bulrush
Vachellia erioloba	Tree
Vachellia hebeclada	Shrub
Vachellia karroo	Tree
Wahlenbergia androsaceae	Herb
Ziziphus mucronata	Tree
Ziziphus zeyheriana	Suffrutex

Appendix C: Soil Samples

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

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

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

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

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

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

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

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

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

Table 1: Soil samples taken in a terrestrial portion of the study area (S 27.952169°, E 25.133918°, S 27.985541°, E 25.169417°).

	
Soil sample taken in the terrestrial area in the western portion of the site Soils are sandy with a reddish brown colouration and unconsolidated without a grey matrix or any mottling and represent soils without any wetland conditions. This soil sample will be used to compare other soil samples against.	Soil sample taken in the terrestrial area in the central portion of the site Soils are sandy with a reddish brown colouration and unconsolidated without a grey matrix or any mottling and represent soils without any wetland conditions. This soil sample will be used to compare other soil samples against.

Table 2: Soil samples taken along a lateral transect of the Vaal River along the northern border of the site (S 27.927111°, E 25.132774°).

<table>
<tr><td></td><td></td></tr>
<tr><td>Soil sample taken in the marginal zone of the river.
A prominent grey matrix (>10%) is clear and feint mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.</td><td>Soil sample taken in the lower zone of the river bank.
A grey matrix (<10%) is present although mottling is very feint and can only be regarded as a seasonal zone of wetness. Wetland conditions are therefore present though not prominent.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Soil sample taken in the upper zone of the river bank.
A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.</td><td></td></tr>
</table>

Table 3: Soil samples taken along a lateral trasect of the Vaal River along the northern portion of the site (S 27.950579°, E 25.131717°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and prominent mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken where a lateral drainage line flows into the Vaal River. A grey matrix (<10%) is present with some mottling also visible and can only be regarded as a seasonal zone of wetness. Wetland conditions are therefore present though not prominent.
	
Soil sample taken where a lateral drainage line flows into the Vaal River. A grey matrix (>10%) is prominent with clear mottling and with some mottling also visible indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	

Table 4: Soil samples taken along a lateral transect of the Vaal River along the central portion of the site (S 27.957856°, E 25.121218°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and feint mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain. This is also evident when compared to the reference sample (Table 1).
	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain. This is also evident when compared to the reference sample (Table 1).	

Table 5: Soil samples taken along a lateral transect of the Vaal River along the southern portion of the site (S 27.971055°, E 25.111214°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and prominent mottling is present indicating a permanent zone of wetness. The soils has a high gravel content. Wetland conditions are clearly present.	Soil sample taken in the lower zone of the river bank. A grey matrix is not clear though a few mottles and oxidised root zones do indicate temporary saturation of soils. Wetland conditions are therefore present but only on a temporary basis.
	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.	Soil sample taken in adjacent terrestrial areas. Note the red colouration of the soil with low organic and silt content and absence of a grey matrix and mottling. This is clearly no longer within the riparian zone of the river.

Appendix D: Index of Habitat Integrity (IHI)/WET-Health Summary

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

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 27.927551
UPPER LONGITUDE	E 25.132316
UPPER ALTITUDE	1200 m
LOWER LATITUDE	S 27.974368
LOWER LONGITUDE	E 25.102445
LOWER ALTITUDE	1200 m
SURVEY SITE (if applicable)	Vaal River Christiana
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Lower Vaal
QUATERNARY	C91D
ECOREGION 2	29_2
DATE	08/11/2021
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	2.0	1.1
BED MODIFICATION	2.0	4.0
BANK MODIFICATION	2.0	3.0
CONNECTIVITTY MODIFICATION	2.0	4.0
INSTREAM IHI%	58.7	
CATEGORY	C/D	
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	2.50	4.00
CONNECTIVITY MODIFICATION	2.00	4.00
RIPARIAN HABITAT INTEGRITY (%)	49.91	
CATEGORY	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

INSTREAM IHI	MRU
Base Flows	-3.0
Zero Flows	1.0
Floods	-3.5
HYDROLOGY RATING	**2.3**
pH	2.5
Salts	2.0
Nutrients	2.0
Water Temperature	1.0
Water clarity	2.0
Oxygen	2.0
Toxics	2.0
PC RATING	**2.0**
Sediment	2.0
Benthic Growth	2.0
BED RATING	**2.0**
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 %	**58.7**
INSTREAM IHI EC	**C/D**
INSTREAM CONFIDENCE	**2.8**

RIPARIAN IHI	MRU
Base Flows	-3.0
Zero Flows	-1.0
Moderate Floods	-3.0
Large Floods	-4.0
HYDROLOGY RATING	**2.8**
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	3.0
Invasive Alien Vegetation (marginal)	2.0
Invasive Alien Vegetation (non-marginal)	2.0
Erosion (marginal)	2.0
Erosion (non-marginal)	2.0
Physico-Chemical (marginal)	2.0
Physico-Chemical (non-marginal)	2.0
Marginal	2.0
Non-marginal	3.0
BANK STRUCTURE RATING	**2.5**
Longitudinal Connectivity	2.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**2.0**
RIPARIAN IHI %	**49.9**
RIPARIAN IHI EC	**D**
RIPARIAN CONFIDENCE	**3.7**

Wetland Attributes

The information in this sheet must be captured before continuing with any other aspects of the assessment. Not capturing all the information required will lead to errors in the spreadsheet calculations, which will prevent a final outcome being obtained.

Wetland Name	IIP 84 Pan
Assessment Unit Name / No.	1
Assessor	Darius van Rensburg
Date of Assessment	08/11/2021
HGM Type (Basic)	Depression
	DEP
HGM Type (Refined)	Depression without flushing
	DEP-endo
Conceptual model	Water and sediment inputs from the topographically defined catchment are assumed to emanate largely from lateral inputs, with limited inputs from the catchment upstream of the wetland. For the the purposes of geomorphic and water quality assesments, a weighting of 80% is therefore allocated to impacts associated with lateral inputs whilst impacts associated with the upstream catchment only contribute 20% to final catchment impact scores. For the hydrological assessment, weightings are based on the relative extent of contributing areas rather than default weightings.
Wetland size (Ha)	20
Upslope catchment size (Ha)	213
Quaternary Catchment[1]	C91D
MAR (Mm3)	2.9
MAR per unit area (m3/Ha)	19.0
MAP (mm)	371.3
PET (mm)	2140
MAP:PET ratio	0.2
Vulnerability Factor	1.0
Hydrogeological Type Setting[2]	Other
Connectivity of wetland to a regional aquifer	No connection
Change in groundwater levels in the regional aquifer	
Water quality of regional aquifer	
Channel characteristics (if present)	
Natural wetness regimes	Dominated by seasonally saturated soils
Broad vegetation attributes	Central portion of pan dominated by fairly dense grass cover while shores dominated by short dwarf karroid shrub layer. Side bordering on centre-pivots contain prominent reedbeds and wetland vegetation.
Number of dams in the catchment	0
Average surface area of dams (m2)	0
Perimeter of wetland (m)	1649
Perimeter-to-area ratio (m/ha)	82.5
Down-slope length of wetland (m)	600
Elevation change over length (m)	3
Longitudinal Slope (%)	0.5%
Propensity to erode (Category)[3]	Low
Propensity to erode (Score)	0.9
Dominant sediment accumulation process	Clastic

WET-Health Level 2 assessment: PES Summary

This worksheet provides an overall summary of the WET-Health Assessment that can be used for reporting purposes

	Wetland PES Summary			
Wetland name	**IIP 84 Pan**			
Assessment Unit	**1**			
HGM type	Depression without flushing			
Areal extent (Ha)	20.0 Ha			
Unadjusted (modelled) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	5.9	2.9	1.0	4.0
PES Score (%)	41%	71%	90%	60%
Ecological Category	D	C	B	D
Combined Impact Score	3.7			
Combined PES Score (%)	63%			
Combined Ecological Category	C			
Hectare Equivalents	12.5 Ha			
Confidence (modelled results)	RATE-TO-HIGH: Field-based assessment including information about the regional a			
Final (adjusted) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	5.9	2.9	2.2	4.0
PES Score (%)	41%	71%	78%	60%
Ecological Category	D	C	C	D
Trajectory of change				
Confidence (revised results)	Not rated	Not rated	Not rated	Not rated
Combined Impact Score	4.0			
Combined PES Score (%)	60%			
Combined Ecological Category	C			
Hectare Equivalents	12.0 Ha			

Appendix E: Risk Assessment Matrix

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

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

No.	Phases	Activity	Aspect	Impact	Severity: Flow Regime	Severity: Physico & Chemical (Water Quality)	Severity: Habitat (Geomorph+Vegetation)	Severity: Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
	Mostly Operational Phase but extending long after closure	Alluvial diamond mining operations	Mining within or on the banks of the Vaal River	Mining within the main channel or the banks of the Vaal River will remove riparian vegetation, transform the soils profile and in so doing the hydrology, geomorphology, flow and flooding regime. Due to the 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.
1	Mostly Operational Phase but extending long after closure		Mining within lateral drainage lines or pan systems in the study area.	Mining within the lateral drainage lines or pan systems 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	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 and wetlands. Due to the nature of this activity is likely to permanently affect the drainage lines and pan systems to a large extent. The hydrological functioning of these systems are 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 drainage lines or pans should be avoided as far as possible. Comprehensive rehabilitation and monitoring may establish a natural vegetation layer but is unlikely to re-establish a

	Mostly Operational Phase but also extending to a degree beyond the closure phase		Mining in close proximity to the Vaal River, floodplain or riparian zone of the river.	Mining will require removal of the vegetation layer in the riparian zone of the Vaal River. Due to the large scale of this lowland river it is unlikely to significantly alter the flow- and flooding regime and will most likely have the highest impact on sediment load. The geomorphology and basic functioning is however anticipated to remain unchanged. Increased establishment of exotic weeds is likely due to disturbance caused by mining.	2	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 lateral drainage lines and pan systems in the study area	Mining will require removal of the vegetation layer in the catchment of drainage lines and pan systems. Where this occurs within 100 meters of these watercourses and wetland the 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 drainage lines and pan systems. 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		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 pan systems are much more easily avoided.

Appendix F: Impact methodology

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

Question	**Answer**
How were ecological integrity considerations taken into account?	Ecological integrity refers the integrity or condition of the ecosystem and ecological processes. The current ecological integrity of the study area was estimated by comparing the reference or pristine condition against the current impacts affecting it. Since alluvial diamond mining is done by removing the vegetation layer and excavating the underlying soils and gravel this results in an extensive degradation of the ecological integrity of an area. The current ecological integrity is then compared to the anticipated ecological integrity caused by mining operations.
How will this development disturb or enhance ecosystems and/or result in the loss or protection of biological diversity?	Alluvial diamond mining removes the vegetation layer and underlying soils and gravel which in turn leads to the extensive loss of ecosystem function, habitat and diversity. Where mining occurs in natural areas the impact would therefore be high.
How will this development pollute and/or degrade the biophysical environment?	The biophysical environment refers to the physical environment which drives an ecosystem, i.e. soil, geology, climate, etc. Since alluvial diamond mining requires the excavation of large volumes of soil and underlying gravel, it leads to the transformation of the biophysical environment of the natural ecosystem which in turn results in high impacts.
How will this development positively or negatively impact on ecological integrity objectives/targets/considerations of the area?	Ecological integrity objectives refer to the preservation of an area in its natural condition. This is also often coupled with the biodiversity management plan of an area. The study area does not fall within a Critical Biodiversity Area which does reduce the impact on the ecological integrity objective for the area. However, Ecological Support Areas are still present and through the transformation of natural areas for mining operations this will decrease the percentage of intact areas of the

Question	Answer
	vegetation types in the area and will therefore also increase the importance of the preservation of remaining natural areas in the surroundings.

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.