A WETLAND DELINEATION, MANAGEMENT AND REHABILITATION PLAN FOR THE DE BEERS VOORSPOED MINE, FREE STATE PROVINCE

Prepared for: De Beers Consolidated Mines (Pty) Ltd
Prepared by: Exigo Sustainability
A WETLAND DELINEATION, MANAGEMENT AND REHABILITATION PLAN FOR THE DE BEERS VOORSPOED MINE, FREE STATE PROVINCE

WETLAND DELINEATION AND REHABILITATION REPORT

July 2017

Conducted on behalf of:

De Beers Consolidated Mines (Pty) Ltd

Compiled by:

Dr. BJ Henning (PhD plant Ecology; M.Sc Botany - Soil Science related Pr.Sci.Nat)

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Declaration

I, Barend Johannes Henning, declare that -

- I act as the independent specialist;
- I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the project proponent;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this project, including knowledge of the National Environmental Management Act, 2014, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the project proponent and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the project; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority or project proponent;
- All the particulars furnished by me in this document are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

___________________________________
SIGNATURE OF SPECIALIST
Company: Exigo Sustainability
Date: July 2017
# Table of contents

1 **ASSIGNMENT** ........................................................................................................... 1  
1.1 **INFORMATION SOURCES** .................................................................................. 1  
1.2 **REGULATIONS GOVERNING THIS REPORT** ......................................................... 1  
   1.2.1 National Environmental Management Act, 1998 (Act No. 107 of 1998) - Regulation No. R982 1  
   1.2.2 The National Water Act (Act No. 36 of 1998) .................................................... 3  
   1.2.3 Conservation of Agricultural Resources Act (Act No. 43 of 1983) ....................... 3  
   1.2.4 The National Environmental Management Act (NEMA) (Act No. 107 of 1998) .... 3  
1.3 **TERMS OF REFERENCE** ....................................................................................... 4  
   1.3.1 **Objectives** ...................................................................................................... 4  
1.4 **LIMITATIONS AND ASSUMPTIONS** .................................................................... 4  
2 **STUDY AREA** ........................................................................................................... 5  
   2.1 **LOCATION AND DESCRIPTION OF ACTIVITY** ................................................... 5  
   2.2 **CLIMATE** .......................................................................................................... 9  
   2.3 **VEGETATION TYPES** ......................................................................................... 9  
   2.4 **GEOLOGY AND SOIL TYPES** ............................................................................. 10  
   2.5 **TOPOGRAPHY & DRAINAGE** ............................................................................ 10  
3 **METHODS** .............................................................................................................. 12  
   3.1 **WETLAND DELINEATION AND CLASSIFICATION** ........................................... 12  
   3.2 **WETLAND INTEGRITY ASSESSMENTS** ............................................................. 14  
   3.2.1 Present Ecological Status (PES) of wetlands ...................................................... 14  
   3.2.2 Ecological Importance and Sensitivity (EIS) ...................................................... 16  
   3.3 **WETLAND FUNCTIONAL ASSESSMENTS (WET-ECOSERVICES)** ............... 17  
   3.3.1 **Risk assessment matrix** ................................................................................. 19  
4 **RESULTS** ................................................................................................................. 24  
   4.1 **WETLAND CLASSIFICATION AND DELINEATION** ......................................... 24  
   4.1.1 Natural depression .............................................................................................. 26  
   4.1.2 Man-made dams ................................................................................................. 30  
5 **WETLAND IMPACT DESCRIPTION AND RISK ANALYSES** .................................. 34  
   5.1 **KEY ISSUES FOR CONSIDERATION IN MANAGEMENT OF THE WETLANDS** ...... 34  
   5.1.1 Alien invasive species (AIS) management ......................................................... 34  
   5.1.2 Water quality and stormwater management ....................................................... 34  
   5.1.3 Rehabilitation ..................................................................................................... 35  
   5.1.4 Monitoring ........................................................................................................... 35  
   5.2 **WETLAND INTEGRITY ASSESSMENT** ................................................................. 31  
6 **MANAGEMENT STRATEGY FOR THE WETLANDS OUTSIDE THE DE BEERS VOORSPOED MINE** ............... 38  
   6.1 **CONSTRAINTS AND OPPORTUNITIES OF THE EXISTING ENVIRONMENT** .......... 38  
   6.1.1 Constraints .......................................................................................................... 38  
   6.1.2 Opportunities ....................................................................................................... 38  
   6.2 **MANAGEMENT STRATEGIES** ........................................................................... 38  
   6.2.1 Management of the wetland Environment .......................................................... 38  
   6.2.2 Stormwater Management: The Sustainable Drainage System (SuDS) ............... 39  
   6.2.3 Erosion control and rehabilitation ..................................................................... 45  
   6.2.4 Prevention of sedimentation .............................................................................. 46  
   6.2.5 Pollution prevention ............................................................................................ 46
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

6.2.6 Littering prevention

6.2.7 Building activity associated impacts

6.3 IMPLEMENTATION

7 RISK ASSESSMENT MATRIX FOR THE PANS OUTSIDE THE MINING BOUNDARIES

8 REHABILITATION PLAN FOR WETLANDS

8.1 WETLAND REHABILITATION PROBLEMS

8.2 WETLAND REHABILITATION OBJECTIVES

8.3 SITE SPECIFIC MEASURES

8.4 REHABILITATION WORKS / METHODS

8.4.1 Identification and Protection of Environmentally Sensitive Areas

8.4.2 Comprehensive Photographic Record

8.4.3 Search and Rescue Activities

8.4.4 Cleared Indigenous Plant Material

8.4.5 Removal of Overburden

8.4.6 Compaction Rehabilitation Measures (ripping and / or scarifying)

8.4.7 Erosion Rehabilitation Measures

8.4.8 Reinstatement of Topsoil

8.4.9 Re-vegetation

8.4.10 Surface Rehabilitation of exposed areas

8.4.11 Alien invasive species

8.4.12 Fire management

8.4.13 Wetland stabilisation

8.4.14 Pollution control

9 MONITORING PLAN

10 DISCUSSION & CONCLUSION

11 REFERENCES

12 APPENDIX A PES SCORES OF THE PANS

13 APPENDIX B EIS SCORES OF THE PANS IN THE STUDY AREA

14 APPENDIX C. SCORES FOR THE WET-ECOSERVICES ASSESSMENT (KOTZE ET AL. 2005)
List of Figures

Figure 1. Location Map of De Beers Voorspoed Mine operations.................................................. 6
Figure 2. Aerial map of the mining site indicating the wetland area outside the mining borders ............... 7
Figure 3. Aerial map of the site indicating the wetland area part of the old farming area in 2005 ............... 8
Figure 4. A cross section through a wetland showing how the soil form indicators and vegetation changes from the centre to the edge of the wetland (adapted from Kotze, 1996) .......................................................... 13
Figure 5. Wetland Map indicating the delineation of the wetlands outside the mining boundaries ............ 25
Figure 6. Comparison of the state of the major pan between 2010 and 2016 .............................................. 28
Figure 7. . Wet-Ecoservices of the natural pan in the project area .......................................................... 33
Figure 8. Wet-Ecoservices of the man-made depressions in the project area .......................................... 33
Figure 9. Natural hydrological system ................................................................................................. 40
Figure 10. Stormwater management approach with little concern for natural environment ...................... 40
Figure 11. Responsible approach to stormwater management ............................................................... 41
Figure 12. Stormwater design hierarchy of the SuDS ........................................................................ 43

List of Tables

Table 1. Land types, geology and dominant soil types of the proposed development site ............................. 10
Table 2. Wetland Unit types based on hydrogeomorphic characteristics (Adapted from Kotze et al. 2005). .... 13
Table 3. Habitat integrity assessment criteria for wetlands (Adapted from DWAF, 2003) .............................. 14
Table 4. Present Ecological Status Class Descriptions ............................................................................ 15
Table 5. Criteria for assessing the Ecological Importance and Sensitivity of Wetlands .............................. 16
Table 6. Ecological Importance and Sensitivity Classes ......................................................................... 17
Table 7. Classes for service scores ......................................................................................................... 18
Table 8. Classes for the overall level of natural services provided by a wetland unit ................................. 18
Table 9. Classes for the overall level of human services provided by a wetland unit ................................. 19
Table 10. Risk rating tables and methodology for the risk assessment .................................................... 20
Table 11. Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) of the wetlands of the proposed development site ............................................................... 31
Table 12. SuDS conceptual design matrix ............................................................................................. 44
Table 13. Potential stormwater pollutants and impacts that needs to be assessed and monitored during the mining phases ........................................................................................................... 45
Table 14. Risk assessment matrix for future operational phase of the De Beers Voorspoed Mine ................ 37
Table 15. Monitoring framework for the rehabilitation plan on the wetlands at the mine ............................. 60
1 ASSIGNMENT

Exigo Sustainability was appointed by De Beers Voorspoed Mine to conduct a wetland delineation, functionality assessment and rehabilitation plan for the wetland area located outside the mining boundaries (fences) on the farm Voorspoed 401, Free State Province.

This report will include a delineation, rehabilitation and management plan for the wetland area located outside the mining borders. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in conjunction with Regulation 982 of 8 December 2014, promulgated in terms of Section 24 (5) of NEMA and Chapter 4 of the National Water Act, Act 36 of 1998.

The assignment is interpreted as follows: Compile a study on the wetlands of the site according to guidelines and criteria set by the Department of Water Sanitation (DWS) and the Free State Department of Economic Development, Tourism and Environmental Affairs.

The study includes a wetland delineation, functionality assessment and rehabilitation plan, with descriptions of the risks associated with the mining development activities and mitigation to reduce impacts that have already been created by the constructed development areas. In order to compile this, the following had to be done:

1.1 Information Sources

The following information sources were obtained for the study:

1. Previous wetland studies conducted for the De Beers Voorspoed Mine by SEF;
2. All relevant topographical maps, aerial photographs and information (previous studies and environmental databases) related to wetlands in the study area;
3. Requirements regarding the wetland survey as stipulated in the following guidelines:
   a. A practical field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2006);
   b. National Wetland Classification System for South Africa (SANBI, 2009);
4. Guidelines regarding development in and around wetlands as stipulated by DWS;

1.2 Regulations governing this report


This report was prepared in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Gazette No. 38282 Government Notice R. 982. Appendix 6 – Specialist reports includes a list
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

of requirements to be included in a specialist report:

1. A specialist report or a report prepared in terms of these regulations must contain:

   a. Details of
      i. The specialist who prepared the report; and
      ii. The expertise of that specialist to compile a specialist report, including a curriculum vitae;

   b. A declaration that the specialist is independent in a form as may be specified by the competent authority;

   c. An indication of the scope of, and purpose for which, the report was prepared;

   d. The date and season of the site investigation and the relevance of the season to the outcome of the assessment;

   e. A description of the methodology adopted in preparing the report or carrying out the specialized process;

   f. The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;

   g. An identification of any areas to be avoided, including buffers;

   h. A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;

   i. A description of any assumptions made and any uncertainties or gaps in knowledge;

   j. A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;

   k. any mitigation measures for inclusion in the EMPr;

   l. any conditions for inclusion in the environmental authorisation;

   m. any monitoring requirements for inclusion in the EMPr or environmental authorisation

   n. a reasoned opinion –
      i. As to whether the proposed activity or portions thereof should be authorised and
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

ii. If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr and where applicable, the closure plan;

o. A description of any consultation process that was undertaken during the course of preparing the specialist report;

p. A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and

q. Any other information requested by the competent authority.

1.2.2 The National Water Act (Act No. 36 of 1998)

Chapter 4 of the National Water Act, Act 36 of 1998 specifies that:

“In general a water use must be licensed unless it is listed in Schedule I, is an existing lawful use, is permissible under a general authorisation, or if a responsible authority waives the need for a licence. The Minister may limit the amount of water which a responsible authority may allocate. In making regulations the Minister may differentiate between different water resources, classes of water resources and geographical areas.”

The relevant listed activities of section 21 of the NWA water uses for this study are:

c. Impeding or diverting the flow of water in a watercourse;

d. Altering the bed, banks, course or characteristics of a watercourse;

1.2.3 Conservation of Agricultural Resources Act (Act No. 43 of 1983)

This Act controls the utilization and protection of wetlands, soil conservation and all matters relating thereto including prevention of veld fires, control of weeds and invader plants, prevention of water pollution resulting from farming practices and losses in biodiversity.

1.2.4 The National Environmental Management Act (NEMA) (Act No. 107 of 1998)

This Act embraces all three fields of environmental concern namely: resource conservation and exploitation; pollution control and waste management; and land-use planning and development. The environmental management principles include the duty of care for wetlands and special attention is given to management and planning procedures.
1.3 Terms of reference

1.3.1 Objectives

The project was done according to the following objectives:

- Conduct a desktop and field investigation to confirm the presence or absence of wetlands and riparian areas within the study area;
- Delineate and map the identified wetland / riparian areas on site;
- Classify wetlands / water courses according to their hydro-geomorphic characteristics;
- Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of all wetlands and riparian areas on site;
- Determine the impacts associated with the proposed development on the wetlands;
- Specify mitigation measures and management plan for the wetlands on site;
- Provide a rehabilitation plan for the wetland to be implemented by engineers;
- Compile a report with the findings and maps.

1.4 Limitations and assumptions

The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative sections, as well as general observations and a desktop analysis.
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

2 STUDY AREA

2.1 Location and description of activity

The De Beers Voorspoed Diamond Mine is located within the Free State Province, 30km North-east of Kroonstad (Figure 1), with the wetland situated on a portion of the farm Voorspoed 401, although outside the boundary fence of the mine itself (Figure 2). The site visit was conducted at the end of July 2017, although the veld was in a good conditions and the herbaceous layer extremely dense, after extended rainfall was received at the end of the summer months. The study focused on the wetland area and man-made dams along the access road to the mine.

The original location of the wetland area and dams before the mining commenced is shown in Figure 3.
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

Figure 1. Location Map of De Beers Voorspoed Mine operations
Figure 2. Aerial map of the mining site indicating the wetland area outside the mining borders
Figure 3. Aerial map of the site indicating the wetland area part of the old farming area in 2005
2.2 CLIMATE

Climate in the broad sense is a major determinant of the geographical distribution of species and vegetation types. However, on a smaller scale, the microclimate, which is greatly influenced by local topography, is also important. Within areas, the local conditions of temperature, light, humidity and moisture vary greatly and it is these factors which play an important role in the production and survival of plants (Tainton, 1981). The climate for the region can be described as warm-temperate.

In terrestrial environments, limitations related to water availability are always important to plants and plant communities. The spatial and temporal distribution of rainfall is very complex and has great effects on the productivity, distribution and life forms of the major terrestrial biomes (Barbour et al. 1987).

The climate experienced is typical of the South African summer rainfall region, with the study region receiving most of its rainfall during the period October – April, averaging 540 mm per year. The region experiences a net loss in precipitation due to an average lake evaporation of 1040 mm per annum (Metago Report 181-002). The net evaporative loss for the region results in the ephemeral nature of the study wetlands. Inundation is likely only after heavy rainfall, which may occur anytime during November to April.

The mean annual temperature is 16.1°C, while the monthly maximum and minimum temperatures for the area are 39°C and -12°C, respectively. Frost occurs frequently to very frequently during the dry winter months.

2.3 VEGETATION TYPES

The developed site occurs within the Grassland biome. The Grassland Biome is found chiefly on the high central plateau of South Africa, and the inland areas of Kwazulu-Natal and the Eastern Cape. The topography is mainly flat and rolling, but includes the escarpment itself. Altitude varies from near sea level to 2 850 m above sea level. Grasslands (also known locally as Grassveld) are dominated by a single layer of grasses. The amount of cover depends on rainfall and the degree of grazing. Trees are absent, except in a few localized habitats. Geophytes are often abundant. Frosts, fire and grazing maintain the grass dominance and prevent the establishment of trees.

The most recent classification by Mucina & Rutherford (2006) that forms part of the development zones represents the Vaal-Vet Sandy Grassland Vegetation Type. This vegetation type has an endangered conservation status with 0.3% statutorily conserved and more than 63% transformed through cultivation and grazing land. The landscape is plains-dominated with some scattered, slightly irregular undulating plains and hills. Vegetation structure is mainly low-tussock grasslands with an abundant karroid element. Dominance of Themeda triandra is an important feature of this vegetation unit.
2.4 GEOLOGY AND SOIL TYPES

Geology is directly related to soil types and plant communities that may occur in a specific area (Van Rooyen & Theron, 1996). A Land type unit is a unique combination of soil pattern, terrain and macroclimate, the classification of which is used to determine the potential agricultural value of soils in an area. The land type unit represented within the study area include the Bd16 land type (Land Type Survey Staff, 1987) (ENPAT, 2001). The land type, geology and associated soil type is presented in Table 1 below as classified by the Environmental Potential Atlas, South Africa (ENPAT, 2000).

Table 1. Land types, geology and dominant soil types of the proposed development site

<table>
<thead>
<tr>
<th>Landtype</th>
<th>Soils</th>
<th>Geology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bd16</td>
<td>Plinthic catena: eutrophic; red soils not widespread, upland duplex and margalitic soils rare</td>
<td>Ecca sandstone and shale with dolerite sills in places; sporadic occurrence of Hekpoort lava mainly in northeast. Aeolian and or colluvial sand covers most rocks. Pans occupy 2% of land type.</td>
</tr>
</tbody>
</table>

An assessment of the local geology and soils was conducted by GEOCON - APES (2003). The following excerpts from their report have relevance to the formation and presence of the pans:

- It was indicated that the area is generally covered by red and/or yellow apedal soils (Bd16) comprising predominantly the Hutton soil form with significant occurrences of Avalon, Bainsvlei, Glencoe and Pinedene forms. The soil cover overlying the site ranged from 4.5 m to 11.5 m with residual soil thickness ranging from 3 m to 10 m (Mulville, 1999). Based on the drilling information, the soils consist of silt and fine-grained sands.

- The above soils are all associated in some way with the formation of wetlands, due to their capacity to store or hold water for extended periods and have also been associated with the formation of pans (Palmer et al. 2002).

2.5 TOPOGRAPHY & DRAINAGE

The ecosystem integrity of surface waters has responded to different environmental impacts within the Free State Province and integrity scores range between poor and fair for the majority of systems studied within the Rivers Health Programme. Furthermore, it would seem that due to impacts on quality of water and flow regimes, the desired ecological state for the majority of systems could never again attain states higher than fair. Major rehabilitation of river banks, alien tree removal and removal of impoundments would be required to achieve this. The latter would not easily be attained due to the scarcity of water resources within the region and the critical need for water storage mechanisms.

The project area is characterised by slightly undulating to flat plains. The topography across the site is flat with the average elevation of 1400 mamsl.
Tsolo Weir Wetland Assessment

The study area is situated within the primary catchment of the Upper Vaal River and within quaternary catchment C70H, which is intersected by the tributaries of the Heuning Spruit, which runs in a northwesterly direction where it joins the Renoster Spruit (Midgley et al. 1994).
3 METHODS

3.1 WETLAND DELINEATION AND CLASSIFICATION

The National Water Act, Act 36 of 1998, defines wetlands as follows:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

Wetlands were delineated according to the delineation procedure given in "A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas" (DWAF, 2003).

Wetland indicators are divided into different unit indicators which need to be given consideration in the delineation of wetlands (Figure 3). The outer edge of the temporary zone requires the delineator to take the following specific indicators into account:

- The terrain unit indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by Macvicar (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

The study area was sub-divided into transects and the soil profile was examined for signs of wetness within 50 cm of the surface using a hand auger along transects. The wetland boundaries were then determined by the positions of augered holes that showed signs of wetness as well as by the presence or absence of hydrophilic vegetation. The wetlands were subsequently classified according to their hydro-geomorphic setting based on the system proposed in the National Wetland Classification System (Table 3) (SANBI, 2009).

Furthermore, as a result of alluvial deposits being visible from the air, aerial photography was also used to assist in determining the extent of deposits, as well as the vegetation line indicating a difference in species composition or more vigorous growth. The aerial photographs were used to guide on-screen delineation of wetlands in ArcView GIS 3.3.
Table 2. Wetland Unit types based on hydrogeomorphic characteristics (Adapted from Kotze et al. 2005).

<table>
<thead>
<tr>
<th>Hydrogeomorphic type</th>
<th>Code</th>
<th>Illustration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Plain</td>
<td>FP</td>
<td><img src="image1.png" alt="Illustration" /></td>
<td>Valley bottom area with a well defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvium (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overtop) and from adjacent slope.</td>
</tr>
<tr>
<td>Valley Bottom with a Channel</td>
<td>VBC</td>
<td><img src="image2.png" alt="Illustration" /></td>
<td>Valley bottom area with a well defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overtop) and from adjacent slope.</td>
</tr>
<tr>
<td>Valley Bottom Without a Channel</td>
<td>VB</td>
<td><img src="image3.png" alt="Illustration" /></td>
<td>Valley bottom area with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slope.</td>
</tr>
<tr>
<td>Channellied Hillslope Seepage feeding a Water course</td>
<td>CHSW</td>
<td><img src="image4.png" alt="Illustration" /></td>
<td>Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse.</td>
</tr>
<tr>
<td>Hillslope Seepage feeding a Water course</td>
<td>HSW</td>
<td><img src="image5.png" alt="Illustration" /></td>
<td>Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow connecting the area directly to a watercourse.</td>
</tr>
<tr>
<td>Hillslope Seepage not feeding a water course</td>
<td>HS</td>
<td><img src="image6.png" alt="Illustration" /></td>
<td>Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a watercourse.</td>
</tr>
<tr>
<td>Depression</td>
<td>D</td>
<td><img src="image7.png" alt="Illustration" /></td>
<td>A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inundated). It may also receive sub-surface water. An outlet is usually absent.</td>
</tr>
</tbody>
</table>

Figure 4. A cross section through a wetland showing how the soil form indicators and vegetation changes from the centre to the edge of the wetland (adapted from Kotze, 1996)
3.2 WETLAND INTEGRITY ASSESSMENTS

3.2.1 Present Ecological Status (PES) of wetlands

The Present Ecological State (PES) assessment of the wetlands within the study area was undertaken to determine the extent of departure of the wetlands from a natural state or reference condition. This method is based on the modified Habitat Integrity approach (Table 3) developed by Kleynhans (1999). Anthropogenic modification of the criteria and its attributes can have an impact on the ecological integrity of a wetland.

For the purpose of this study, the scoring system as described in the document “Resource Directed Measures for Protection of Water Resources, Volume 4. Wetland Ecosystems” (DWAF, 1999) was applied for the determination of the PES (Table 3).

Table 3. Habitat integrity assessment criteria for wetlands (Adapted from DWAF, 2003)

<table>
<thead>
<tr>
<th>Criteria and Attributes</th>
<th>Relevance</th>
</tr>
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<tbody>
<tr>
<td>Hydrologic</td>
<td></td>
</tr>
<tr>
<td>Flow Modification</td>
<td>Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to or from a wetland.</td>
</tr>
<tr>
<td>Permanent Inundation</td>
<td>Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.</td>
</tr>
<tr>
<td>Water Quality</td>
<td></td>
</tr>
<tr>
<td>Water Quality Modification</td>
<td>From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.</td>
</tr>
<tr>
<td>Sediment Load Modification</td>
<td>Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.</td>
</tr>
<tr>
<td>Hydraulic/Geomorphic</td>
<td></td>
</tr>
<tr>
<td>Canalization</td>
<td>Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.</td>
</tr>
<tr>
<td>Topographic Alteration</td>
<td>Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.</td>
</tr>
<tr>
<td>Biota</td>
<td></td>
</tr>
<tr>
<td>Terrestrial Encroachment</td>
<td>Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.</td>
</tr>
<tr>
<td>Indigenous Vegetation Removal</td>
<td>Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.</td>
</tr>
<tr>
<td>Invasive Plant Encroachment</td>
<td>Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).</td>
</tr>
<tr>
<td>Alien Fauna</td>
<td>Presence of alien fauna affecting faunal community structure.</td>
</tr>
<tr>
<td>Over utilization of Biota</td>
<td>Overgrazing, over fishing, etc.</td>
</tr>
<tr>
<td>Attributes above are rated and scored as one of the following:</td>
<td></td>
</tr>
<tr>
<td>Natural/Unmodified</td>
<td>5</td>
</tr>
<tr>
<td>Largely Modified</td>
<td>2</td>
</tr>
<tr>
<td>Moderately Modified</td>
<td>4</td>
</tr>
<tr>
<td>Largely Natural</td>
<td>1</td>
</tr>
<tr>
<td>Critically Modified</td>
<td>0</td>
</tr>
</tbody>
</table>

Two tools have recently been developed to facilitate the derivation of scores to reflect the present ecological state, namely the Index of Habitat Integrity (IHI) DWA, 2007, and Wet-Health, developed by...
Tsolo Weir Wetland Assessment

Macfarlane et al., 2008. Both these tools have limitations in that they were developed primarily to assess conditions of floodplain and valley bottom wetlands and Hill slope seepage wetlands linked to drainage lines. The former tool was developed to provide a rapid assessment of the PES specifically for application in reserve studies, while the latter tool was developed to support the Working for Wetlands program. The objective of the latter tool was to provide a semi quantitative assessment of the state of wetland prior to rehabilitation, and one post rehabilitation to demonstrate “improvement”. The intention in defining the health category (PES) of a wetland is to provide an indication of the current “condition” of a wetland in order to inform a management class. The latter provides the guidelines against that inform water quality and quantity required to maintain or improve the quality of the water resource.

The PES or health of wetlands has only been applied to the “natural” wetlands, i.e. those that have developed naturally as a consequence of the presence of water. Wetlands are rated on a scale of A to F, with A being a natural wetland and F being a completely modified and disturbed wetland (Table 6). The Wet-Health assesses the following four factors that influence the “health” or condition of wetlands and in this particular application floodplains and river channels associated with the site:

- Hydrology;
- Geomorphology
- Vegetation, and ideally
- Water quality.

The Present Ecological Status Class (PESC) of the wetlands was based on the available information for each of the criteria listed in Table 3 and the mean score determined for each wetland (Table 4). This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the PESC (DWAF, 2003).

Table 4. Present Ecological Status Class Descriptions

<table>
<thead>
<tr>
<th>CLASS</th>
<th>CLASS BOUNDARY</th>
<th>CLASS DESCRIPTION</th>
</tr>
</thead>
</table>
| A     | >4             | Unmodified, natural;  
|       |                | • The resource base reserve has not been decreased;  
|       |                | • The resource capability has not been exploited |
| B     | >3 and <=4     | Largely natural with few modification;  
|       |                | • The resource base reserve has been decreased to a small extent;  
|       |                | • A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. |
3.2.2 Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the guidelines as discussed by DWAF (1999). Here DWAF defines “ecological importance” of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. “Ecological sensitivity”, according to DWAF (1999), is the system’s ability to resist disturbance and its capability to recover from disturbance once it has occurred.

In the method outlined by DWAF a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 5). The median of the determinants is used to determine the EIS of the wetland unit (Table 6).

Table 5. Criteria for assessing the Ecological Importance and Sensitivity of Wetlands

<table>
<thead>
<tr>
<th>Determinant</th>
<th>PRIMARY DETERMINANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Rare &amp; Endangered Species</td>
</tr>
<tr>
<td></td>
<td>2. Populations of Unique Species</td>
</tr>
<tr>
<td></td>
<td>3. Species/taxon Richness</td>
</tr>
<tr>
<td></td>
<td>4. Diversity of Habitat Types or Features</td>
</tr>
<tr>
<td></td>
<td>5. Migration route/breeding and feeding site for wetland</td>
</tr>
</tbody>
</table>
Tsolo Weir Wetland Assessment

<table>
<thead>
<tr>
<th>PRIMARY DETERMINANTS</th>
<th>MODIFYING DETERMINANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Sensitivity to Water Quality Changes</td>
<td>10. Ecological Integrity</td>
</tr>
<tr>
<td>8. Flood Storage, Energy Dissipation &amp; Particulate/Element Removal</td>
<td></td>
</tr>
</tbody>
</table>

Score guideline: Very high = 4; High = 3; Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating: Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 6. Ecological Importance and Sensitivity Classes

<table>
<thead>
<tr>
<th>Ecological Importance and Sensitivity Category (EIS)</th>
<th>Range of Median</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very high</strong></td>
<td></td>
</tr>
<tr>
<td>Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands 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.</td>
<td>&gt;3 and &lt;=4</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
</tr>
<tr>
<td>Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.</td>
<td>&gt;2 and &lt;=3</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td></td>
</tr>
<tr>
<td>Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these Wetlands 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.</td>
<td>&gt;1 and &lt;=2</td>
</tr>
<tr>
<td><strong>Low/marginal</strong></td>
<td></td>
</tr>
<tr>
<td>Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these Wetlands 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.</td>
<td>&gt;0 and &lt;=1</td>
</tr>
</tbody>
</table>

3.3 Wetland functional assessments (WET-Ecoservices)

Wetland functional assessments (ecosystem services delivery) were conducted for wetlands in the study area using the tool WET-Ecoservices (Kotze et al., 2005).

WET-Ecoservices provides guidelines for assessing the importance of a wetland in delivering different ecosystem services. A total of 15 ecosystem services are assessed including, flood attenuation, sediment trapping, phosphate trapping, nitrate removal, toxicant removal, erosion control, stream flow augmentation, carbon trapping, water for human use, harvestable natural resources, cultivated food and biodiversity maintenance. The potential of a wetland to deliver these services is also assessed based upon future changes in activities within the wetland and catchment. A Level 2 assessment was undertaken which examines and rates Natural and Human services.
The following natural services were assessed:

- Flood attenuation;
- Stream flow regulation;
- Sediment trapping;
- Phosphate trapping;
- Nitrate removal;
- Toxicant removal;
- Erosion control;
- Carbon storage;
- Maintenance of biodiversity.

Scores for each of the above natural service assessments were allocated a class based on the class boundaries shown in Table 7. These scores were then added to determine the overall level of natural services for the wetland unit using the classes shown in Table 8.

### Table 7. Classes for service scores

<table>
<thead>
<tr>
<th>Class Boundary</th>
<th>Class Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.99</td>
<td>1</td>
</tr>
<tr>
<td>1 - 1.99</td>
<td>2</td>
</tr>
<tr>
<td>2 - 2.99</td>
<td>3</td>
</tr>
<tr>
<td>3 - 4</td>
<td>4</td>
</tr>
</tbody>
</table>

### Table 8. Classes for the overall level of natural services provided by a wetland unit

<table>
<thead>
<tr>
<th>Class Boundaries</th>
<th>Class</th>
<th>Class Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 36</td>
<td>Very High</td>
<td>Unmodified or approximated natural condition.</td>
</tr>
<tr>
<td>24 - 29.9</td>
<td>High</td>
<td>Largely natural with few modifications, but with some loss of natural habitats.</td>
</tr>
<tr>
<td>18 - 23.9</td>
<td>Moderate</td>
<td>Moderately modified, but with some loss of natural habitats.</td>
</tr>
<tr>
<td>12 - 17.9</td>
<td>Low</td>
<td>Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.</td>
</tr>
<tr>
<td>6 - 11.9</td>
<td>Very Low</td>
<td>Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.</td>
</tr>
<tr>
<td>0 - 5.9</td>
<td>Non Existent</td>
<td>Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.</td>
</tr>
</tbody>
</table>

The following human services were assessed:
Tsolo Weir Wetland Assessment

- Water supply for human use
- Natural resources
- Cultivated foods
- Cultural significance
- Tourism and recreation
- Education and research.

Scores for each of the above human service assessments were allocated a class based on the class boundaries shown in Table 7. These scores were then added to determine the overall level of human services for the wetland unit using the classes shown in Table 9.

### Table 9. Classes for the overall level of human services provided by a wetland unit

<table>
<thead>
<tr>
<th>Class Boundaries</th>
<th>Class</th>
<th>Class Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 24</td>
<td>Very High</td>
<td>Local people are extremely dependent on the wetland and benefit from it greatly.</td>
</tr>
<tr>
<td>16 - 19.9</td>
<td>High</td>
<td>Local people have a high level of dependence on the wetland and benefit from it considerably.</td>
</tr>
<tr>
<td>12 - 15.9</td>
<td>Moderate</td>
<td>Local people are moderately dependent on the wetland and benefit from it occasionally.</td>
</tr>
<tr>
<td>8 - 11.9</td>
<td>Low</td>
<td>Local people have a low dependency on the wetland and seldom benefit from it.</td>
</tr>
<tr>
<td>4 - 7.9</td>
<td>Very Low</td>
<td>Local people rarely rely on the wetland and almost never benefit from it.</td>
</tr>
<tr>
<td>0 - 3.9</td>
<td>Non Existent</td>
<td>Local people have no interaction with the wetland and never receive any benefits from it.</td>
</tr>
</tbody>
</table>

1.1. **Risk assessment matrix**

A Risk Assessment, as required in terms of the General Authorisation Notice 509 of 2016 (Gazette No.40229), for any proposed future activities within the wetland. The risk assessment should be based on the following ratings (Table 10).
### Table 10. Risk rating tables and methodology for the risk assessment

#### SEVERITY
How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, habitat)?

<table>
<thead>
<tr>
<th>Impact Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insignificant / non-harmful</td>
<td>1</td>
</tr>
<tr>
<td>Small / potentially harmful</td>
<td>2</td>
</tr>
<tr>
<td>Significant / slightly harmful</td>
<td>3</td>
</tr>
<tr>
<td>Great / harmful</td>
<td>4</td>
</tr>
<tr>
<td>Disastrous / extremely harmful and/or wetland(s) involved</td>
<td>5</td>
</tr>
</tbody>
</table>

Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.

#### SPATIAL SCALE
How big is the area that the aspect is impacting on?

<table>
<thead>
<tr>
<th>Area Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area specific (at impact site)</td>
<td>1</td>
</tr>
<tr>
<td>Whole site (entire surface right)</td>
<td>2</td>
</tr>
<tr>
<td>Regional / neighboring areas (downstream within quaternary catchment)</td>
<td>3</td>
</tr>
<tr>
<td>National (impacting beyond secondary catchment or provinces)</td>
<td>4</td>
</tr>
<tr>
<td>Global (impacting beyond SA boundary)</td>
<td>5</td>
</tr>
</tbody>
</table>

#### DURATION
How long does the aspect impact on the resource quality?

<table>
<thead>
<tr>
<th>Duration Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>One day to one month, PES, EIS and/or REC not impacted</td>
<td>1</td>
</tr>
<tr>
<td>One month to one year, PES, EIS and/or REC impacted but no change in status</td>
<td>2</td>
</tr>
<tr>
<td>One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation</td>
<td>3</td>
</tr>
<tr>
<td>Life of the activity, PES, EIS and/or REC permanently lowered</td>
<td>4</td>
</tr>
<tr>
<td>More than life of the organisation/facility, PES and EIS scores, a E or F</td>
<td>5</td>
</tr>
</tbody>
</table>

**PES and EIS (sensitivity) must be considered.**

**FREQUENCY OF THE ACTIVITY**
How often do you do the specific activity?

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annually or less</td>
<td>1</td>
</tr>
<tr>
<td>6 monthly</td>
<td>2</td>
</tr>
<tr>
<td>Monthly</td>
<td>3</td>
</tr>
<tr>
<td>Weekly</td>
<td>4</td>
</tr>
<tr>
<td>Daily</td>
<td>5</td>
</tr>
</tbody>
</table>

**FREQUENCY OF THE INCIDENT/IMPACT**
How often does the activity impact on the resource quality?

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost never / almost impossible / &gt;20%</td>
<td>1</td>
</tr>
<tr>
<td>Very seldom / highly unlikely / &gt;40%</td>
<td>2</td>
</tr>
<tr>
<td>Infrequent / unlikely / seldom / &gt;60%</td>
<td>3</td>
</tr>
<tr>
<td>Often / regularly / likely / possible / &gt;80%</td>
<td>4</td>
</tr>
<tr>
<td>Daily / highly likely / definitely / &gt;100%</td>
<td>5</td>
</tr>
</tbody>
</table>

**LEGAL ISSUES**
How is the activity governed by legislation?

<table>
<thead>
<tr>
<th>LEGAL ISSUES</th>
<th>LEGAL ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>No legislation</td>
<td>1</td>
</tr>
<tr>
<td>Fully covered by legislation (wetlands are legally governed)</td>
<td>5</td>
</tr>
</tbody>
</table>

**Located within the regulated areas**
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

**DETECTION**
How quickly/easily can the impacts/risks of the activity be observed on the resource quality, people and property?

| Immediately | 1 |
| Without much effort | 2 |
| Need some effort | 3 |
| Remote and difficult to observe | 4 |
| Covered | 5 |

**RATING CLASSES**

<table>
<thead>
<tr>
<th>RATING</th>
<th>CLASS</th>
<th>MANAGEMENT DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 55</td>
<td>(L) Low Risk</td>
<td>Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.</td>
</tr>
<tr>
<td>56 – 169</td>
<td>M) Moderate Risk</td>
<td>Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.</td>
</tr>
<tr>
<td>170 – 300</td>
<td>(H) High Risk</td>
<td>Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.</td>
</tr>
</tbody>
</table>

A low risk class must be obtained for all activities to be considered for a GA
CALCULATIONS

| Consequence = Severity + Spatial Scale + Duration |
| Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection |
| Significance/Risk = Consequence X Likelihood |

RISK ASSESSMENT MUST BE CONDUCTED BY A SACNASP REGISTERED PROFESSIONAL MEMBER AND THE ASSESSOR MUST:

1) CONSIDER BOTH CONSTRUCTION AND OPERATIONAL PHASES OF PROPOSED ACTIVITIES;

2) CONSIDER RISKS TO RESOURCE QUALITY POST MITIGATION CONSIDERING MITIGATION MEASURES LISTED IN TABLES PROVIDED;

3) CONSIDER THE SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS) AND STATUS (PRESENT ECOLOGICAL STATUS - PES) OF THE WATERCOURSE AS RECEPTOR OF RISKS POSED;

4) CONSIDER POSITIVE IMPACTS/RISKS REDUCTION AS A VERY LOW RISK IN THIS ASSESSMENT;

5) INDICATE CONFIDENCE LEVEL OF SCORES PROVIDED IN THE LAST COLUMN AS A PERCENTAGE FROM 0 - 100%.
4 RESULTS

4.1 WETLAND CLASSIFICATION AND DELINEATION

One Hydro-Geomorphic (HGM) unit were investigated and represent wetlands on the proposed development site according to the National Wetland Classification System (SANBI, 2009). These HGM units are classified as follows:

1. Depressions:
   - Natural
     - Endorheic depressions without channelled inflow
   - Artificial
     - Man-made depressions (dams)

Wetland zone identification was done according to soil types, topography of the landscape and vegetation. The wetland map for the area is indicated in Figure 5.
Figure 5. Wetland Map indicating the delineation of the wetlands outside the mining boundaries
4.1.1 Natural depression

The main wetland area outside the De Beers Voorspoed Mine premises represents an endorheic depression known as a pan, where water exits by means of evaporation and infiltration. A depression is classified as a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. For ‘depressions with channelled inflow’, concentrated overland flow is typically a major source of water for the wetland, whereas this is not the case for ‘depressions without channelled inflow’. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flat-bottomed (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.

The depressions are also known as ‘salt pans’ and is classified as forming part of the Highveld Salt pans vegetation type (Mucina & Rutherford, 2006). These pans are also known as playas. They occur on plains of low relief, as a result of which drainage is poor. Their bases are impervious to downward (vertical) drainage. The base is often dolomite as observed in the study area. Some drainage occurs laterally, both into and out of the pan. Geomorphological processes, including wind-driven deflation, lead to the formation of depressions, which hold water for varying periods (Walsmley, 2003).

Anderson (2003) noted that the pans could be threatened by disturbances common to other land use practices in the area, such as trampling by livestock which transforms well-vegetated pan shorelines to open mud. Alien plants could invade the pans if their spread is not controlled. These unnatural alien thickets increase evapo-transpiration and decrease the amount of water draining into pans and lower the entire water table (Allen et al. 1995). In some cases the mine diverted stormwater away from the pans which caused further dewatering.

In a size class management system developed for pans in Southern Mpumalanga (SEF 2004), the Voorspoed pan would be classified as a Class B pan (Size between 6.5 and 12.7 ha). Pans in this class are moderately inundated for short periods each year and dominated mostly by grasses and bare soils areas. These particular pans are sensitive to physical change, which alters catchment characteristics. Physical change for this pan was mainly caused by alien vegetation such as Eucalyptus stands that abstract water in the catchment and creation of dam walls inside the pan to collect water. Major changes such as roads and mining infrastructure in the pan catchment alter the runoff characteristics and in turn reduce the
amount water inundating the pans (SEF 2004).

The pan has a small catchment where water collects from 4 different wind directions into the pan, allowing the pan to still have a relatively normal functioning, although some dewatering will still occur as a result of the opencast mining activities to the east.

4.1.1.1  Background

Livestock watering into the man-made dams originally affected this pan, which not only reduced the physical amount of water in the pan, but also resulted in trampling and overgrazing of the surrounding grassland vegetation. Furthermore, a canal was created that diverted water from the pan into the northern of the two man-made dams. In 2004, this did not affect the ecological functioning of the pan as it still supported a variety of animal life.

4.1.1.2  Current Status

The pan has degraded even further with some signs of terrestrial species encroachment indicating that the pan has become dewatered along its edges. The pan represents seasonal and temporary wetland zones dominated by hygrophilous grasses such as Setaria incrassatae and Echinochloa colona; and weeds indicative of wet conditions (e.g. Gomphocarpus fruticosus, Verbena brasiliensis). Invasion by alien species invasion is by terrestrial species such as Tagetes minuta (Photograph 1). The dam construction inside the wetland and alien species (bluegum trees) has probably caused major dewatering of the pan. Rehabilitation measures are needed to allow water to collect in the pan. The canal is also not functional as a result of the access road that was built to the Voorspoed Mine, although water still collects into the canal after major rainfall events.

The pan supports a healthy population of species such as marsh owl (tall grass dependant for breeding), rodents, reptiles and generalised birds.

The pan changed from its original functional status in 2004 to being slightly less functional in 2017, although compared to the two pans inside the Voorspoed Mine is still considered in a more functional state. The pan will however still be able to recover to its former state through rehabilitation.

Figure 6 indicates an aerial image of the pan and two dams between 2010 and 2017.
Figure 6. Comparison of the state of the major pan between 2010 and 2016
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

Photograph 1. State of the Pan outside the De Beers Voorspoed Mine premises

Photograph 2. Landscape associated with the pan as seen from the Voorspoed Mine access road
4.1.2 Man-made dams

The two man-made dams occur to the south of the major pan (Photograph 3) and to the north of the access road (Photograph 4) to the west of the Voorspoed Mine. The dams are classified as artificial depressions and were probably built to collect water in for livestock many years ago. The canal that connects the pan to the northern dam is no longer functional considering that the access road bisected this canal. Both dams only have a small section that can be considered as functional along the dam walls, while the remainder of the dams is considered dewatered as indicated by the many terrestrial species that invaded the dams.

The vegetation associated with functional section of the dams is mostly sedges and hydrophilic plants such as *Persicaria serullata*, *Schoenoplectus corymbosus*, *Ludwigia stolonifer* and *Leersia hexandra*. These plants mostly grow along the shallow edges of the dams at the dam wall. The remainder of both dams have become colonized by terrestrial grasses and weeds (especially *Tagetes minuta*).

Photograph 3. State of the dam to the south of the major pan outside the De Beers Voorspoed Mine premises
Photograph 4. Dam to the north of the access road to the mine indicating the functional section along the dam wall

4.2 WETLAND INTEGRITY ASSESSMENT

In determining the integrity of the wetland the condition of the site and the indirect and direct disturbances is taken into account. Roads, dam impoundments, alien invasive vegetation species, etc. was taken into account in determining the Present Ecological Status and Ecological Importance & Sensitivity of the major pan on site (Table 11). Appendix A and B indicate the scores for the PES and EIS respectively.

Table 11. Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) of the wetlands of the proposed development site

<table>
<thead>
<tr>
<th>Wetland</th>
<th>PES</th>
<th>EIS</th>
<th>Hydrofunctional Importance</th>
<th>Direct Human Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pans</td>
<td>Class C: Moderately Modified</td>
<td>Moderate</td>
<td>17 Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.</td>
<td>6 Very Low: Local people rarely rely on the wetland and almost never benefit from it.</td>
</tr>
<tr>
<td>Man-made dams</td>
<td>Class E: Seriously Modified</td>
<td>Low</td>
<td>16 Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.</td>
<td>6 Very Low: Local people rarely rely on the wetland and almost never benefit from it.</td>
</tr>
</tbody>
</table>
Evidence was observed on site of transformation of the floristic characteristics of the wetlands. Impacting activities which have altered the expected floristic composition include impoundments, alien infestations, road crossings and diversion canals. All of the above impacts have resulted in the current condition of the wetlands on site departing significantly from the reference or unimpacted condition of the wetland. The changes in the state of the wetland are clearly indicated comparing the current state of the wetland to the 2004 state of the wetland. From these aerial images it can be concluded that that the land uses of the site has moved from mainly agriculture to more intensive mining development.

The most important feature of the pan in terms of its Hydro-functional Importance (HFI) is flood attenuation, with more or less equal distribution of the other factors contributing to the HFI (Figure 7). The pans have a very limited ecological and hydro-functional importance as a result of the following:

- The Mean Annual Potential Evaporation as a result of the climatic conditions for the vegetation type is considered very high. The pans will therefore only keep water for a very limited period of time (2 weeks or less depending on precipitation) during the wet season (October to April);

- The geological formation associated with the pans show that their bases are impervious to downward (vertical) drainage. The pans are therefore not as sensitive as would be expected since it represents closed-off ecosystems with little connectivity with the groundwater.

- The biodiversity of the pans is very low and will only provide temporary foraging area to some waterfowl and larger bird species for short periods of the year depending on the availability of water in the pans. There is no specific faunal character to the pans in the area. No rare or threatened species were found, which might be of specific conservation importance.

- The pans also have a ‘Very Low’ contribution in terms of direct human benefits.
Both man-made dams are currently in a degraded and dewatered state and have lost all of their hydrological functioning as a result of the impacts created by the Voorspoed Mine. This is reflected in the PES state being ‘Seriously Modified’ and the EIS having a ‘Low’ value. Although water will still collect in the depressions after rainfall events, the alien species in the pans will consume the water before any potential wetland species associated with the pans can recolonize the area. The hydrofunctional importance of these depressions is also classified as ‘Largely modified’ indicating that a large loss of natural habitats and basic ecosystem functions has occurred, while the direct human benefits from these pans are very low. The individual components for the Wet-Ecoservices assessment are indicated in Figure 8.
5 WETLAND IMPACT DESCRIPTION AND RISK ANALYSES

An impact assessment was conducted for the wetlands on site. Impacts relating to the proposed mining development on the wetlands are as follows:

- Direct wetland destruction through direct impoundments or indirect impacts (alien species, mining activities);
- Dewatering of wetlands;
- Soil erosion and sedimentation;
- Water pollution from spillages, vehicle emissions and dust;
- Spread and establishment of alien invasive species in wetlands;

The mining layout plan never impeded the wetlands directly considering that the wetlands are located outside the mining boundaries, although indirect impacts still occur on the wetlands to a certain extent.

5.1 Key issues for consideration in management of the wetlands

The following section is a more detailed focus on the management and monitoring of the wetlands on the site considering the wetland environment, hydrology, pest species management, water quality, rehabilitation and monitoring.

5.1.1 Alien invasive species (AIS) management

Exotic weed and alien infestations are a major problem for the regeneration of the wetland environment. AIS pose a threat to biodiversity and thrive in disturbed environments where these species are at an advantage over species occurring naturally in those areas. The spread and establishment of AIS has to be prevented in order to prevent AIS impacting on existing plant communities, water resources and natural biodiversity.

The implementation of the measures stipulated in the AIS management plan previously conducted for the mine will effectively prevent the establishment and spread of AIS from the De Beers Voorspoed Mine to the neighbouring areas, and where these species do establish, the measures detailed in this procedure will ensure the early detection and immediate management of such species.

5.1.2 Water quality and stormwater management

The wetlands on the site have a varying water quality, although these systems are non-perennial and will only hold water during the wet season (November to April). However, the mining operations could potentially impact on the water quality in the wetlands. The stormwater needs
to be addressed on the site to ensure that the water quality in the wetlands is not affected. Sediment trapping, erosion and stormwater control should be addressed by a hydrological engineer in a detailed stormwater management plan.

5.1.3 Rehabilitation

A rehabilitation strategy to undertake all the works in an integrated way is important. Firstly a hydrologic regime needs to be decided. Once patterns of wetting and drying are established then plant species can be selected and planted. There are many wetland rehabilitation guides which will assist rehabilitation. Management of weeds needs to occur prior to establishment of plants.

Once a rehabilitation program has been implemented an ongoing management regime is essential to ensure the ongoing survival of the vegetation. This ongoing management should include: regular monitoring; regular patrolling of the area to ensure that the wetland is being used appropriately; resources to reinstate plantings and recreation facilities where they have failed.

5.1.4 Monitoring

Wetlands are very complex ecosystems and the consequences of particular management prescriptions are often difficult to predict precisely. Monitoring of the wetland is essential for planning and management. Given the interest of the local community and environmental institutions there is an opportunity to develop a comprehensive monitoring program providing management directions and educational benefit. Many guides and programs on wetland monitoring exist. Biomonitoring form the basis for wetland monitoring and encompasses the following:

5.1.4.1 Biological Monitoring

Biological monitoring techniques have been introduced as part of routine monitoring programmes due to certain shortcomings in standard physical and chemical methods. Because of the difficulty of chemically analysing every potential pollutant in a sample of water, and of interpreting results in terms of the severity of impact, it makes sense to turn to the monitoring of aquatic biota. Results given by biological monitoring are also more cost effective and results can be obtained more rapidly than an extensive chemical analysis.

The main advantage of a biological approach is that it examines organisms whose exposure to water and any pollutants therein is continuous. Thus species present in riverine ecosystems reflect both the present and past history of the water quality at a particular point in the river, allowing detection of disturbances that might otherwise be missed (Eekhout et al., 1996).

Biological communities reflect overall ecological integrity by integrating various stressors over
time and thus providing a broad measure of their synergistic impacts. Aquatic communities (e.g. fish, riparian vegetation, macro-invertebrates) can integrate and reflect the effects of chemical and physical disturbances that occur in river ecosystems over extended periods of time. These communities can provide a holistic and integrated measure of the integrity or health of the river as a whole (Barber-James, 2001; Roux, 2001).

Numerous methods have been developed for the bioassessment of the integrity of aquatic systems. Some of these are based on some or other aspect of a single species, but most are based on the attributes of whole assemblages of organisms such as fish, algae or invertebrates. Although some methods have been available for many years, biomonitoring has only recently become a routine tool in the management of South Africa’s inland waters (Davies & Day, 1998).

Dixit et al. (1992) lists the ideal characteristics of biological indicators: they should be simple; be able to quantify the rate of degradation (or recovery) in water quality; be applicable over large geographic regions; and furnish data on background or reference conditions.

5.1.4.2 Vegetation and wildlife

Wetland creation and enhancement has been designed to establish open water, shallow water, emergent and wet meadow wetland habitat types using planting and natural succession revegetation techniques. The rehabilitation of the wetlands needs to be prioritized as part of the proposed development adjacent to the wetlands. Wetland ecologists will evaluate plant communities that are representative of various wetland types. Evaluations will be made of the percent vegetation cover, relative frequency of each plant species, and the wetland frequency indicator value.

Wetland rehabilitation and restoration should focus on providing diverse habitat for a variety of wildlife. Feeding, nesting and brood-rearing habitat for waterfowl, wading birds, passerine birds as well as mammals, reptiles and amphibians will be targeted in the wetland rehabilitation.

5.2 Risk assessment matrix for the pans outside the mining boundaries

Table 14 indicates the impacts described above and specific ratings of significance the impact during the operational phase of the mine will potentially have on the wetland outside the mining boundaries. The most significant impacts are dewatering and soil erosion, although impacts such as alien species invasion and spillages are limited during the operational phase or can be successfully mitigated.
### Table 12. Risk assessment matrix for future operational phase of the De Beers Voorspoed Mine

<table>
<thead>
<tr>
<th>Phases</th>
<th>Activity</th>
<th>Aspect</th>
<th>Impact</th>
<th>Flow Regime</th>
<th>Physico &amp; Chemical (Water Quality)</th>
<th>Habitat (Geomorph + Vegetation)</th>
<th>Biodiversity</th>
<th>Spatial Scale</th>
<th>Duration</th>
<th>Consequence</th>
<th>Frequency of activity</th>
<th>Frequency of Impact</th>
<th>Legal Issues</th>
<th>Likelihood</th>
<th>Significance</th>
<th>Risk Rating</th>
<th>Confidence level</th>
<th>PES AND EIS OF WATERCOURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Phase</td>
<td>Future operational mining activities of the Voorspoed Mine</td>
<td>Any future activities that will directly or indirectly cause wetland destruction or dewatering</td>
<td>Habitat destruction of wetlands / dewatering of wetlands</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>13</td>
<td>65</td>
<td>Moderate (80%)</td>
</tr>
<tr>
<td>Operational Phase</td>
<td>Future operational mining activities of the Voorspoed Mine</td>
<td>Any future activities that will directly or indirectly cause soil compaction and erosion</td>
<td>Soil compaction and erosion leading to sedimentation of wetland/water resources</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1.25</td>
<td>3</td>
<td>2</td>
<td>4.25</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>13</td>
<td>81.25</td>
<td>Moderate (80%)</td>
</tr>
<tr>
<td>Operational Phase</td>
<td>Future operational mining activities of the Voorspoed Mine</td>
<td>Any future activities that will directly or indirectly cause soil and water pollution of wetlands</td>
<td>Soil and Water pollution</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.75</td>
<td>2</td>
<td>2</td>
<td>4.75</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>51</td>
<td>Low Risk (80%)</td>
</tr>
<tr>
<td>Operational Phase</td>
<td>Future operational mining activities of the Voorspoed Mine</td>
<td>Any future activities that will cause import and spread of alien invasive vegetation</td>
<td>Import and spread of alien invasive vegetation</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1.75</td>
<td>2</td>
<td>2</td>
<td>4.75</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>51.75</td>
<td>Low Risk (80%)</td>
</tr>
</tbody>
</table>
6 MANAGEMENT STRATEGY FOR THE WETLANDS OUTSIDE THE DE BEERS VOORSPOED MINE

6.1 Constraints and opportunities of the existing environment

The existing environment presents a number of constraints and opportunities which have been considered in the development of the recommendations for the site as part of the proposed mining development.

6.1.1 Constraints

- Potential loss of wetland habitat
- Pollution of the wetlands: Mining stormwater runoff contains a number of potentially harmful pollutants, including fuels and oils, lead, etc.
- Increased stormwater runoff: The construction of hardened surfaces on the property will lead to an increase in the quantity of runoff flowing across the site.
- Loss of surface and subsurface water recharge to groundwater: Any loss of seep or stream habitat, or condition, could interfere with the natural recharge of subsurface water resources. In addition, if natural surface runoff is diverted away from infrastructure on the site, this might interfere with subsurface drainage across the site.
- Increased erosion and sedimentation: Runoff from mining areas can lead to increased mobilisation of fine sediments during rain and storm events.
- Increased disturbance of aquatic fauna and flora: The proximity of homes to the riverine corridor will lead to an increase in disturbance in the form of noise, light, pets and physical disturbance from trampling.
- Introduction of alien invasives.

6.1.2 Opportunities

- Opportunity to manage and monitor the wetland effectively and thereby increasing knowledge base on the specific wetlands of the area;
- Opportunity to create wetland offset strategy that can improve the wetlands of the larger area.

6.2 Management Strategies

6.2.1 Management of the wetland Environment

The following strategies are proposed for the management of the wetland environment:

- Ensure that all current activities consider the wetland boundaries. No vehicles are to
enter or drive through the wetland area unnecessarily;

- Demarcate all wetland boundaries with pegs and danger tape;

- Edge effects of pre-construction and construction activities, including erosion, sedimentation and alien/weed control, need to be strictly managed in wetland areas as well as their associated buffer zones;

- Implement appropriate silt traps and filters to ensure optimal water quality to the wetland from stormwater run-off. Stormwater should be conveyed into detention ponds that are earth-lined, thereby allowing settling out of sediments.

- Ensure that an adequate buffer of 50m (or the 1:100 year floodline, whichever is greater) is provided around the wetlands that lie outside the layout footprint area. These buffers provide guidelines for the "non-development" areas of the De Beers Voorspoed Mine.

- Unnecessary excavation and infilling of the wetland areas (unless associated with rehabilitation) must be avoided or, where unavoidable, kept to a minimum;

- Construction of mining infrastructure should take place during the dry season, to reduce the risks of contamination of the streams and wetlands through rainfall, runoff and erosion.

6.2.2 Stormwater Management: The Sustainable Drainage System (SuDS)

Mining developments such as the De Beers Voorspoed Mine reduces the natural permeability characteristics of land by replacing free draining surfaces with impermeable surfaces, typically drained by pipes and/or canals. This also results in the general loss of vegetation, biodiversity and amenity. Conventional drainage systems are generally focused on eliminating local flood nuisances and ignore the water quality, amenity, and biodiversity. It is widely recognised that developments impact negatively on natural drainage systems in several ways, including:

- Reduced permeability of catchment areas by introduction of impervious surfaces such as roads, mining dumps and other mining related infrastructure. This results in increased catchment runoff volumes.

- The introduction of efficient stormwater drainage results in reduced catchment response times with concomitant increased downstream flow peaks.

- Manipulation of groundwater tables, which can have severe effects on wetland functioning and the survival of many terrestrial plant communities.

- Alteration to the natural flow regimes in wetland systems resulting in both
geomorphologic (e.g. erosion) and aquatic ecosystem changes over time.

- Deteriorating water quality as a result of industrial fallout, fertilisers and other pollutants that are conveyed by stormwater systems directly to receiving water bodies, without any attempt to ameliorate enroute.

These guidelines require greater cognisance to be taken of natural hydrological patterns and systems in the development of stormwater management systems and that the potential negative impacts highlighted above are reduced as far as is practically possible. This is illustrated by means of Figures 9 to 11 below, depicting both the traditional and recommended approaches to stormwater management within the urban context.

![Figure 9. Natural hydrological system](image1)

![Figure 10. Stormwater management approach with little concern for natural environment](image2)
Stormwater management objectives should include the following:

- Minimise the Threat of Flooding: This remains a key objective of any stormwater management system. However the challenge when contemplating design of stormwater management systems is to consider the following:
  - To mimic pre-development responses to storms
  - To reduce the volume of runoff by promoting infiltration
  - To reduce the peak flows and increase the time-to-peak through detaining the runoff and releasing it at a gradual rate
  - Where necessary, to construct means to contain flood waters and safely convey them out of the urban area

- Protection of Receiving Water Bodies: Receiving water bodies include the following:
  - Groundwater;
  - Wetlands;

It should be noted that the “receiving water body” is not necessarily the system into which stormwater is discharged directly, but can also be a natural system located further downstream in the catchment. Every endeavour should be made to achieve the following as far as possible:

- Maintain natural flow regimes and seasonality
- Prevent deterioration in water quality
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

- Prevent erosion or sedimentation of natural wetlands or rivers
- Preserve natural wetlands and vegetation, and preclude engineering interventions that may alter their physical and ecological characteristics.

The need to design appropriate stormwater management systems for developments should be seen as an opportunity to preserve or, if possible, improve natural freshwater ecosystems that have suffered degradation as a result of past activities, and in some cases, to create additional freshwater habitats that will contribute to the availability of appropriate, high quality river and wetland habitat that mimics the natural condition.

- Promote Multi-Functional Use of Stormwater Management Systems: Resources such as land and water are becoming increasingly scarce and multiple use of these must be strived for. Stormwater systems provide a wide range of opportunities for multi-functionality.

- Development of Sustainable Environments: Developers should think beyond their short-term involvement with the project and consider the sustainability of the stormwater management system that is to be implemented. All relevant factors that will impact on future operation and maintenance should be taken into account. Maintenance requirements should be minimised as far as possible in order to maximise the available local authority funding, personnel and equipment. Responsibilities for maintenance must be resolved with the relevant local authority department at an early stage of the design. The possibility of developing public/private partnerships should be explored with local authorities (e.g. division of funding of capital versus maintenance costs between public and private sectors). Environmental policies such as promoting the use of locally indigenous vegetation in planting programmes will also reduce the long-term maintenance requirements of the development.

Conventional drainage systems are generally focused on eliminating local flood nuisances and ignore the water quality, amenity, and biodiversity. Sustainable drainage systems (SuDS) aim to mimic the natural hydrological cycle thereby improving water quality, preserving biodiversity, and enhancing amenity. The result is a more sustainable and liveable city.

The key objectives of the SuDS approach are the effective management of: stormwater runoff quantity, quality and the associated amenity and biodiversity as described by the hierarchy below (Figure 12) where each level contributes to an improved, more sustainable drainage system.
Figure 12. Stormwater design hierarchy of the SuDS

Treatment trains are critical in designing an effective SuDS scheme. The SuDS Treatment Train starts with good housekeeping before moving on to source controls, local controls and regional controls. SuDS controls should be used sequentially in order to optimally treat stormwater runoff. Good Housekeeping ensures that as much as possible is done to minimise the release of pollutants – such as solid waste – into the environment where it may subsequently be transported by stormwater.

Source controls manage stormwater runoff as close to its source as possible, usually on site. Typical SuDS options include: green roofs, rainwater harvesting, permeable pavements and soakaways.

Local Controls manage stormwater runoff in the local area, typically within the road reserves and around mining infrastructure. Typical SuDS options include: bio-retention areas, filter strips, infiltration trenches, sand filters and swales.

Regional Controls manage the combined stormwater runoff from several developments. Typical SuDS options include: constructed wetlands, detention ponds and retention ponds.

These aspects and specific management practices that can be considered for implementation for the De Beers Voorspoed Mine is indicated in Table 12.
Table 13. SuDS conceptual design matrix

<table>
<thead>
<tr>
<th>Source controls</th>
<th>Rainwater harvesting</th>
<th>Infiltration</th>
<th>Detention</th>
<th>Conveyance</th>
<th>Long-term storage</th>
<th>Sedimentation</th>
<th>Filtration</th>
<th>Adsorption</th>
<th>Biodegradation</th>
<th>Plant uptake</th>
<th>Nitrification</th>
<th>Recreational benefits</th>
<th>Aesthetic enhancement</th>
<th>Amenity</th>
<th>Biodiversity</th>
<th>Costing</th>
<th>Operation and maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green roofs</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>x</td>
<td></td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>L/M</td>
<td>M</td>
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</tr>
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<td>Rainwater Harvesting</td>
<td>P</td>
<td>x</td>
<td>S</td>
<td>P</td>
<td></td>
<td></td>
<td>PR</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>N</td>
<td>L</td>
<td>M/H</td>
<td>M</td>
</tr>
<tr>
<td>Soakaways</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>x</td>
<td></td>
<td></td>
<td>PR</td>
<td>P</td>
<td>P</td>
<td>x</td>
<td>x</td>
<td>N</td>
<td></td>
<td>N</td>
<td>M</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Permeable pavements</td>
<td>P/5</td>
<td>P/5</td>
<td>S</td>
<td>x</td>
<td></td>
<td></td>
<td>P</td>
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<td>S</td>
<td>x</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>L/M</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Local controls</td>
<td>Filter strips</td>
<td>x</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>x</td>
<td>P</td>
<td>P</td>
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<td>S</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>H</td>
<td>L/L</td>
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<td>Swales</td>
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<td>P</td>
<td>x</td>
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<td>S</td>
<td>S</td>
<td>x</td>
<td>Y</td>
<td>Y</td>
<td>M</td>
<td>L/L</td>
</tr>
<tr>
<td>Infiltration trenches</td>
<td>S</td>
<td>P</td>
<td>S</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>S</td>
<td>x</td>
<td>x</td>
<td></td>
<td>N</td>
<td>L</td>
<td>L/M</td>
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<tr>
<td>Bio-retention areas</td>
<td>S</td>
<td>P</td>
<td>P</td>
<td>S</td>
<td>x</td>
<td>x</td>
<td>P</td>
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<td>P</td>
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<td>P</td>
<td>x</td>
<td></td>
<td>x</td>
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<td>N</td>
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<td>M/L</td>
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<tr>
<td>Regional controls</td>
<td>Detention ponds</td>
<td>x</td>
<td>S</td>
<td>P</td>
<td>x</td>
<td>x</td>
<td>P</td>
<td>x</td>
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<td>x</td>
<td>x</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>H</td>
<td>L/L</td>
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</tr>
<tr>
<td>Retention ponds</td>
<td>P</td>
<td>S</td>
<td>S</td>
<td>S</td>
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<td>x</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>H/L</td>
<td>L/L</td>
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<tr>
<td>Constructed wetlands</td>
<td>S</td>
<td>S</td>
<td>P</td>
<td>x</td>
<td>P</td>
<td>x</td>
<td>S</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>H/L/L</td>
<td>L/L/L</td>
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</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Quantity</th>
<th>Quality</th>
<th>Amenity</th>
<th>Biodiversity</th>
<th>Costing</th>
<th>Operation and maintenance</th>
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<tbody>
<tr>
<td>Quantity</td>
<td>Quality</td>
<td>Amenity</td>
<td>Biodiversity</td>
<td>Costing</td>
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<td>Costing</td>
<td>Operation and maintenance</td>
</tr>
</tbody>
</table>

There are circumstances where SuDS may be unsafe; for example where there is a serious risk of contamination resulting from point or non-point sources. These risks should be taken into consideration in the design and precautions taken. Table 13 highlights pollutants that may be found in stormwater. The potential risks of each pollutant on a site need to be assessed. This is especially important in the case of pathogens where stormwater facilities are open to the general public.
Table 14. Potential stormwater pollutants and impacts that needs to be assessed and monitored during the mining phases

<table>
<thead>
<tr>
<th>Pollutant Group</th>
<th>Pollutant</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrients</td>
<td>Nitrogen &amp; phosphorus</td>
<td>Excessive nutrients result in eutrophication. It is commonly associated with algal plumes, reduced clarity resulting in decreased bio-diversity</td>
</tr>
<tr>
<td>Sediments</td>
<td>Suspended &amp; settle solids</td>
<td>Increased turbidity, sedimentation, smothering of aquatic plant and animal life</td>
</tr>
<tr>
<td>Organic material</td>
<td>Plant litter</td>
<td>Increased nutrients &amp; sediment.</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Bacteria, viruses &amp; protozoa</td>
<td>Public health risk. contaminated recreational areas. Decreased economic value of natural recreational areas</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>Oils, grease &amp; others</td>
<td>Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity</td>
</tr>
<tr>
<td>Metals</td>
<td>Lead, copper, zinc and others</td>
<td>Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity</td>
</tr>
<tr>
<td>Toxic chemicals</td>
<td>Pesticides &amp; insecticides</td>
<td>Polluted water may become toxic. Aquatic life becomes toxic due to bioaccumulation. Decrease of biodiversity</td>
</tr>
<tr>
<td>Solids</td>
<td>Debris &amp; rubbish</td>
<td>Threat to wildlife. Aesthetic appeal decreased</td>
</tr>
</tbody>
</table>

6.2.3  Erosion control and rehabilitation

Erosion control will need to be undertaken to ensure the successful landscape and rehabilitation of the wetlands on site. Specific soil management practices needs to be implemented to prevent erosion and sedimentation as stipulated below:

6.2.3.1  Disturbance to wetland soil

Stringent controls must be put in place to prevent any unnecessary disturbance or compaction of wetland soils. Compaction of soils should be limited and / or avoided as far as possible. Compaction will reduce water infiltration and will result in increased runoff and erosion. Where any disturbance of the soil takes place (have taken place in the past), these areas must be stabilized and any alien plants which establish should be cleared and follow up undertaken for at least 2 years thereafter and preferably longer. Where compaction results, remedial measures must be taken (e.g. “ripping” the affected area). Topsoil should preferably be separated from the subsoil, and topsoil sections should be kept intact as deep as possible.
6.2.3.2 Erosion prevention

During the construction phase the clearing of the site left the soil exposed and this caused erosion. The following list provides a guide to preventing erosion on construction sites:

- Programming: Install erosion control measures before construction commences. Schedule construction activities to minimize land disturbance.
- Land clearing: minimize the extent and duration of land clearing.
- Stormwater and run-off systems: install temporary drains and minimize concentrated water flows. Control stormwater velocity where necessary with temporary energy dissipater structures. Divert run-off around trench excavations or disturbed areas.
- Rehabilitation: revegetate or stabilize all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed development to enhance the aesthetic value of the site and stabilize soil conditions.
- Services: coordinate the provision of site services to minimize disturbance.
- Stockpiles: locate stockpiles away from concentrated flows and divert run-off around them.

6.2.4 Prevention of sedimentation

Erosion is likely to occur on site, with sediment export being an inevitable risk. Measures must be employed to capture sediment and reduce the amount of sediment that leaves the site. The generation of dust, litter and debris need to be minimized. A regular site maintenance schedule needs to be introduced. Sediment control devices need to be installed to capture mobilized sediment. The following sediment control devices are suggested:

- Grass filter strips: it encourages sediment to settle as water passes over a vegetated area.
- Sediment filters: use materials such as fine mesh or geofabric to filter run-off prior to discharge.
- Sediment traps: temporary sedimentation basins.
- Drop inlet filters: e.g. hay bales and silt fences, which prevent sediment entry into the drainage system.

6.2.5 Pollution prevention

Stored material that has been poorly located or left unprotected can be a source of pollutants. The following measures need to be taken to prevent pollution to the wetland:
Stockpile location: locate stockpiles and material storage 30m or more away from drainage lines and identified wetland habitat.

Stockpile construction: minimize the number and size of stockpiles. Construct stockpiles with a height to width ratio of less than 2:1. Surround unstabilised stockpiles and batters with silt fences or drainage systems that will collect and treat uncontaminated water.

Stockpile maintenance: cover any stored material to protect it from rainfall. Mulch, roughen and grass seeding can be used on any batter or topsoil stockpile that is to be maintained for longer than 28 days.

6.2.6 Littering prevention

Uncontrolled littering can be a source of pollution to the wetland. The following measures need to be taken in order to mitigate against littering in wetlands:

- Litter storage and housekeeping: maintain a high standard of housekeeping. Store all litter carefully so it cannot be washed or blown into the stormwater drainage systems.
- Rubbish bins: provide bins for construction workers and staff at appropriate location, particularly where food is consumed.
- Daily site clean-up: clean-up site of all litter daily.
- Rubbish disposal: dispose of scrap materials (e.g. off-cuts and scrap machinery components) in a responsible manner.

6.2.7 Building activity associated impacts

Dust concrete, solvents, steel fillings, fuel and other wastes are all produced during building construction and can cause impacts to the wetlands. Take the following mitigation measures:

- Materials storage: store building materials under cover or in contained areas.
- Site cleaning: clean the repair or construction site daily. Do not use water for cleaning the site.
- Leakage containment and treatment: ensure that oil, fuel or solvent leakages cannot enter the stormwater system.
- Temporary filters: fit temporary inlet pit filters near wash-down areas to prevent pollutant entry into the drainage system.

6.3 Implementation

The cost of implementation of the Wetlands Management Plan includes initial costs of environmental works, plus the capital costs associated with infrastructure development as well as
De Beers Voorspoed Mine Pan Assessment & Rehabilitation Plan

an ongoing maintenance cost. Implementation of the plan needs to be balanced with the likely use the site will receive and the benefits to the community of the improved amenity.

The proposed staging of works is based on the criteria of:

- Improved environment – the wetland area is enhanced by the rehabilitation and alien clearing program;

- Community value – The local people are better able to use or appreciate the site

This project will require a commitment to ongoing maintenance.
7 REHABILITATION PLAN FOR WETLANDS

This rehabilitation plan is applicable to the activities directly associated with the wetlands and the mining site.

7.1 Wetland Rehabilitation Problems

The ecological integrity of the wetlands on site has been impacted by several factors including:

- Flow impediment through impoundents / road construction in wetlands;
- Transformation of natural vegetation by alien or terrestrial plant infestation.
- Habitat transformation and alteration of natural hydrological processes by roads, canals and other mining infrastructure.

7.2 Wetland Rehabilitation Objectives

In order to address the problems identified, a number of objectives were established to guide rehabilitation planning for the impacted wetland units identified. In order to achieve the rehabilitation objective defined, a number of wetland interventions have been proposed. These have been prioritized from a wetland rehabilitation perspective but implementation may need to be re-ordered due to practical or financial constraints. The proposed interventions aim to:

- Control alien invasive species in wetland areas;
- Destruction of man-made dams that prevent flow of water into wetlands;
- Support catchment overland flow intervention to reduce risk of failure;

7.3 Site specific measures

- Ensure that all current activities consider the wetland boundaries. No vehicles are to enter or drive through the wetland area unnecessarily;
- Demarcate all wetland boundaries with pegs and danger tape;
- Edge effects of mining activities, including erosion, sedimentation and alien/weed control, need to be strictly managed in wetland areas as well as their associated buffer zones;
- Stormwater on site should be addressed in a detailed stormwater management plan compiled by a hydrological engineer;
- Monitoring of all stormwater management structures in the wetlands should be conducted on a 6 monthly basis.

7.4 Rehabilitation works / methods

The Environmental Rehabilitation process at the site should form an integral part of site development,
operation and post-construction activities. A Rehabilitation Specialist and/or Environmental Control Officer (ECO) should therefore be appointed, and be available on-site as part of the rehabilitation management / construction team. The ECO should form an integral part of the management team, attending regular site meetings, receiving Project Meeting Minutes and being kept fully updated regarding the closure plan and site rehabilitation process.

This information is vital in ensuring that the necessary preventative measures and Search and Rescue activities are affected timeously.

Rehabilitation measures that may be affected on site include systems such as soil terracing, berm creation, grass blocks, fascine work, gabion basket work, reno mattresses, retaining block mechanisms, sand bags, boulder and rock placement, stone pitching, and grading. Decisions pertaining to plant material choices and specific vegetation utilisation for specific areas from an integral part of the process, as the hard landscape components work in conjunction with the soft landscape components. For example, the utilisation of plants with substantial roots for bank stabilisation purposes.

7.4.1 Identification and Protection of Environmentally Sensitive Areas

The on-site Environmental Control Officer and/or Rehabilitation Specialist should be fully aware of the scale and extent of the rehabilitation operations. No further vegetation clearing, levelling, excavation, topsoil removal or plant material removal is to be permitted without prior consent from the ECO and Rehabilitation Specialist based on the rehabilitation plan for the site unless instructed by them. Care must be taken during rehabilitation to avoid the natural drainage areas adjacent to the construction site. No vegetation clearance, topsoil collection or movement of machinery and vehicles should be allowed here as to keep the ecological integrity of the drainage areas and banks intact.

7.4.2 Comprehensive Photographic Record

In order for practical and attainable rehabilitation goals to be defined, it is recommended that a comprehensive photographic record of the entire property be created. Video footage may also be useful in compiling such a record. A photographic record of the entire property should be kept as it could become a very valuable tool for the Rehabilitation Works in future. It would serve as the basis for rehabilitation requirements, informing decisions on drainage, soil shaping, levels, plant choices and rehabilitation in general. It can also serve as a verification report to authorities and land administrators regarding the legislative processes, sustainable approach and progressive improvement.

7.4.3 Search and Rescue Activities

Search and Rescue activities could be initiated as part of the Rehabilitation process. Where
rehabilitation actions will commence, viable, transplantable plant species could be identified by the ECO / Rehabilitation Specialist, removed and stored in a potential ‘on-site’, self-sustaining nursery, to be re-used in rehabilitation activities in future.

Plant material that is to be “rescued” must be potted up into bags utilising local soil obtained from the previously stored topsoil heap. Adequate root systems per plant material type must be carefully excavated and retained in order for plant material to remain viable. Search and Rescue activities would include the removal of grass clumps, smaller transplantable shrubs and trees and endangered species such as geophytes and succulents should be placed into bags using local soil.

Animals like small mammals, reptiles and birds encountered during rehabilitation operations should be captured or moved by a specialist and released in a safe area. No animals may be poached at the property or adjacent areas. Many animals are protected by law and poaching or other interference could result in a fine or jail term.

7.4.4 Cleared Indigenous Plant Material

Where construction or rehabilitation activities are to commence in a specific area, certain indigenous plant material from the construction footprint area could be collected and bagged to be used in re-vegetation or as mulch during rehabilitation. To protect drainage areas and small streams as well as erosion prone areas, encroachers such as sickle bush could be cut and used to “brush pack” these problem areas to protect it. This will also restrict movement of animals and humans over sensitive erosion probe areas until pioneer vegetation has established.

7.4.5 Removal of Overburden

Removal of Overburden (or spoil material) means the total removal of soil and rock material from the site up to natural surrounding ground level. Overburden may be used to backfill excavated areas. Where overburden remains after backfilling excavated areas to natural ground level, this needs to be transported off-site by the contractor to a location approved by the Engineers.

In addition to the removal of excess rock and soil from the site, all other construction-related materials (bricks, concrete, steel rods, machinery etc.) also have to be taken off-site after cessation of construction activities.

7.4.6 Compaction Rehabilitation Measures (ripping and / or scarifying)

Soil compaction is often an effect of high traffic areas on development sites. It can become a major problem and can be recognized by:

- Excess surface moisture and slow drying soils due to deeper compaction preventing the percolation of water through the soil profile;
- Water runoff due to surface compaction preventing penetration and absorption (ponding of water), especially on banks and sloping surfaces;

- Large clear or sparsely covered areas devoid of a good vegetative cover due to hardened topsoil layers.

Ripping and / or Scarifying means the loosening of compacted soils by hand or appropriate machinery. The removal of overburden by excavator will loosen some of the upper compacted soils to some degree. Soils are to be loosened to a depth not less than 500mm. Slope angles should not exceed 18° incline angles (unless where specifically required in which case slope stabilization methods have to be implemented). Re-shaped land must resemble the pre-construction landscape as closely as possible. Ripping/Scarifying should preferably be done before the rainy season. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen.

Compacted soil can also be decompacted by “Rotary Decompactors” to effectively aerate soils for vegetation establishment.

### 7.4.7 Erosion Rehabilitation Measures

Water has the gift to sustain life, but also the potential to maim, damage and destroy if not managed correctly. Remedial actions must be established to ensure that potential erosion on site is addressed with an erosion control strategy towards rehabilitation. The following management measures are proposed for the rehabilitation process:

- Reprofiling of the banks of disturbed drainage areas to a maximum gradient of 1:3 to ensure bank stability;

- Reinforce banks and drainage features where necessary with gabions, reno mattresses and geotextiles. This is especially relevant for the stormwater outlet area;

- Reseed any areas where earthworks have taken place with indigenous grasses to prevent further erosion;

- Erosion control mechanisms must be established as soon as possible. Further financial provision should be continued over the subsequent years to allow for maintenance of the gabions, reno mattresses, and associated structures;

- A stormwater plan must be developed with the aid of an engineer to ensure that water runoff is diverted off the site without pooling and stagnation or erosion. Financial provision for closure will include the estimated costs for erosion control post-construction;

- Topsoil stockpiles should be vegetated to control loss from erosion and should have berms on top to reduce erosion from surface runoff. In areas where soil stockpiles are greater than
2 m high, soils should be ameliorated during closure to ensure their suitability for use in rehabilitation;

- If compaction occurs, rectification can be done by application and mixing of manure, vegetation mulch or any other organic material into the area. Use of well cured manure is preferable as it will not be associated with the nitrogen negative period associated with organic material that is not composted;

- Vehicle traffic should not be allowed on the rehabilitated areas, except on allocated roads, must not be allowed. It will have a negative impact due to the dispersive/compaction characteristics of soils and its implications on the long term;

- Foot action should be prevented by brush-packing the area during the establishment phase of vegetation on the rehabilitated areas, especially the first two seasons.

### 7.4.8 Reinstatement of Topsoil

Topsoil is the most important factor in re-vegetation and should receive substantial attention in rehabilitation strategies at the construction site during re-vegetation of areas. When the topsoil was previously stripped at the site, it contained large amounts of seed from the natural environment and considering the short-term nature of the construction, this soil will still be available for reinstatement.

The manner in which topsoil are created and maintained is important with regards to the implementation of a successful rehabilitation process. Soil management practices must be adhered to in order to reduce soil loss and to encourage rehabilitation post-construction. The two most important aspects to consider when removing topsoil are the depth of soil to be removed and the conditions of storage.

The topsoil layer (0-25 cm) is important as it contains nutrients, organic material, seed, and communities of micro-organisms, fungi and soil fauna. The biologically active upper layer of soil is fundamental in the development of soils and the sustainability of the entire ecosystem.

The correct handling of topsoil is vital in conserving the seed bank and nutrients which occur within this layer thereby ensuring successful rehabilitation:

- Topsoil must only be used for rehabilitation purposes and not for any other use example i.e. construction of roads;

- Previously excavated areas on the site should be backfilled with suitable topsoil, levelled to resemble the surrounding topography and slopes and scarified for re-vegetation/re-seeding;

### 7.4.9 Re-vegetation

Revegetation is the process of vegetation establishment and care, as part of the process of
reclamation, rehabilitation or restoration. The biggest challenge of rehabilitation is to establish a sustainable ecosystem that is self-productive and able to survive without continued anthropogenic interventions (irrigation, fertilization or re-seeding). After the construction on a landscape has ceased, processes of self-restoration are often slow (decades) and the final community of plants may not be the most desirable. Re-vegetation may be achieved by three main techniques, namely planting of trees and shrubs, direct seeding, or by self-regeneration.

Topsoil needs to be used wisely to achieve successful re-vegetation. Analysing the chemical properties of the soil can be helpful in directing possible soil amendments and guiding species selection. A well-prepared site will provide the most suitable conditions for plant germination, survival and to promote long-term re-vegetation success.

Plant species that have been rescued or removed and relocated to the temporary nursery could be used in replanting rehabilitation areas. Additional plant material (indigenous trees) as required should be sourced from local indigenous nurseries and specifications regarding plant sizes, heights and the installation process of these plants should be developed by the On Site ECO and Rehabilitation Specialist. Standard horticultural best practice would apply, with specific reference to the fact that the plant material would have to be in good condition, free from pests and diseases (any such plant would have to be removed from the site), well-formed and well rooted, potting materials are weed free and with sufficient root cover. Groundcovers and sedges are often supplied in trays, and the same standards would apply.

- A plant species specification for the rehabilitated areas is included below. Re-grassing or planting of wetland species should be undertaken (as far as possible) during the summer months, as germination and establishment is best at this time of year. Spring rains are also conducive to good germination results, and as such rehabilitation programmes should take these factors into consideration;

- There are two methods for seeding, hand broadcasting and hydro-seeding. The methods utilised will be site specific and the On Site ECO and Rehabilitation Specialist will determine them;

- Re-vegetation (grassing) should occur immediately after topsoil reinstatement. Seeding on the site can in most cases be done by hand. The contractor is to guarantee a success rate of 80% for all re-seeded areas, and follow up will be conducted monthly until such time as 80% success of vegetation cover has been achieved.

- In certain areas grass runners may be required, and grass sods where instant cover is necessary;
Indigenous seed tends to germinate much easier going into spring and summer than in midsummer as temperatures escalate slower. This method has been used the past several years abroad with great results and in South Africa as well the last three years;

The following hydrophilic plant species are considered suitable to be planted in the pans:
- *Cyperus sexangularis*
- *Juncus kraussii* (sedge);
- *Imperata cylindrica* (grass);
- *Paspalum urvillei* (grass)
- *Mariscus congestus* (sedge);
- *Schoenoplectus corymbosus* (sedge);
- *Stenotaphrum secundatum* (grass);

Lightly compact the area mechanically with a Cambridge roller or manually by raking;

Monitor.

7.4.10 Surface Rehabilitation of exposed areas

All areas where material will be removed for backfill and rehabilitation construction purposes should be graded and shaped in such a way as to resemble the natural surrounding landscape;

All disturbed surface areas will be re-shaped to resemble the surrounding natural topography. Surfaces will be ripped / scarified, and re-vegetated with indigenous grass species.

The ripped areas should be revegetated with grass species according to the seeding specification. The area between the wetland and constructed areas should be seeded to allow a stable grass cover to develop over time. No slashing of these grassland areas should occur in future. This will ensure that the tall grassland area increases the surface roughness that will reduce the flow velocity of water from the paved areas. The only area that needs to be slashed should directly adjacent to the constructed areas and / or palisade fence to create a firebreak.

The re-establishment of a mixed community of indigenous hydrophytic species in the within the cleared / impacted areas within the wetland boundary is important for a number of reasons. The most obvious is the increase in habitat and biodiversity value of the wetlands. Secondly, a well established vegetation covering across the wetland greatly increase the
roughness of the system, helping slow water moving through the wetland, trapping sediment and improving water quality. Re-establishment of the wetness regime will promote the return of hydrophytic species and wetland communities.

- Limited planting of locally occurring species such as *Cyperus latifolius*, *Cyperus dives*, *Cyperus prolifer*, *Cyperus textilis* and *Cyperus sphaerospermus* could occur in areas of significant disturbance, especially areas exposed once alien plans are removed. Much of the material required can be selectively harvested from the site itself. Tubers and rhizomes of wetland species can be collected and replanted where required. In addition the growth of species such as *Leersia hexandra*, *Imperata cylindrica*, *Ischaemum fasciculatum*, *Dissotis canescens* and *Ludwigia octovalvis* should be within the wetland areas.

- As far, as is practical, implement concurrent rehabilitation processes in order to limit degradation of soil biota.

- Terrestrial invasive removal programs must be maintained throughout the proposed development as well as in the aftercare and maintenance phases;

- Use Natural Infiltration and Best Practices for Stormwater Management;

- The creation of wetland vegetation could act as an effective pollution filter through absorptive and assimilative capacities of wetland plants and their soils. It could further aid in capturing sediment through filtration by plants and spreading out of flows. Any building rubble should be removed from the site;

7.4.11 **Alien invasive species**

Alien plants in the pans and the catchment are having a negative impact on the hydrology of the wetland. These plants should be cleared and controlled by the landowner as part of the rehabilitation strategy of the wetland. Alien plant control should be implemented as follows (No Kemprin type herbicides to be used):

- Frill all tree type alien plants located within the wetland body by chopping a frill into the bark near the base of the tree and painting the frill with herbicide. Once dead to selectively cut down and remove trees.

- All shrub type alien plants need to be cut down and the stems treated with herbicide.

- All other smaller forb type alien invader plants need to be removed by hand weeding.

7.4.12 **Fire management**

- Based on mean annual precipitation, wetland areas should be burnt every 3 to 4 years.
where possible, burning should be undertaken on a rotational basis. If this is impractical, the entire wetland may be burnt every third year provided there are other un-burnt wetlands nearby for wetland-dependant species to utilize.

- Cool and patchy burns should be promoted where possible by burning when relative humidity is high and air temperatures are low, preferably after rain.

- Preference should be given to burning of areas with abundant dead (moribund) stem and leaf material that limits new growth.

- Autumn/early winter breeding species such as the marsh owl and marsh harrier may be negatively impacted by early winter burning. If these species are recorded at the site, burn rotationally through block burning and check before burning by having 'beaters' 10 m apart walking through the area and then closely examining all localities where these birds are flushed. Leave areas unburnt where chicks have still not fledged, or, if possible, delay burning for that year.

7.4.13 Wetland stabilisation’

The operation of heavy equipment and vehicles in and around the pans might cause destruction of the soil profile or soil compaction, thereby increasing erosion by reducing soil infiltration and causing overland flow (Hill & Kleynhans, 1999). When stockpiles are too closely located to the pans might also increase the risk of erosion. If riparian land is not well-vegetated with deep-rooted plants, then flood-outs, stripping of topsoil from the floodplain, and accelerated bank erosion can occur; all of these can lead to the loss of valuable agricultural land. The following measurements should be implemented:

- Identify activities, which are causing erosion and incision of any of the wetland feature and mitigate these impacts immediately;

- Adequate erosion control and siltation control measures should be put in place;

- Care must be taken to ensure that machinery used does not erode the embankments further. Where embankments along the alignment are severely eroded, the ECO may request the Contractor to install erosion control measures.

- The wetland edges should be sloped according to engineer’s specification. The slopes must then be stabilized, with a biodegradable matt if necessary, and after re-vegetated with indigenous grass seed mixtures according to specification;

- Where any disturbance of the soil takes place (have taken place in the past), these areas must be stabilized and any alien plants which establish should be cleared and follow up undertaken for at least 2 years thereafter and preferably longer. Where compaction
results, remedial measures must be taken (e.g. “ripping” the affected area);

- Reseed any areas where earthworks have taken place with indigenous grasses to prevent further erosion (where applicable);
- The time in which soils are exposed during construction activities should remain as short as possible;
- During the construction of the bridge, erosion berms should be installed to prevent gully formation and siltation of the riparian resources;

7.4.14 Pollution control

For the health of the wetland, a programme is suggested to clean up the litter especially near the wetlands. Litter, sewage and run-off from the mine in the wetlands allows chemicals into the wetland, decreasing the health in the wetland which will lead to lower biodiversity. Specific measures to be implemented for the site during the construction phase of the road should include:

- Ensure that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. Regularly inspect all vehicles for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil (SAS, 2012);
- No dumping of waste should take place within the wetland and associated buffer zone. If any spills occur, they should be immediately cleaned up (SAS, 2012);
- Contain all dirty water in the dirty water system and contain all dirty storm water up to a 1:50 year flood event as a minimum. Ensure that all activities impacting on ground water resources of the subject property are managed according to the relevant DWA Licensing regulations and ground water monitoring and management requirements (SAS, 2012).
8 MONITORING PLAN

Several methods exist to monitor rehabilitated areas to scientifically prove that a self-sustainable ecosystem has developed or show a positive trend towards successful rehabilitation. This will prove that environmental degradation and biological diversity have been mitigated and restored where it has been negatively impacted upon. The important aspect to keep in mind is that it is not only a visual inspection, but measurable information gathering e.g. soil samples, vegetation diversity, biomass, basal cover, species composition etc. The monitoring data must be of such a standard that meaningful conclusions can be made and a trend indicated. Good record keeping is essential. All illegal invader plants and weeds shall be eradicated as required in terms of Sections 119 to 126 of The Environmental Management Act.

Monitoring should also take place on regular time intervals to establish if the re-vegetation strategy was successful. Table 15 indicate the monitoring strategy and aspects to be monitored at the crossings:
### Table 15. Monitoring framework for the rehabilitation plan on the wetlands at the mine

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>METHODS</th>
<th>SAMPLING FREQUENCY</th>
<th>PERFORMANCE INDICATOR</th>
<th>MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrity of stormwater structures where relevant:</td>
<td>On-site inspections; Fix point photography; Field markers at headcuts</td>
<td>Monthly and after rainfall events for first year and then yearly (1-3 years)</td>
<td>Arresting of erosion / headcut. Sedimentation behind structure; Spreading of flow</td>
<td>Stabilising of erosion front; Filled up to gabian level</td>
</tr>
<tr>
<td>Gabions / weirs / infilling of furrows, etc.</td>
<td></td>
<td></td>
<td></td>
<td>Regular overtopping of streambanks on floodplains or sustained diffuse flow</td>
</tr>
<tr>
<td>Vegetation cover</td>
<td>Map main vegetation cover (and or aerial or fix point photography)</td>
<td>Baseline study before project start, then yearly (1-3 years)</td>
<td>Spreading of distribution of dominant species in specified wet zones</td>
<td>Identify climax species in specified wet zones</td>
</tr>
<tr>
<td>Plant species composition</td>
<td>Fix transects to determine the species composition by means of the nearest to the point plant technique</td>
<td>Baseline study before project start, then yearly (1-3 years)</td>
<td>Presence / absence of species composition in specified wet zones</td>
<td>Identify climax species in specified wet zones</td>
</tr>
<tr>
<td>Water quality</td>
<td>Collect water samples and do inorganic scan and organic analyses</td>
<td>Monthly for first year, including low and high flow events, then yearly during seasons</td>
<td>Levels of heavy metals / pollutants within acceptable levels; Levels of bacteria counts / pollutants within acceptable levels</td>
<td>Levels of heavy metals / pollutants / bacteria count / within specified limits</td>
</tr>
<tr>
<td>Water quantity / outflow</td>
<td>Measure water level outflow at existing gabians</td>
<td>Monthly, including low and high flow levels</td>
<td>Flood attenuation, and baseflow maintenance</td>
<td>Reduced peak flows, reduced energy flow, Permanent/sustainable baseflow</td>
</tr>
<tr>
<td>Invertebrate and / or frog survey</td>
<td>Compile invertebrate and / or frog study</td>
<td>Invertebrate: Yearly during low flow period; Frogs: Yearly during rainy season</td>
<td>Presence / absence of species composition in specified wet zones</td>
<td>Identify climax species in specified wet zones</td>
</tr>
<tr>
<td>Catchment and causative factors</td>
<td>Monitor catchment condition (GIS) and causative factors in wetlands</td>
<td>3 Monthly</td>
<td>Conservation and improvement of natural resources in catchment</td>
<td>Specific catchment components within set limits, e.g. grazing. Stabilising of causative problems in water course / wetlands</td>
</tr>
</tbody>
</table>
9 DISCUSSION & CONCLUSION

The wetland delineation for the proposed water supply project was done according to the criteria set by the Department of Water Affairs and the National Wetland Classification System for South Africa (SANBI, 2009). The soils, vegetation associated with wetlands and landscape were all used as parameters in identifying the wetland zones.

The wetlands on site can be classified as follows:

1. Depressions:
   - Natural
     - Endorheic depressions without channelled inflow
   - Artificial
     - Man-made depressions (dams)

Baseline soil information, landscape profile and vegetation were used to confirm wetland and terrestrial properties within the study area. In many instances the soils in the wetlands did not show any signs of wetness within 50cm of the surface and did not display typical hydromorphic characteristics, although they were still classified as wetlands due to the state of the wetland in the past and the potential to become rehabilitated. In many instances sections of the wetlands have become dewatered and invaded by terrestrial species, and in these instances the edge of the wetland was determined by aerial photography from previous years.

The impact risks associated with the site is reflected in the results of the PES assessment which indicates that the pan is ‘Moderately Modified’. The main negative impacts that cause changes to the wetland conditions at present are impoundments (dams), alien species invasion, dewatering, mining infrastructure and roads. The EIS of the pan are considered to be MODERATE and are considered to be ecologically important and sensitive at least on a local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications and may play a small role in moderating the quantity and quality of water flowing downstream. The Hydrological Functional and Importance of the wetlands differed for the HGM units. The pans are classified as Largely Modified in terms of these aspects. Direct Human Benefits obtained from the wetlands on site were considered to be Very Low in general. Local communities therefore have a low dependency on the wetland and seldom benefit from it.

The man-made dams in comparison have a “Seriously Modified” PES, with a “LOW” EIS. These dams have become completely modified and dewatered over time. The
importance to destroy these dams to allow natural flow of water into the wetlands is considered the most important rehabilitation activities with the alien invasive species management on site.

An impact risk assessment was conducted for the wetlands on site. Impacts relating to the proposed mining development on the wetlands are as follows:

- Direct wetland destruction;
- Dewatering of wetlands
- Soil erosion and sedimentation;
- Water pollution from spillages, vehicle emissions and dust;
- Spread and establishment of alien invasive species in wetlands;

Specific mitigation measures need to be implemented in the areas surrounding the wetland zones to prevent any impacts on the wetland. Furthermore, a rehabilitation, management and monitoring plan was conducted for the specific pan as part of the Voorspoed Mine Operational and Closure phases that should be implemented by the engineers as well as the rehabilitation specialist.
10 REFERENCES


### APPENDIX A PES SCORES OF THE PANS

<table>
<thead>
<tr>
<th>Criteria and Attributes</th>
<th>Relevance</th>
<th>Pan</th>
<th>Man-made dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Modification</td>
<td>Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Permanent Inundation</td>
<td>Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Water Quality Modification</td>
<td>From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Sediment Load Modification</td>
<td>Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Canalisation</td>
<td>Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Topographic Alteration</td>
<td>Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Terrestrial Encroachment</td>
<td>Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Indigenous Vegetation Removal</td>
<td>Transformation of habitat for farming, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and in increases potential for erosion.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Invasive Plant Encroachment</td>
<td>Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Alien Fauna</td>
<td>Presence of alien fauna affecting faunal community structure.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Over utilisation of Biota</td>
<td>Overgrazing, overfishing, etc.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Mean</td>
<td>2.1</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Category</td>
<td>Moderately Modified</td>
<td></td>
<td>Seriously modified</td>
</tr>
<tr>
<td>Ecological Management Class</td>
<td>Class C</td>
<td></td>
<td>Class E</td>
</tr>
</tbody>
</table>
## APPENDIX B EIS SCORES OF THE PANS IN THE STUDY AREA

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Pan</th>
<th>Man-made dams</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRIMARY DETERMINANTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rare &amp; Endangered Species</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2. Populations of Unique Species</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3. Species/taxon Richness</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. Diversity of Habitat Types or Features</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. Migration route/breeding and feeding site for wetland species</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Sensitivity to Changes in the Natural Hydrological Regime</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Sensitivity to Water Quality Changes</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. Flood Storage, Energy Dissipation &amp; Particulate/Element Removal</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>MODIFYING DETERMINANTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Protected Status</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10. Ecological Integrity</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td><strong>MEDIAN</strong></td>
<td>1.8</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>OVERALL ECOLOGICAL SENSITIVITY AND IMPORTANCE</strong></td>
<td>Moderate</td>
<td>Low / marginal</td>
</tr>
</tbody>
</table>
## APPENDIX C. SCORES FOR THE WET-ECOSERVICES ASSESSMENT (KOTZE ET AL. 2005)

<table>
<thead>
<tr>
<th></th>
<th>Pan</th>
<th>Man-made dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-functional Importance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood attenuation</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Stream flow regulation;</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sediment trapping;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Phosphate trapping;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Nitrate removal;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Toxicant removal;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Erosion control;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Carbon storage; and</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maintenance of biodiversity</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total Score</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

| Direct Human Benefits       |      |               |
| Water supply for human use; | 1    | 1             |
| Natural resources           | 1    | 1             |
| Cultivated foods            | 1    | 1             |
| Cultural significance       | 1    | 1             |
| Tourism and recreation      | 1    | 1             |
| Education and research      | 1    | 1             |
| Total score                 | 6    | 6             |