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EKO•ENVIRONMENTAL

Wetland Assessment for alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near the town of Windsorton, Northern Cape Province.

February 2016

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DECLARATION OF INDEPENDENCE

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

Report Version	Final 1.0		
Title	Wetland Assessment for alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near the town of Windsorton, Northern Cape Province.		
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Executive Summary

The vegetation types within the study area consists of Scmidtsdrif Thornveld (SVk 6), Kimberley Thornveld (SVk 4) and Upper Gariep Alluvial Vegetation (AZa 4). According to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) these vegetation types are considered to be of least Concern (LC) (Map 3). They are not currently subjected to any pronounced transformation or development pressures.

As previously mentioned the Vaal River, associated wetland, ephemeral pans and seasonal streams are considered sensitive ecosystems and their conservation value must therefore be considered as relatively high (Map 2).

The majority of the river bank along this section is narrow and steep and as a consequence the associated wetlands with the Vaal River are also narrow and not extensive. However, several island also occur within the river. Along the north western corner of the site along the river an extensive floodplain is present. Soil samples indicate that the marginal zone of the river must be considered a wetland area. The marginal zone is indicative of a permanent zone of wetness while the lower zone is indicative of a seasonal zone of wetness. Where seasonal streams enter the river small alluvial fans occur which also enlarge the wetland zone along the river bank. The soil samples taken within the marginal and lower zones of the river are clearly indicative of wetland conditions on a perennial (marginal) and seasonal (lower) basis. The Vaal River and its banks are clearly defined and easily identifiable as wetland areas and easily differentiated from the surrounding terrestrial habitats.

The site contains two seasonal streams within the interior and western portion of the site and one flows east to the Vaal River whilst the other flows to the west of the site. Soil samples indicate a temporary zone of wetness and this indicates that the stream cannot be considered a wetland but rather a watercourse. The soil indicates a low amount of mottling indicating the oxidation of iron due to short periods of inundation. This further indicates that the streams are ephemeral in nature, meaning that they will only have main channel connected flow every couple of years and not annually.

The two interior seasonal streams are largely intact with few impacts. Several artificial dams have been constructed in the main channel of the streams. This has caused alteration in the flow characteristics and flooding of the streams. These are considered the most relevant impacts on the streams.

A single ephemeral pan is situated within the interior of the study area. Vegetation within and surrounding the pan clearly indicate a high moisture regime compared to the surroundings. Soil samples taken indicate a clear seasonal zone of wetness which confirms the presence of this ephemeral pan. Soil samples indicate clear and well defined mottling.

The ephemeral pan within the interior of the site is largely intact although trampling by domestic stocks is high and has lead to degradation of the pan to some extent. As this is a grassy pan and collects water it is favoured by stock which then cause high levels of trampling. Despite the high level of trampling the pan is still considered relatively intact and natural.

Three distinct seasonal streams originate within the low hill terrain in the eastern portion of the site and drain towards and into the Vaal River. The streams occur within shallow valleys within the low hills. The streams, especially the northern stream, contain dense riparian vegetation.

The stream in the north of the site is evidently in a natural condition with few impacts. The remaining two streams to the south has been clearly degraded by historical mining as the stream has been excavated for diamond mining. The excavated material has not been returned to the stream which is consequently altered from the natural condition.

The three seasonal streams in the hilly terrain within the eastern portion of the site has also been subjected to several impacts. The stream bordering on the north of the site is relatively intact with few impacts. The stream is considered natural and in a very good condition. The habitat it supports is also varied and high in diversity. The two seasonal streams to the south is in a degraded condition. This is due to historical mining as discussed above. The topography of the surroundings has been altered thereby altering the runoff into the streams. The stream morphology has also been altered and has modified the flow regime, flood dynamics and riparian component of the streams. These streams support a degraded habitat with relatively low diversity.

The Vaal River and its associated floodplains are considered a fifth order watercourse. 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 historical alluvial diamond mining which has had a high impact on the site. The majority of the site is still considered largely natural although the previously mined areas degrades the conditions of the site and alter the ecological function of the watercourses within the study area as well as the Vaal River itself. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream 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 C). The results of the IHI indicated that the Vaal River has an Inseam and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant upstream impacts as well as historical 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.

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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.

Some vegetation units perform vital functions in the larger ecosystem. 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.

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 open pit mining, has several detrimental impacts on the environment. These impacts are numerous but the most pronounced impacts are associated with the excavation of large amounts of earth materials, the storage and disposal thereof and the sedimentation associated with it. This usually causes degradation of waterways due to sedimentation as well as the transformation of the vegetation and ecosystem on the site.

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

The study area consists of a large portion of land on the banks of the Vaal River near the town of Windsorton which is proposed for alluvial diamond mining operations. The current land use on the site and surrounding region is primarily concerned with livestock grazing. Alluvial diamond mining is also a common land use in the area along the Vaal River. The mining area is situated approximately 10 km north of the town of Windsorton on the western banks of the Vaal River. The study area is approximately 2500 hectares in size and includes the entire mining area (Map 1).

A site survey was conducted on 8 February 2016.

1.2 The value of biodiversity

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

The balancing of atmospheric gases through photosynthesis and carbon sequestration is reliant on biodiversity, while an estimated 40% of the global economy is based on biological products and processes (Johnson 2005).

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

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

2. Scope and limitations

- To evaluate the present state of the wetlands and riparian vegetation included within the study area. The importance of the ecological function and condition will also be assessed.
- Identify and delineate watercourses including rivers, streams, pans and wetlands and ascertain condition and status therefore and recommend mitigation.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the wetlands in the study area.

2.1 Riparian Vegetation

Aspects of the riparian vegetation that will be assessed include:

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

The amount of disturbance present on the study area assessed according to:

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

2.2 Wetlands

Aspects of the wetlands that will be assessed include:

- Identification and delineation of watercourses including rivers, streams, pans and wetlands.
- Describe condition and status of watercourses and importance relative to the larger system.

2.3 Limitations

Due to the current drought several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to the drought.
Several of the streams and wetlands away from the Vaal River are seasonal in nature and do not contain an aquatic component (including invertebrates and fish species).
Due to time constraints only limited soil sampling could be done.

3. Methodology

3.1 Several literature works were used for additional information.

Vegetation:
Red Data List (Raymondo *et al*. 2009).
Vegetation types (Mucina & Rutherford 2006).
Field guides used for riparian species identification (Bromilow 1995, 2010, Coates-Palgrave 2002, Gerber *et al* 2004, Manning 2009, Onderstall 1996, Pooley 1998, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Wyk & Malan 1998).

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

3.2 Survey

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

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

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

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

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

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

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

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

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

3.3 Criteria used to assess sites

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

3.3.1 Vegetation characteristics

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

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

Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely – 3.

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

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

3.3.2 Vegetation condition

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

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

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

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

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

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

3.3.3 Faunal characteristics

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

3.4 Biodiversity sensitivity rating (BSR)

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

Table 1: Biodiversity sensitivity ranking

BSR	BSR general floral description	Floral score equating to BSR class
Totally transformed (5)	Vegetation is totally transformed or in a highly degraded state, generally has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area has lost its inherent ecological function. The area has no conservation value and potential for successful rehabilitation is very low.	29 – 30
Advanced Degraded (4)	Vegetation is in an advanced state of degradation, has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area's ecological function is seriously hampered, has a very low conservation value and the potential for successful rehabilitation is low.	26 – 28
Degraded (3)	Vegetation is notably degraded, has a medium level of species diversity although no species of concern are present. Invasive plants are present but are still controllable. The area's ecological function is still intact but may be hampered by the current levels of degradation. Successful rehabilitation of the area is possible. The conservation value is regarded as low.	21 – 25
Good Condition (2)	The area is in a good condition although signs of disturbance are present. Species diversity is high and species of concern may be present. The ecological function is intact and very little rehabilitation is needed. The area is of medium conservation importance.	11 – 20
Sensitive/Pristine (1)	The vegetation is in a pristine or near pristine condition. Very little signs of disturbance other than those needed for successful management are present. The species diversity is very high with several species of concern known to be present. Ecological functioning is intact and the conservation importance is high.	0 - 10

4. Wetland Assessment

For the purpose of this report the general ecology of the study area will first be discussed followed by a discussion of the wetland system.

4.1 General ecology and description of the study area (Mucina & Ruterford 2006)

The study area consists of a large portion of land approximately 2500 hectares in size near the town of Windsorton which is proposed for alluvial diamond mining (Map 1). The entire mining area forms part of the study area. The study area is situated along the western banks of the Vaal River and stretches inland for approximately 7 km. The region is predominately utilised as natural grazing for domestic stock. Alluvial diamond mining is also common in the region along the Vaal River. The majority of the study area consists of natural vegetation although certain areas consist of historical mining areas which are considered degraded. Although natural vegetation has re-established in these area it does not consist of a natural species composition. The largest impact on the area is considered those consisting of historical mining activities since in those times no rehabilitation was done. Grazing by domestic stock is considered relatively low. The ecological functioning of the area is largely intact. The area is situated in the savannah biome with a well developed though low tree layer. Encroaching of certain tree and shrub species is evident and alters the vegetation structure to some degree. A well developed grass layer forms the understorey although sparse in many areas this is considered natural to this arid region. The region is considered to have a low rainfall and forms part of an arid area.

The study area consists of a varying topography and altitude varies from 1150 m to 1200 m. In the western portion of the study area the topography is relatively flat and undulating with isolated low dolerite hills. The substrate is sandy with outcrops and superficial pebbles in some areas. This area is relatively uniform. The eastern portion of the site develops low dolerite hills from west to east. The slope gradient and uneven terrain increases with proximity to the river. This portion closer to the river contains a much higher diversity of habitat, topography and species. The interior of the study area contains two distinctive seasonal streams. The relatively flat terrain does not promote the formation of watercourses. A single but distinctive pan is also located in the interior portion of the study area. In the eastern portion of the site the uneven terrain causes the presence of several seasonal streams. The floodplain of the river contains wetlands within the marginal zone in certain areas of the study area.

The region has an approximate mean annual rainfall of 280 mm with most rainfall occurring mainly during summer. This is considered a relatively low rainfall and causes the area to form part of the more arid parts of South Africa. The occurrence of wetlands are therefore not common, however, due to the proximity to the Vaal River the area adjacent to the river contains several wetlands associated with the marginal zone of the Orange River. The average maximum temperature ranges from 18˚C in June to 32˚C in January.

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.

The study area does not contain extensive built up areas and only contains a farmstead, surrounding buildings and scattered dilapidated buildings. A water canal is situated within the eastern portion and transects the site from north to south. These are not considered to have

been responsible for transformation of a significant area. The proposed mining operations will consist of a plant with infrastructure and offices. The mining operations and clearing and stripping of material is considered to have a high level of impact on the area. Mining may lead to transformation of large areas subjected to alluvial diamond mining.

No extensive infestation by exotic weeds and invaders occur in the study area although indigenous weeds and pioneer species occur along the Orange River. This is considered natural as the floodplain of rivers are characterised as disturbance driven ecosystem and therefore will contain weeds and pioneer species.

The vegetation types within the study area consists of Kimberley Thornveld (SVk 4) and Scmidtsdrif Thornveld (SVk 6) (Map 3). According to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) these vegetation types are considered to be of least Concern (LC) (Map 3). They are not currently subjected to any pronounced transformation or development pressures.

Vegetation cover within the study area is relatively uniform over the site despite the variety in topography especially in the east of the site. The diversity of species does however seem higher in the eastern portion although the vegetation structure remains unchanged as a relatively dense shrubland/tree layer with a grass understorey. The tree layer varies from shrub to tree height and is relatively dense over the site. The height of the tree layer increases substantially near seasonal streams, pans and along the Vaal River. Dominant tree/shrub species include *Senegalia mellifera* subsp. *detinens* (Black Thorn), *Grewia flava* (Raison Bush) and *Tarchonanthus camphoratus* (Camphor Bush). These species are strictly terrestrial and does not occur within the riparian vegetation zone. Trees and shrubs indicating and being diagnostic of the riparian zone include *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), *Searsia lancea* (Karree), *Salix mucronata* (Cape Willow) and *Diospyros lycioides* (Bluebush) which are exclusively associated with the higher moisture regime and can therefore be taken as indicators of the riparian zone.

South Africa has a large amount of endemic species and in terms of biological 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.

The Beeskloutjie (*Lithops leslei* subsp. *leslei*) is known to occur in the vicinity of the site and it is highly likely that it occurs on the site. It is of conservational concern and must be considered sensitive. Due to the drought the species will likely hide underground and will not currently be visible within the study area.

South Africa contains 19 known centres of endemism. These areas contain a high number of species endemic to this specific area. Due to the limited range of most of these species many are rare, protected or endangered. The mining area is situated within the Griqualand West Centre of Endemism. Many species occurring within this centre is unique and localised to this area. As a result the study area may contain such species which are of conservational importance.

4.2 Wetland Delineation

The study area consists of the diamond mining area and is bordered on the east by the Vaal River (Map 2). Several prominent seasonal streams occur in the uneven terrain in the eastern portion of the site. These drain from the low hills into the Vaal River. Within the western portion which has a much more uniform topography only one significant seasonal stream occurs as well as a single ephemeral pan.

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

Watercourse means:

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

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

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the presence of wetland soils along the Vaal River, seasonal streams and the ephemeral pan (Appendix B). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The majority of the river bank along this section is narrow and steep and as a consequence the associated wetlands with the Vaal River are also narrow and not extensive. However, several island also occur within the river. Along the north western corner of the site along the river an extensive floodplain is present (Map 2). Soil samples indicate that the marginal zone of the river must be considered a wetland area. The marginal zone is indicative of a permanent zone of wetness while the lower zone is indicative of a seasonal zone of wetness. Where seasonal streams enter the river small alluvial fans occur which also enlarge the wetland zone along the river bank. The soil samples taken within the marginal and lower zones of the river are clearly indicative of wetland conditions on a perennial (marginal) and seasonal (lower) basis. The Vaal River and its banks are clearly defined and easily identifiable as wetland areas and easily differentiated from the surrounding terrestrial habitats.

The site contains two seasonal streams within the interior and western portion of the site and one flows east to the Vaal River whilst the other flows to the west of the site (Map 2). Both streams flow over a long distance. Both streams are confined within the interior of the site and the eastern stream has its confluence with the Vaal River outside the study area boundary. Both streams contain several artificial dams in the main channel. Vegetation along the streams area readily identified as riparian vegetation. Tree species along the streams are characteristic of watercourses in these arid areas. These species include *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), S*earsia lancea* (Karree) and *Diospyros lycioides* (Bluebush). Soil samples indicate a temporary zone of wetness and this indicates that the stream cannot be considered a wetland but rather a watercourse. . The soil indicates a low amount of mottling indicating the oxidation of iron due to short periods of inundation (Appendix

B). This further indicates that the streams are ephemeral in nature, meaning that they will only have main channel connected flow every couple of years and not annually. The in-field observations of the streams confirms this. The streams are easily identifiable and distinguished from the surrounding terrestrial habitats by the presence of these riparian tree species which are also taller than the surrounding vegetation.

A single ephemeral pan is situated within the interior of the study area (Map 2). The pan has no distinct in or outflow. The pan has a diameter of approximately 150 m. Vegetation within and surrounding the pan clearly indicate a high moisture regime compared to the surroundings. The fringe of the pan is dominated by trees which area characteristic riparian species. These species include *Ziziphus mucronata* (Buffalo Thorn), S*earsia lancea* (Karree) and *Diospyros lycioides* (Bluebush). The interior of the pan is dominated by a single grass species, namely *Diplachne fusca*. This is a wetland species clearly indicating that the pan should be considered a wetland. A small area in the centre of the pan contains a low percentage vegetation cover where the moisture regime and also trampling by domestic stock is highest. In this area the aquatic fern, *Marsilea capensis*, is present indicating clear wetland conditions. Soil samples taken indicate a clear seasonal zone of wetness which confirms the presence of this ephemeral pan (Appendix B). Soil samples indicate clear and well defined mottling. The pan is easily identifiable and distinguishable from the surrounding environment. The pan can be categorised as a Highveld Alluvial Pan.

Three distinct seasonal streams originate within the low hill terrain in the eastern portion of the site and drain towards and into the Vaal River (Map 2). The streams occur within shallow valleys within the low hills. The streams, especially the northern stream, contain dense riparian vegetation. Riparian tree species along the streams are similar for all three streams as well as along the flow of each stream. These consist of *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), *Searsia lancea* (Karree), *Salix mucronata* (Cape Willow) and *Diospyros lycioides* (Bluebush). The vegetation within the main channel varies over the length of the streams as well as between the streams. This is due to the difference in slope, catchment size, pools, etc, within and between the streams. Although differing, all of the vegetation consist of riparian species of grasses and sedges which support the presence of a watercourse. These species include *Cyperus congestus, C. eragrostis, Panicum maximum, Paspalum dilatatum, P. distichum* and *Schoenoplectus sp.* The stream in the north of the site is evidently in a natural condition with few impacts. The remaining two streams to the south has been clearly degraded by historical mining as the stream has been excavated for diamond mining. The excavated material has not been returned to the stream which is consequently altered from the natural condition.

The marginal zone and banks of the Vaal River can be characterised as 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.

The above description accurately describes the wetland areas along the Vaal River in the study area. They are situated adjacent to the Vaal River which is a lowland river of large scale (Map 2). These areas are undoubtedly inundated on an annual basis during flooding although the magnitude and frequency of these have been diminished due to building of large dams in the river which now regulate flooding events. These wetland areas are absent along the majority of the study area and present within alluvial floodplains where streams flow into the river or on the inside of the river bends. The floodplain of the river is considered small and narrow except in the north of the site where it is quite extensive. The riparian trees, *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), *Searsia lancea* (Karree), *Salix mucronata* (Cape Willow) and *Diospyros lycioides* (Bluebush) occur exclusively associated with the higher moisture regime of the floodplain and can therefore be taken as indicators of the riparian zone. The floodplain in the north of the site is quite extensive and also associated with a braided river pattern with several small islands. This floodplain is flooded on an annual basis. Historical mining has also occurred in this area and excavations have not been rehabilitated. This causes transformation of the floodplain to some degree.

The ephemeral pan on the site can be characterised as a depression wetland (SANBI 2009):

A depression wetland is a basin shaped area with a closed elevation contour 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.

This accurately describes the pan on the site. It also has no definite in- or outflow. The pan is fringed by a well defined riparian tree strip. The pan itself is dominated by riparian grass species and the centre contains a small area of aquatic fern. The pan is ephemeral in nature. the centre portion of the pan is likely to have standing water on an annual basis while the majority of the pan will only contain water during years of exceptional precipitation. The pan is being trampled by cattle which is considered the only significant impact on the pan.

The seasonal streams on the site can be characterised as valley bottom wetlands with a channel (SANBI 2009):

This wetland occurs in valley bottom areas with well defined stream channel but lacking characteristic floodplain features. It may be gentle sloped and characterised by the alluvial transport and deposition of material by water or may have steeper slopes and characterised by the loss of sediment. The seasonal streams on the site is of the latter type except where they flow in to the Vaal River and sediment deposition takes place. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.

This accurately describes the seasonal streams on the site. The streams are seasonal in nature, flowing for short periods during the rainy season. Due to the steep slopes the streams drain relatively quickly. Small pools do however occur where water will remain for a longer period. The northern stream is still in a good condition and is dominated by riparian trees along its banks and within the main channel a dense stand of riparian grasses and sedges. The two

southern streams has been transformed due to historical diamond mining and here the wetland nature is not as evident and the streams are markedly degraded. However, wetland species do still occur within these streams.

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

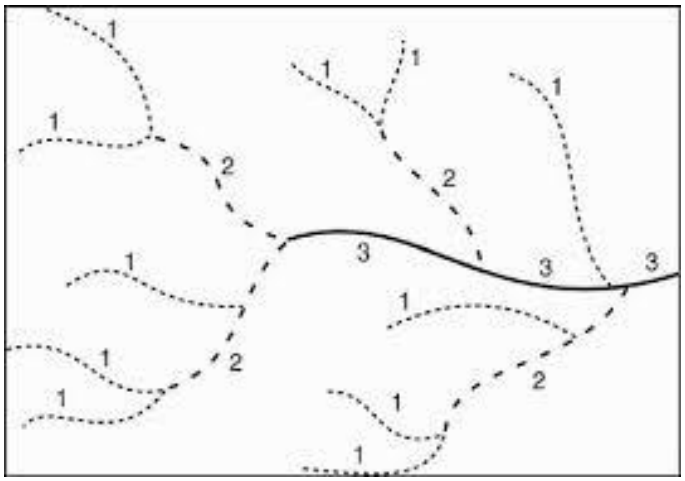

Figure 1: The classification of stream orders from 1 to 3 (Strahler 1952)

Table 2 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 3 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).

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 2 & 3). The marginal zone within the Vaal River as it occurs within the study area is well defined and easily identifiable by the presence of a dense riparian and sedge layer which are inundated on an annual nature. The marginal zone is very narrow along the majority of the river in the study area. However, one area in particular contain extensive marginal zones and several other areas contain smaller but still prominent marginal areas. These areas are predominately consisting of alluvial deposits on the outside of the river bends and the inflows of tributary streams. These marginal zones also constitute perennial wetland areas. Historical diamond mining of these shallow areas has caused transformation of these areas to some extent.

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 2 & 3). The lower zone along the Vaal River is clearly defined and is easily visible but may differ along the section within the study area. The majority of the lower zone is exceedingly steep with a sudden increase in slope over a short distance where after it levels off into the upper zone. In small section of the river and especially where the marginal zone is extensive the lower zone extends over a larger distance and the increase in slope and elevation is more gradual. The boundary between the zones in these areas are more difficult to discern. The lower zone is inundated infrequently and only during larger flooding events. The lower zone is clearly defined by a dense riparian thicket dominated by several tree species. This can also be explained by the infrequent flooding of the lower zone. Large-scale flooding has a disturbance effect whereby vegetation is removed and allows for vegetation to re-establish through an ongoing cycle which is well known in river systems. Trees are also being affected most by flooding due to their increased volume presented to floods. Grasses, sedges and the like growth forms are much better adapted to flooding and able to withstand being uprooted to a much better degree. As a result the marginal zone contains almost no trees whereas the lower zone is dominated by trees. The lower zone has also been considerably transformed due to historical mining activities.

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 2 & 3). The upper zone of the Vaal River is clearly visible as a decrease in slope and an increase in the woodland component. The tree canopy is higher along the lower zone due to less flood disturbance and the understorey is much sparser with a low percentage vegetation cover due to the lower moisture regime. This understorey is anticipated to be increased by annuals during the summer rain period. The tree species are able to attain height and age due to the deep root systems still able to access the higher moisture levels and as flood disturbance in the upper zone is much less the trees are allowed to grow old without being removed by flood damage. The riparian tree species within the upper zone is dominated by *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn) and *Diospyros lycioides* (Bluebush) which then also indicate the border of the upper zone. The small tree, *Senegalia mellifera* subsp. *detinens, Tarchonanthus camphoratus* and *Grewia flava,* replaces these riparian trees and indicates the terrestrial habitat outside the floodplain. The upper zone has also been transformed to some extent.

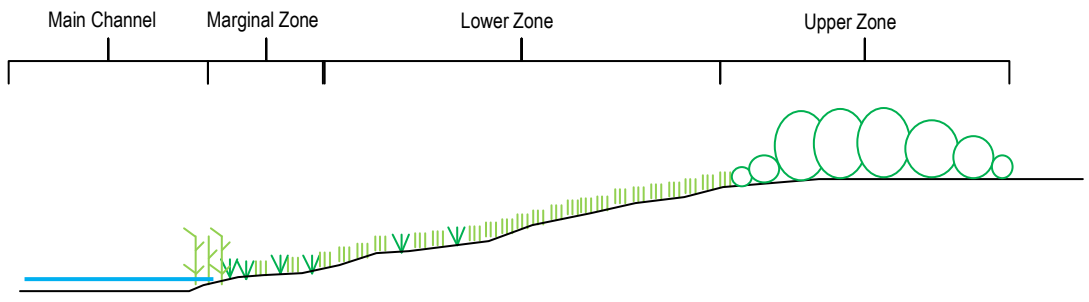

Figure 2: Illustration showing the different riparian zones of Vaal River in the study area. Note the extensive marginal and lower zone which occurs in the north of the study area.

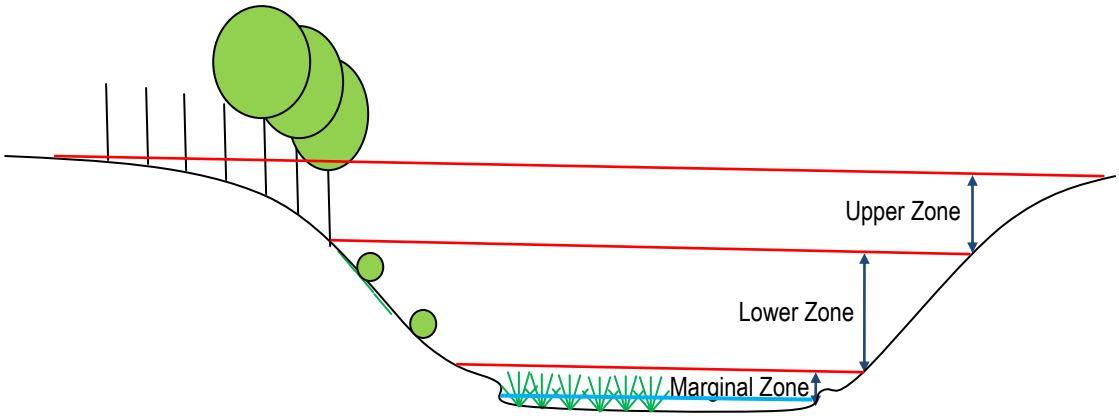

Figure 3: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation over the majority of the section in the study area. Note the narrow marginal zone and steep lower zone.

Table 2: Ecological categories for Present Ecological Status (PES).

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

Table 3: Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very High Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be	>2 and <=3	B

sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.		
Moderate Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

The Vaal River and its associated floodplain wetlands, seasonal streams and ephemeral pan were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix B & C). The following guidelines and frameworks were used to determine and delineate the drainage lines 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 section of the Vaal River within the study area is considered to be moderately modified by several impacts (Appendix C). The flood dynamics of the river has been altered to a large degree by the construction of large dams upstream.

Impacts on the Vaal River are many and several are considered as large impacts. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. Historical mining is also evident on the site. The impact is considered high since no rehabilitation was undertaken in those days. Shallow excavations and rock heaps are common on the site. The two seasonal streams in the southern portion near the Vaal River has especially been degraded by this where the mining took place within the main channel of the streams end left un-rehabilitated. Extensive historical mining had also occurred in the main channel of the Vaal River itself and its banks. This has altered the bed and bank morphology to some extent and will undoubtedly also have had an effect on sediment and flow dynamics. The impact of historical mining has diminished to some extent as the environment rehabilitates itself although the change in topography and morphology is not rehabilitatable through succession of the environment itself. Centre-pivot irrigation does not take place near the site but is extensive in Vaal-Harts region which is approximately 35 km upstream of the site. There would undoubtedly still be some impact as a result of this such as fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. Grazing by domestic stock and trampling of the riparian zone also causes impacts although currently not considered a significant impact. The construction of large containment dams such as the

Vaalharts Dam, Bloemhof Dam and Vaal Dam 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 waterbodies and watercourses within the interior of the site has also been subjected to several impacts.

The two interior seasonal streams are largely intact with few impacts. Grazing and trampling by domestic stock is moderate with a relatively low impact. Several artificial dams have been constructed in the main channel of the streams. This has caused alteration in the flow characteristics and flooding of the streams. These are considered the most relevant impacts on the streams.

The ephemeral pan within the interior of the site is largely intact although trampling by domestic stocks is high and has lead to degradation of the pan to some extent. As this is a grassy pan and collects water it is favoured by stock which then cause high levels of trampling. Natural fauna such as game do not cause this level of trampling as they are not as dependant on water as livestock. Despite the high level of trampling the pan is still considered relatively intact and natural.

The three seasonal streams in the hilly terrain within the eastern portion of the site has also been subjected to several impacts. The stream bordering on the north of the site is relatively intact with few impacts. The stream is considered natural and in a very good condition. The habitat it supports is also varied and high in diversity. The two seasonal streams to the south is in a degraded condition. This is due to historical mining as discussed above. The topography of the surroundings has been altered thereby altering the runoff into the streams. The stream morphology has also been altered and has modified the flow regime, flood dynamics and riparian component of the streams. These streams support a degraded habitat with relatively low diversity.

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix C). 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 historical alluvial diamond mining which has had a high impact on the site. The majority of the site is still considered largely natural although the previously mined areas degrades the conditions of the site and alter the ecological function of the watercourses within the study area as well as the Vaal River itself. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream 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 C). The results of the IHI indicated that the Vaal River has an Inseam and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant upstream impacts as well as historical 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 recent 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.
- Alteration of river channels and flows due to mining of alluvial deposits in the river bed.
- Excavation of river sediments exposes these sediments to oxidising conditions and enhances the solubility and release of any metal ions that may previously have been previously trapped as insoluble sulphides.
- Wind-blown dusts from unprotected tailings and waste rock dumps enter aquatic environment.

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Furthermore, many areas along the Vaal and Orange Rivers were mined a century ago and the environmental footprints are still prevalent. It is important that rehabilitation is comprehensive and successful and that the prevalent impacts as listed be managed and mitigated adequately.

5. Biodiversity condition and sensitivity rating

5.1 Overall condition of the study area

Habitat diversity and species richness:
Habitat diversity within the study area is considered moderate. The study area contains numerous different vegetation communities which are coupled to different soil conditions and topographical units as well as varied habitats associated with the Vaal River and its floodplain. These varied habitats also contribute to species diversity. The vegetation types in the study area is not known for high diversity levels but the varied habitats contribute nonetheless to diversity.

Presence of rare and endangered species:
No rare or endangered species were encountered on the site, however, the area was only limitedly surveyed and the time of year many species are not identifiable due to the dry conditions. The area is situated within the Griqualand West Centre of Endemism and does contain species of significance. The likelihood of significant species occurring on the site is considered as moderate.

The Beeskloutjie (*Lithops leslei* subsp. *leslei*) is known to occur in the vicinity of the site and it is highly likely that it occurs on the site. It is of conservational concern and must be considered sensitive. Due to the drought the species will likely hide underground and will not currently be visible within the study area.

Ecological function:
The Vaal River, associated wetland and drainage lines within the study area play a vital role in the continued functioning of the river in terms of water transport and drainage of the area. The habitat provided by the river and associated habitats support a rich faunal component and is considered to perform an important ecological function in this regard. The drainage functioning and flooding regime has been altered but these systems are nonetheless still considered sensitive.

Degree of rarity/conservation value:
The vegetation types within the study area consists of Scmidtsdrif Thornveld (SVk 6), Kimberley Thornveld (SVk 4) and Upper Gariep Alluvial Vegetation (AZa 4) (Map 2). According to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) these vegetation types are considered to be of least Concern (LC) (Map 3). They are not currently subjected to any pronounced transformation or development pressures.

South Africa contains 19 known centres of endemism. These areas contain a high number of species endemic to this specific area. Due to the limited range of most of these species many are rare, protected or endangered. The mining area is situated within the Griqualand West Centre of Endemism. Many species occurring within this centre is unique and localised to this area. As a result the study area may contain such species which are of conservational importance.

The Beeskloutjie (*Lithops leslei* subsp. *leslei*) is known to occur in the vicinity of the site and it is highly likely that it occurs on the site. It is of conservational concern and must be considered sensitive. Due to the drought the species will likely hide underground and will not currently be visible within the study area.

As previously mentioned the Vaal River, associated wetland, ephemeral pans and seasonal streams are considered sensitive ecosystems and their conservation value must therefore be considered as relatively high (Map 2).

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

Vegetation structure:
The study area is situated within the Savanna Biome and therefore contains a well developed tree layer with grass and dwarf shrub understorey. Overgrazing may be responsible for an increase in the density of the tree and shrub layer especially the small tree, *Senegalia mellifera* subsp. *detinens.*

Infestation with exotic weeds and invader plants:
No extensive infestation by exotic weeds and invaders occur in the study area although indigenous weeds and pioneer species occur along the Vaal River. This is considered natural as the floodplain of rivers are characterised as disturbance driven ecosystem and therefore will contain weeds and pioneer species.

Degree of grazing/browsing impact:
The area has been utilised as stock farming area for some time. Grazing and browsing is considered moderate and not responsible for significant impacts on the site.

Signs of erosion:
Erosion is considered moderate. Within the interior and along seasonal streams erosion is evident within the sandy soils although this still within the natural condition of the area. Erosion along the seasonal streams affected by historical mining is also considered moderate although as a result of the mining impact.

Terrestrial animals:
Along the Vaal River the mammal activity is exceptionally high as these areas provide water and food. They therefore play an important role as habitat for mammals and there is a likelihood that species of conservational importance may occur in the area.

Table 5: Biodiversity Sensitivity Rating for the diamond mining study area.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness			1
Presence of rare and endangered species			1
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		2	
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species			1
Sub total		14	3
Total		17	

5.2. Biodiversity sensitivity rating (BSR) interpretation

Table 6: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Rooidam diamond mining area	17	Good Condition	2

6. Discussion and conclusions

The vegetation types within the study area consists of Scmidtsdrif Thornveld (SVk 6), Kimberley Thornveld (SVk 4) and Upper Gariep Alluvial Vegetation (AZa 4). According to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) these vegetation types are considered to be of least Concern (LC) (Map 3). They are not currently subjected to any pronounced transformation or development pressures.

South Africa contains 19 known centres of endemism. These areas contain a high number of species endemic to this specific area. Due to the limited range of most of these species many are rare, protected or endangered. The mining area is situated within the Griqualand West Centre of Endemism. Many species occurring within this centre is unique and localised to this area. As a result the study area may contain such species which are of conservational importance.

The Beeskloutjie (*Lithops leslei* subsp. *leslei*) is known to occur in the vicinity of the site and it is highly likely that it occurs on the site. It is of conservational concern and must be considered sensitive. Due to the drought the species will likely hide underground and will not currently be visible within the study area.

As previously mentioned the Vaal River, associated wetland, ephemeral pans and seasonal streams are considered sensitive ecosystems and their conservation value must therefore be considered as relatively high (Map 2).

The study area consists of a varying topography and altitude varies from 1150 m to 1200 m. In the western portion of the study area the topography is relatively flat and undulating with isolated low dolerite hills. The substrate is sandy with outcrops and superficial pebbles in some areas. This area is relatively uniform. The eastern portion of the site develops low dolerite hills from west to east. The slope gradient and uneven terrain increases with proximity to the river. This portion closer to the river contains a much higher diversity of habitat, topography and species. The interior of the study area contains two distinctive seasonal streams. The relatively flat terrain does not promote the formation of watercourses. A single but distinctive pan is also located in the interior portion of the study area. In the eastern portion of the site the uneven terrain causes the presence of several seasonal streams. The floodplain of the river contains wetlands within the marginal zone in certain areas of the study area.

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the presence of wetland soils along the Vaal River, seasonal streams and the ephemeral pan (Appendix B). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The majority of the river bank along this section is narrow and steep and as a consequence the associated wetlands with the Vaal River are also narrow and not extensive. However, several island also occur within the river. Along the north western corner of the site along the river an extensive floodplain is present. Soil samples indicate that the marginal zone of the river must be considered a wetland area. The marginal zone is indicative of a permanent zone of wetness while the lower zone is indicative of a seasonal zone of wetness. Where seasonal streams enter the river small alluvial fans occur which also enlarge the wetland zone along the river bank. The soil samples taken within the marginal and lower zones of the river are clearly indicative of wetland conditions on a perennial (marginal) and seasonal (lower) basis. The Vaal

River and its banks are clearly defined and easily identifiable as wetland areas and easily differentiated from the surrounding terrestrial habitats.

The site contains two seasonal streams within the interior and western portion of the site and one flows east to the Vaal River whilst the other flows to the west of the site (Map 2). Both streams flow over a long distance. Both streams are confined within the interior of the site and the eastern stream has its confluence with the Vaal River outside the study area boundary. Both streams contain several artificial dams in the main channel. Soil samples indicate a temporary zone of wetness and this indicates that the stream cannot be considered a wetland but rather a watercourse. The soil indicates a low amount of mottling indicating the oxidation of iron due to short periods of inundation (Appendix B). This further indicates that the streams are ephemeral in nature, meaning that they will only have main channel connected flow every couple of years and not annually. The streams are easily identifiable and distinguished from the surrounding terrestrial habitats by the presence of these riparian tree species which are also taller than the surrounding vegetation.

A single ephemeral pan is situated within the interior of the study area (Map 2). The pan has no distinct in or outflow. The pan has a diameter of approximately 150 m. Vegetation within and surrounding the pan clearly indicate a high moisture regime compared to the surroundings. Soil samples taken indicate a clear seasonal zone of wetness which confirms the presence of this ephemeral pan (Appendix B). Soil samples indicate clear and well defined mottling. The pan is easily identifiable and distinguishable from the surrounding environment. The pan can be categorised as a Highveld Alluvial Pan.

Three distinct seasonal streams originate within the low hill terrain in the eastern portion of the site and drain towards and into the Vaal River (Map 2). The streams occur within shallow valleys within the low hills. The streams, especially the northern stream, contain dense riparian vegetation. The stream in the north of the site is evidently in a natural condition with few impacts. The remaining two streams to the south has been clearly degraded by historical mining as the stream has been excavated for diamond mining. The excavated material has not been returned to the stream which is consequently altered from the natural condition.

Impacts on the Vaal River are many and several are considered as large impacts. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. Historical mining is also evident on the site. The impact is considered high since no rehabilitation was undertaken in those days. The two seasonal streams in the southern portion near the Vaal River has especially been degraded by this where the mining took place within the main channel of the streams end left un-rehabilitated. Extensive historical mining had also occurred in the main channel of the Vaal River itself and its banks. This has altered the bed and bank morphology to some extent and will undoubtedly also have had an effect on sediment and flow dynamics. The construction of large containment dams such as the Vaalharts Dam, Bloemhof Dam and Vaal Dam 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 waterbodies and watercourses within the interior of the site has also been subjected to several impacts.

The two interior seasonal streams are largely intact with few impacts. Several artificial dams have been constructed in the main channel of the streams. This has caused alteration in the flow characteristics and flooding of the streams. These are considered the most relevant impacts on the streams.

The ephemeral pan within the interior of the site is largely intact although trampling by domestic stocks is high and has lead to degradation of the pan to some extent. As this is a grassy pan and collects water it is favoured by stock which then cause high levels of trampling. Despite the high level of trampling the pan is still considered relatively intact and natural.

The three seasonal streams in the hilly terrain within the eastern portion of the site has also been subjected to several impacts. The stream bordering on the north of the site is relatively intact with few impacts. The stream is considered natural and in a very good condition. The habitat it supports is also varied and high in diversity. The two seasonal streams to the south is in a degraded condition. This is due to historical mining as discussed above. The topography of the surroundings has been altered thereby altering the runoff into the streams. The stream morphology has also been altered and has modified the flow regime, flood dynamics and riparian component of the streams. These streams support a degraded habitat with relatively low diversity.

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix C). 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 historical alluvial diamond mining which has had a high impact on the site. The majority of the site is still considered largely natural although the previously mined areas degrades the conditions of the site and alter the ecological function of the watercourses within the study area as well as the Vaal River itself. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream 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 C). The results of the IHI indicated that the Vaal River has an Inseam and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and other significant upstream impacts as well as historical 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.

The impacts of alluvial diamond mining primarily affect the instream and riparian habitat due to riverbed degradation, increased suspended sediment and changes in the river morphology and hydraulics. Furthermore, many areas along the Vaal and Orange Rivers were mined a century ago and the environmental footprints are still prevalent. It is important that rehabilitation is comprehensive and successful and that the prevalent impacts as listed be managed and mitigated adequately.

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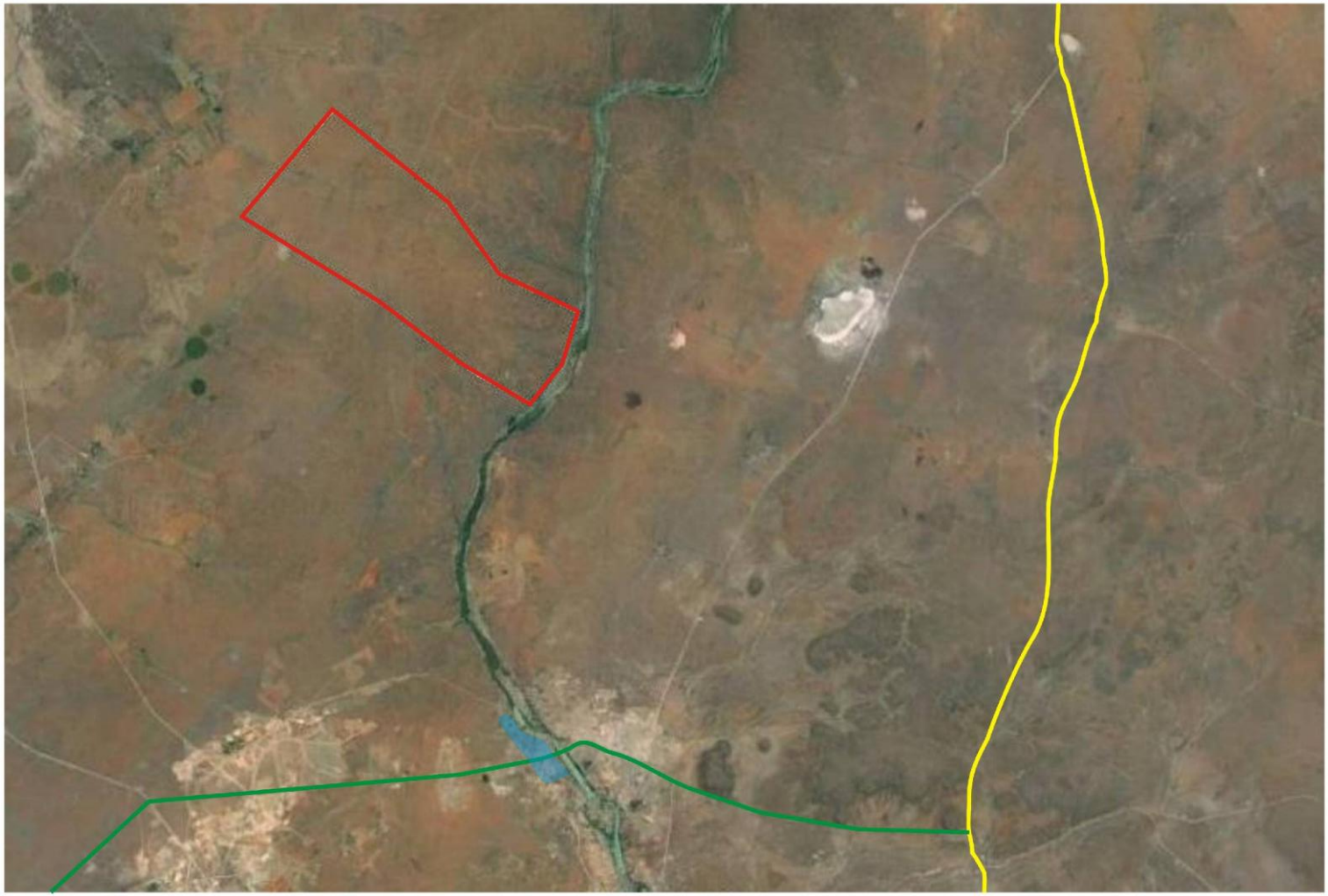
Annexure A: Maps and Site photos

Locality of the proposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near Windsorton, Northern Cape Province.



Preparred for:
Rooidam Plaas (Pty) Ltd
P.O. Box 5
Windsorton
8510

Legend:

- Mining Area (Study Area)
- Windsorton
- N12 National Road
- R374 Provincial Road

Map Information

S 28.226284°
E 24.683696°

Spheroid: WGS 84

0 2.18 4.36 6.54
Scale (km)

Environmental Consultant
EKO Environmental
Contact Darius van Rensburg at:
darius@ekogroup.co.za
Suite 158, P/Bag X01, Brandhof, 9324
Tel: 051 4444 700
Fax: 086 6976 132

Map 1: Locality of theproposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near the town of Windsorton, Northern Cape Province. Note the Vaal River adjacent to the mining area.

Surface water of the proposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near Windsorton, Northern Cape Province.

Preparred for:
Rooidam Plaas (Pty) Ltd
P.O. Box 5
Windsorton
8510

Legend:

- Mining Area (Study Area)
- Wetlands
- Seasonal stream

Map Information

S 28.226284°
E 24.683696°

Spheroid: WGS 84

0 0.85 1.7 2.55
Scale (km)

Environmental Consultant
EKO Environmental
Contact Darius van Rensburg at:
darius@ekogroup.co.za
Suite 158, P/Bag X01, Brandhof, 9324
Tel: 051 4444 700
Fax: 086 6976 132

Map 2: Surface water features of the proposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near the town of Windsorton, Wetland areas are associated with the floodplain of the Vaal River, Seasonal streams and ephemeral pan. The seasonal streams within the interior of the study area is also indicated.

Broad ecology of the proposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near Windsorton, Northern Cape Province.

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Windsorton
8510

Legend:

- Mining Area (Study Area)
- Road network
- Watercourses
- Wetlands
- Upper Gariep Alluvial Veg
- Scmidtsdrif Thornveld
- Kimberley Thornveld

Map Information

S 28.226284°
E 24.683696°

Spheroid: WGS 84

Scale: 1:66 000

Environmental Consultant
EKO Environmental
Contact Darius van Rensburg at:
darius@ekogroup.co.za
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Tel: 051 4444 700
Fax: 086 6976 132

Map 3: Broad ecology of the proposed alluvial diamond mining operations on Portion 1 and the Remaining Extent of the Farm Rooidam 101 near the town of Windsorton, Northern Cape Province. No Threatened Ecosystems, Important Bird Areas or other significant areas occur in the study area.

Figure 1: Panorama of the ephemeral pan within the study area. Note dominance of wetland grass, *Diplachne fusca*. The centre (red circle) contains an area of higher moisture regime.

Figure 2: Panorama of the ephemeral pan. Note the fringe of riparian trees around the pan.

Figure 3: View of the seasonal stream within the interior of the study area.

Figure 4: View of the seasonal stream within the interior of the study area.

Figure 5: Artificial dam constructed in the seasonal stream.

Figure 6: Panorama of the region within the interior of the study area. Note the relatively flat topography.

Figure 7: Historical excavation within the interior of the study area which does not represent a waterbody.

Figure 8: Panorama of the eastern portion of the study area where the terrain is uneven with low hills and ridges and promotes the formation of ravines and streams.

Figure 9: View of the seasonal stream within the northern portion of the study area supporting a diversity of wetland vegetation species.

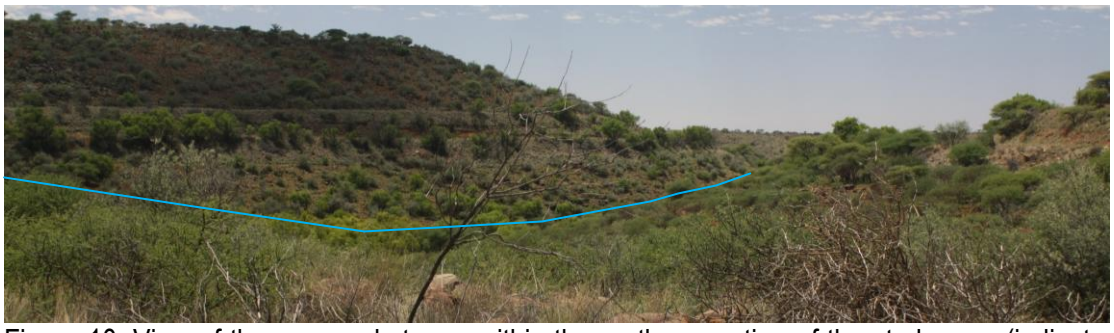

Figure 10: View of the seasonal stream within the northern portion of the study area (indicated in blue).

Figure 11: View of one of the seasonal streams in the southern portion of the study previsouly affected by historical mining.

Figure 12: View of the other seasonal stream within the southern portion of the study area. This stream has been heavily affected by previous historical mining.

Figure 13: Panorama of the Vaal River in the study area. This area contains extensive floodplain also considered wetland areas. Historical mining has however affected a large portion of this area.

Figure 14: The lower zone of the Vaal River. Note the disturbance caused by historical mining operations.

Appendix B: 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 and several of the associated streams and pans. 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 within the floodplain of the Vaal River along the eastern border of the Rooidam study area (S 28˚ 14' 19.88" E 24˚ 43' 20.41").

	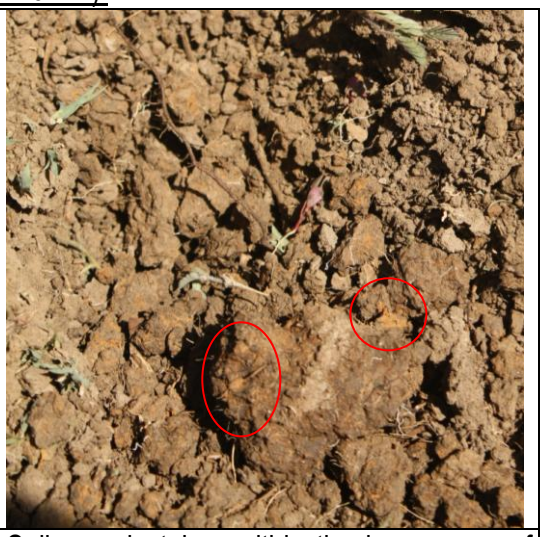
Soil sample taken within the upper zone of the river. A low grey matrix is present with few low chroma mottles indicating temporary zone of moisture. The riparian vegetation also support this.	Soil sample taken within the lower zone of the river. A grey matrix (>10%) is present with many low chroma mottles indicating a seasonal zone of wetness. The riparian vegetation also support this.
	
Soil sample taken within the marginal zone of the river. A prominent grey matrix is present with some high chroma mottles present. The areas is clearly part of the permanent zone of wetness.	

Table 2: Soil samples taken within the ephemeral pan within the interior of the Rooidam study area (S 28˚ 13' 57.38" E 24˚ 41' 58.66").

	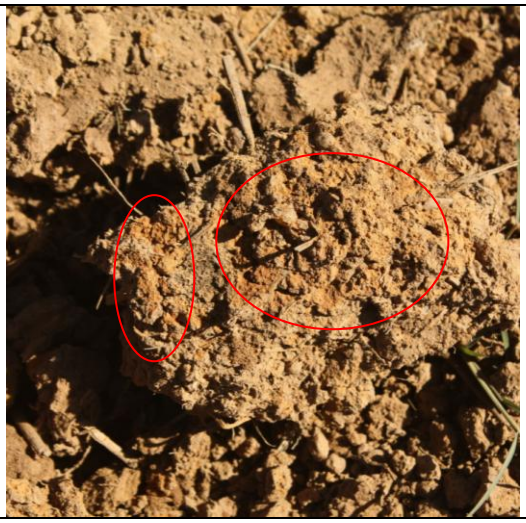
Soil sample taken outside the pan but within the riparian periphery of the pan. The soil does not contain a prominent grey matrix or any mottles and is not considered as a wetland area.	Soil sample taken within the pan. The soil contains a somewhat grey matrix with numerous mottles. It may be considered as part of the seasonal zone of wetness. The riparian grasses within the pan confirms this.
	
Soil sample taken within the centre of the pan. A grey matrix (>10%) is present and numerous mottles are evident. This also indicates a seasonal zone of wetness. The presence of aquatic ferns confirm the presence of this wetland area.	

Table 3: Soil samples taken within the interior seasonal streams of the Rooidam study area (S 28˚ 12' 33.62" E 24˚ 39' 51.34").

	
Soil sample taken within the main channel of the seasonal stream. The soil does not contain a visible grey matrix although a low degree of mottles is present indicating a temporary zone of wetness.	Soil sample taken within the main channel of the seasonal stream. The soil does not contain a grey matrix or mottles and is not considered as having wetland condition. This is also confirm by the vegetation which does not contain wetland species although riparian trees are present.
	
Soil sample taken within the main channel of the seasonal stream. The soil does not contain a grey matrix or mottles and is not considered as having wetland condition. This is also confirm by the vegetation which does not contain wetland species although riparian trees are present.	

Appendix C: Index of Habitat Integrity (IHI) Summary

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

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.236769
UPPER LONGITUDE	E 24.724219
UPPER ALTITUDE	1135
LOWER LATITUDE	S 28.255690
LOWER LONGITUDE	E 24.712099
LOWER ALTITUDE	1134
SURVEY SITE (if applicable)	Vaal River Windsorton
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	
QUATERNARY	C91D
ECOREGION 2	
DATE	8/2/2016
RIVER	Vaal River
TRIBUTARY	
PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	2.3	1.7
PHYSICO-CHEMICAL MODIFICATION	2.5	1.1
BED MODIFICATION	1.2	4.0
BANK MODIFICATION	1.8	3.0
CONNECTIVITTY MODIFICATION	0.6	4.0
INSTREAM IHI%	65.3	
CATEGORY	C	
CONFIDENCE	2.8	

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

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY	2.85	3.00
BANK STRUCTURE MODIFICATION	1.00	4.00
CONNECTIVITY MODIFICATION	1.25	4.00
RIPARIAN HABITAT INTEGRITY (%)	66.58	
CATEGORY	C	
CONFIDENCE	3.67	

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

INSTREAM IHI	MRU
Base Flows	-3.0
Zero Flows	1.0
Floods	-3.5
HYDROLOGY RATING	**2.3**
pH	3.0
Salts	2.5
Nutrients	2.0
Water Temperature	3.0
Water clarity	2.0
Oxygen	2.0
Toxics	3.0
PC RATING	**2.5**
Sediment	1.5
Benthic Growth	1.0
BED RATING	**1.2**
Marginal	2.0
Non-marginal	1.5
BANK RATING	**1.8**
Longitudinal Connectivity	1.0
Lateral Connectivity	0.0
CONNECTIVITY RATING	**0.6**
INSTREAM IHI %	**65.3**
INSTREAM IHI EC	**C**
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)	1.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	1.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	1.0
Physico-Chemical (non-marginal)	1.0
Marginal	1.0
Non-marginal	1.0
BANK STRUCTURE RATING	**1.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.3**
RIPARIAN IHI %	**66.6**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.7**

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