APPENDIX O

Wetland Assessment

WETLAND STUDY WITHIN THE EXXARO GROOTEGELUK COMPLEX - TURFVLAKTE

REPORT

NOVEMBER 2018

GroundTruth Reference: GTW726/091218/01

Exxaro Reference: GG/G20/29/03/2017

GroundTruth
Water, Wetlands and Environmental Engineering

Head Office KwaZulu-Natal
P.O. Box 916, Hilton 3245, South Africa
Tel: +27 33 343 2229 - Fax: +27 86 599 2300
admin@groundtruth.co.za
www.groundtruth.co.za

COMPILED BY:

TITLE	SIGNATURE	DATE
Fiona Eggers		21/11/2018
Vere Ross-Gillespie		24/05/2018

ACCEPTED AND APPROVED BY:

TITLE	SIGNATURE	DATE
Craig Cowden		09/12/2018

DOCUMENT APPROVALS

ROLE	NAME	SIGNATURE	DATE

DISTRIBUTION LIST

AGENCY, ORGANISATION OR PERSON	NO. OF COPIES

DOCUMENT CONTROL
DOCUMENT INFORMATION

INFORMATION	
Document Owner	
Publish Date	[Publish Date]

DOCUMENT HISTORY

VERSION	DATE	CHANGES
Version 2	10/09/2018	Addressing comments received from Exxaro
Version 3	09/12/2018	Addressing comments received from Exxaro
Version 4	17/09/2019	Addressing comments received from Exxaro
Version 5	17/10/2019	Addressing comments received from Exxaro

COPYRIGHT

All intellectual property rights and copyright associated with GroundTruth's services are reserved and project deliverables[1] may not be modified or incorporated into subsequent reports, in any form or by any means, without the written consent of the author/s. Similarly, this report should be appropriately referenced if the results, recommendations or conclusions stated in this report are used in subsequent documentation. Should this report form a component of an overarching study, it is GroundTruth's preference that this report be included in its entirety as a separate section or annexure/appendix to the main report.

INDEMNITY

The project deliverables, including the reported results, comments, recommendations and conclusions, are based on the author's professional knowledge as well as available information. The study is based on assessment techniques and investigations that are limited by time and budgetary constraints applicable to the type and level of survey undertaken. GroundTruth therefore reserves the right to modify aspects of the project deliverables if and when new/additional information may become available from research or further work in the applicable field of practice, or pertaining to this study.

GroundTruth exercises reasonable skill, care and diligence in the provision of services, however, GroundTruth accepts no liability or consequential liability for the use of the supplied project deliverables (in part or in whole) and any information or material contained therein. The client, including their agents, by receiving these deliverables indemnifies GroundTruth (including its members, employees and sub-consultants) against any actions, claims, demands, losses, liabilities, costs, damages and expenses arising directly or indirectly from or in connection with services rendered, directly or indirectly by GroundTruth.

VALIDITY PERIOD

It should be noted that the findings of these freshwater ecosystem studies are considered to be valid for a period of five (5) years unless new/additional information warrants a change in project findings. This is based on the likelihood of changes within the systems (e.g. changes in vegetation composition or altered flow patterns) and the associated catchment areas (e.g. increased runoff or establishment of streamflow reduction activities.

[1] Project deliverables (including electronic copies) comprise *inter alia:* reports, maps, assessment and monitoring data, ESRI ArcView shapefiles, and photographs.

TABLE OF CONTENTS

1.	INTRODUCTION	1
1.1	Background	3
1.2	Terms of reference	3
2.	KNOWLEDGE GAPS	6
2.1	Assumptions	6
2.2	Limitations	7
3.	EXPERTISE OF THE SPECIALISTS	9
4.	STUDY AREA	10
4.1	Regional context	10
4.2	Climate	10
4.3	Vegetation types	10
4.4	Wetland classification	11
4.5	Threat status of the wetlands	11
4.6	National Freshwater Ecosystem Priority Areas	12
4.7	Aquatic invertebrates	14
5.	METHODS	16
5.1	Dry season sampling	16
5.1.1	Desktop analysis	16
5.1.2	Dry season site visit	16
5.1.2.1	Collection of soil samples and visual assessment of wetlands in the dry phase	16
5.1.2.2	Invertebrate incubation	18
5.1.2.3	Identification of invertebrates	19
5.1.2.4	Water chemistry	20
5.2	Wet season sampling	20
5.2.1	Desktop analysis	20
5.2.1.1	HECRAS modelling	20
5.2.1.2	Refinement of points of interest	20
5.2.2	Wet season site visit	21
5.2.2.1	Wetland habitat identification and mapping	21
5.2.2.2	Wet Season Invertebrate sampling	22
5.2.2.3	Water chemistry	22
5.3	Assessment of wetland functioning and condition	23
5.3.1	Assessment of wetland functioning	23
5.3.2	Assessment of wetland condition/integrity	25
5.3.3	Freshwater ecosystem risk assessment	27
5.4	SANBI offset calculator	28

6. RESULTS 30
6.1 Characteristics of the freshwater ecosystems 30
6.1.1 Artificial systems 32
6.1.1.1 Watering holes 32
6.1.1.2 Dams .... **Error! Bookmark not defined.**
6.1.2 Wetland habitat 33
6.2 Assessment results of the wetlands identified 39
6.2.1 Wetland clusters 41
6.2.2 Wetland ecosystem functioning assessment 41
6.2.3 Wetland ecological integrity assessment 47
6.2.4 Summary of overall ecosystem integrity for the wetlands 57
6.2.5 Freshwater ecosystem risk assessment 58
6.3 SANBI offset calculator 61
6.4 Invertebrate sampling 61
6.4.1 Invertebrate incubation and wet season sampling 61
6.4.2 Findings discussion 64
6.4.2.1 Scarcity of the invertebrates collected 65
6.5 Water quality data 66
7. RECOMMENDATIONS/CONCLUSION 68
8. REFERENCES 70
9. APPENDICES 73

LIST OF FIGURES

Figure 1-1 Overview of the study area within the specified cadastral boundary 2
Figure 1-2 Overview of the proposed mining activities within the study area 5
Figure 4-1 Overview of NFEPA systems (Nel et al. 2011) within the greater study area 13
Figure 5-1 Localities of soil samples that were collected from suspected temporary wetlands at Grootegeluk for incubation and invertebrate hatching experiments 17
Figure 5-2 Crusts (A) comprising the shells of Copepoda (B) and Conchostraca (C) – both obligate temporary wetland invertebrates - observed on the uppermost sediments of wetlands/pans at Grootegeluk. 17
Figure 5-3 Collection of surface crusts and soils from the deepest parts of a temporary wetland at Grootegeluk during the dry season. Hard soils in places necessitated the need for a pick-axe to be used to collect soils instead of an auger. 18
Figure 5-4 Incubation trials setup showing inundated sediment samples in a controlled environment room. 19
Figure 5-5 Wetness zones within wetland ecosystems 21
Figure 5-6 Overview of the location of the soil sample plots 22
Figure 5-7 Outline of the approach used to identify the required offset for water resources and ecosystem services, habitat conservation and species of conservation concern 29
Figure 6-1 Overview of the freshwater ecosystems identified within the study area 31
Figure 6-2 View of the watering hole during the dry season site visit (left) and the wet season site visit (right) 32
Figure 6-3 View of the dams during the dry season site visit (top left), the wet season site visit (top right), ... 33
Figure 6-4 Examples of the desiccated soils of two of the wetlands during the dry season site visit 35
Figure 6-5 Examples of the some of the wetlands visited during the wet season site visit and the variable amount of water within the systems 36
Figure 6-6 An example of a string of smaller wetlands aligned with a dendritic drainage network 37
Figure 6-7 An example of trees within an inundated wetland 37
Figure 6-8 An example of two wetland systems containing seasonal wetland vegetation within the portions of the systems with sustained wet conditions 38
Figure 6-9 Examples of bush encroachment into some of the wetlands identified within Turfvlakte 39
Figure 6-10 Overview of the identified freshwater ecosystems in relation to the proposed mining activities on Turfvlakte 40
Figure 6-11 Overview of the ecosystem services provided by the wetland systems within the eastern portion of the study area for the current scenario 44

Figure 6-12 Overview of the ecosystem services provided by the wetland systems within the western portion of the study area for the current scenario 45
Figure 6-13 Overview of the wetlands within the study area and their associated 200m buffer zones 48
Figure 6-14 Overview of the identified wetlands located to the east of the coal conveyor, their associated numbering and PES category for the current scenario 50
Figure 6-15 Overview of the identified wetlands located to the west of the coal conveyor, their associated numbering and PES category for the current scenario 51
Figure 6-16 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed operational-mining scenarios without mitigation measures. 58
Figure 6-17 Ambient air temperature and water temperature records collected for the duration of the incubation experiments 62
Figure 6-18 No of families recorded hatching from incubation experiments (dry season) and in-situ field sampling (wet season) of temporary wetlands located at Turfvlakte 64
Figure 6-19 Water quality parameters measured for each sample used in the incubation experiments at the beginning of the experiment (Dry 1) at the end of the experiment 41 days later (Dry 2) as well as during the in-situ field sampling (Wet) 67

LIST OF TABLES

Table 3-1 Team members, roles, and experience levels 9
Table 4-1 A description of the onsite wetlands based on the SANBI (2009) classification and Kotze et al. 2007. 11
Table 4-2 Description of NFEPA wetland condition categories.. 13
Table 5-1 Ecosystem services supplied by wetlands 24
Table 5-2 Ratings for describing the EIS of wetlands... 25
Table 5-3 Impact scores and present ecological state categories for describing the integrity of wetlands 26
Table 5-4 List of descriptors for the significance score of an impact. 28
Table 6-1 Summary of current Ecosystem Services Scores for all of the wetlands identified within the study area 43
Table 6-2 EIS scores for the Group 1 for the current scenario 46
Table 6-3 EIS scores for the Group 2 for the current scenario 46
Table 6-4 EIS scores for the Group 3 for the current scenario 46
Table 6-5 EIS scores for the Group 4 for the current scenario 46
Table 6-6 EIS scores for the Group 5 for the current scenario 47
Table 6-7 EIS scores for the Group 6 for the current scenario 47
Table 6-8 Summary of the assessment of the ecological integrity for Group 1 for the current scenario and the loss of hectare equivalents within the operational-mining landscape.. 52
Table 6-9 Summary of the assessment of the ecological integrity for Group 2 for the current scenario and the loss of hectare equivalents within the operational-mining landscape.. 53
Table 6-10 Summary of the assessment of the ecological integrity for Group 3 for the current scenario and the loss of hectare equivalents within the operational-mining landscape 54
Table 6-11 Summary of the assessment of the ecological integrity for Group 4 for the current scenario and the loss of hectare equivalents within the operational-mining landscape 55
Table 6-12 Summary of the assessment of the ecological integrity for Group 5 for the current scenario and the loss of hectare equivalents within the operational-mining landscape 56
Table 6-13 Summary of the assessment of the ecological integrity for Group 6 for the current scenario and the loss of hectare equivalents within the operational-mining landscape 57
Table 6-14 Summary of the hectare equivalents for the current and operational-mining scenarios for the identified wetland groups 58
Table 6-15 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the operational-mining scenario. 60

Table 6-16 Invertebrate taxa recorded from sediment inundation experiments and wet season sampling at Grootegeluk. Families in red represent obligate temporary wetland indicator species, while families in black represent good dispersers able to establish in any nearby water body 63

LIST OF ACRONYMS

Acronym	Explanation
DO	Dissolved Oxygen
DWE	Digby Wells Environmental
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EIS	Ecological Importance and Sensitivity
FEPA	Freshwater Ecosystem Priority Area
GIS	Geographic Information System
GPS	Global Positioning System
Ha equiv	Hectare Equivalents
HGM	Hydrogeomorphic
IUCN	International Union for Conservation of Nature
LEDET	Limpopo Department of Economic Development, Environment and Tourism
MAP	Mean Annual Precipitation
NFEPA	National Freshwater Ecosystem Priority Areas
ORP	Oxidation-reduction Potential
PES	Present Ecological State
PET	Potential Evapotranspiration
pH	Potential of Hydrogen
QGIS	Quantum Geographic Information System
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System
SVcb	Central Bushveld
SVcb 19	Limpopo Sweet Bushveld
Temp	Temperature
TSS	Total Suspended Solids
WRC	Water Research Commission
YSI	Yellow Springs International

1. INTRODUCTION

The Grootegeluk opencast coal mine is located approximately 20km to the west of the town of Lephalale within the Limpopo Province of South Africa. Portions of land located to the west of the mine have been identified to have suitable coal reserves and thus Exxaro intends on expanding its mining activities into these identified areas. This area forms part of the existing mining right. For the purpose of this report the study area focussed on the portion of the Turfvlakte 463 LQ area that is located within the Manketti Reserve, i.e. it excluded the area associated with the Renoster Dump, Dump 6 and the Tyre Dump. The area is utilised for game farming purposes and covers an area of approximately 900ha. Even though the study area currently has no mining related infrastructure within its boundaries, the coal conveyor transects the middle of the study area, which also restricts the movement of game in the study area (Figure 1-1). Although Turfvlakte is part of the current mining rights areas, the mining of coal in the study area is a new proposed activity and as such Exxaro Coal Grootegeluk is currently in the process of amending the Environmental Authorisations.

Local, regional and national regulatory bodies, such as the Department of Water and Sanitation (DWS) and the Limpopo Department of Economic Development, Environment and Tourism (LEDET), have adopted legislation, policies and guidelines that regulate the use of freshwater ecosystems to protect and maintain these systems' benefits and services to society and the natural environment. In order to be regulated, these systems must first be identified and delineated.

The objective of the delineation procedure is to identify the boundary between the wetland systems and adjacent terrestrial areas. The process of wetland system delineation identifies the extent of these ecosystems based on the following legal definition[2]:

- *"Wetland means 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."* [3]

[2] As per the National Water Act (Act No. 36 of 1998)

[3] It should be noted that the wetlands identified within the study area are considered to be non-perennial pans that only contain water during the rainy season. Furthermore, these systems are not sustained by subsurface water inputs and as such are considered to be transient in nature, which is further supported by the low rainfall and high evaporative rates for this area. The formation of these systems coincides with depressions in the landscape that are underlain by suitable substrate, e.g. clay layer. The combination of these factors has resulted in the formation of these non-perennial systems within the landscape and are considered to be the only wetlands identified within the study area.

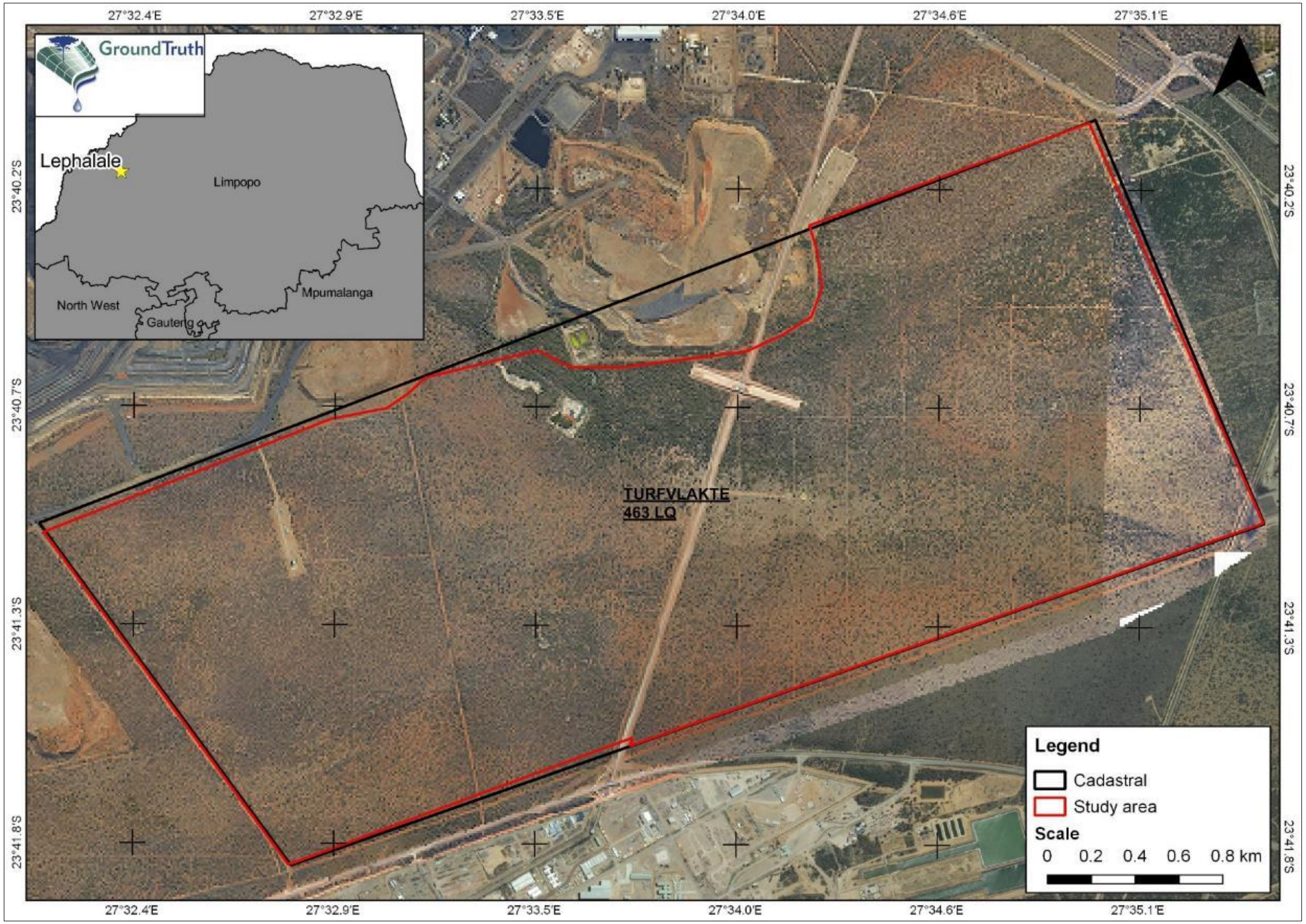


Figure 1-1 Overview of the study area within the specified cadastral boundary

1.1 Background

The Grootegeluk coal mine operation is an opencast mining operation and is located within the Waterberg coalfield of the Limpopo province and is currently the largest of Exxaro's coal mines. The coal reserves within the study area are considered to be relatively shallow, and as such opencast mining is considered the most desirable option to access these coal reserves. The coal reserves are considered to include A-grade export-quality coal and power station coal, with both of Eskom's Medupi and Matimba power stations being beneficiaries of the coal.

Opencast coal mining is an operation which results in the excavation of a large pit, the associated infrastructure and the overburden dumps. Associated with these activities includes a suite of potential risks and impacts on water resources and include not only the direct loss of freshwater ecosystems due to the mining activities, but also the contamination of these freshwater resources.

Currently it is proposed that the majority of the study area be mined over a thirty (30) year period. The proposed mining footprint extends over the entire eastern portion of the study area, and over approximately two-thirds of the western portion of the study area (Figure 1-2). Therefore, any planned infrastructure within the remaining portion to the west of the conveyor will require careful planning to fall outside of a 200m buffer of any identified pans and/or that linear features will be aligned with existing linear features, e.g. roads; with the intent of not destroying any wetlands.

1.2 Terms of reference

The study area is located along the southern boundary of the current Grootegeluk mine and falls under the management of the Manketti Game Reserve, which is an Exxaro owned entity and operates under Ferroland. Prior to any proposed mining activities taking place within the study area, it is considered essential to ascertain the extent of any freshwater ecosystems within the study area. The identification of these systems allows for appropriate planning to be undertaken in order to mitigate the impacts associated with the proposed activities. The terms of reference for this study included the following:

- Dry and wet season sampling site visits to verify and delineate the outer edge of the temporary zone[4] of the identified wetland systems;
- Invertebrate sampling and specimen collection for comparison between the seasonal site visits;
- Water quality, turbidity and Yellow Springs International (YSI) sampling for selected sites;
- Mapping of wetland areas at an appropriate scale;
- Functional assessment of the wetland habitat within the study area;
- Description of the current state/integrity of the wetland systems within the study area;

[4] The temporary zone of wetness refers to "the outer zone of a wetland characterised by saturation within 50cm of the soil surface for less than three months of the year (DWAF 2005, p.27)

- Description of the loss of wetland habitat associated with the proposed expansion of the mine and a description of the offset targets as per the SANBI Offset Guidelines (Macfarlane et al. 2014);
- Identification of other sensitivities and important issues not identified within the assessment process, if applicable.

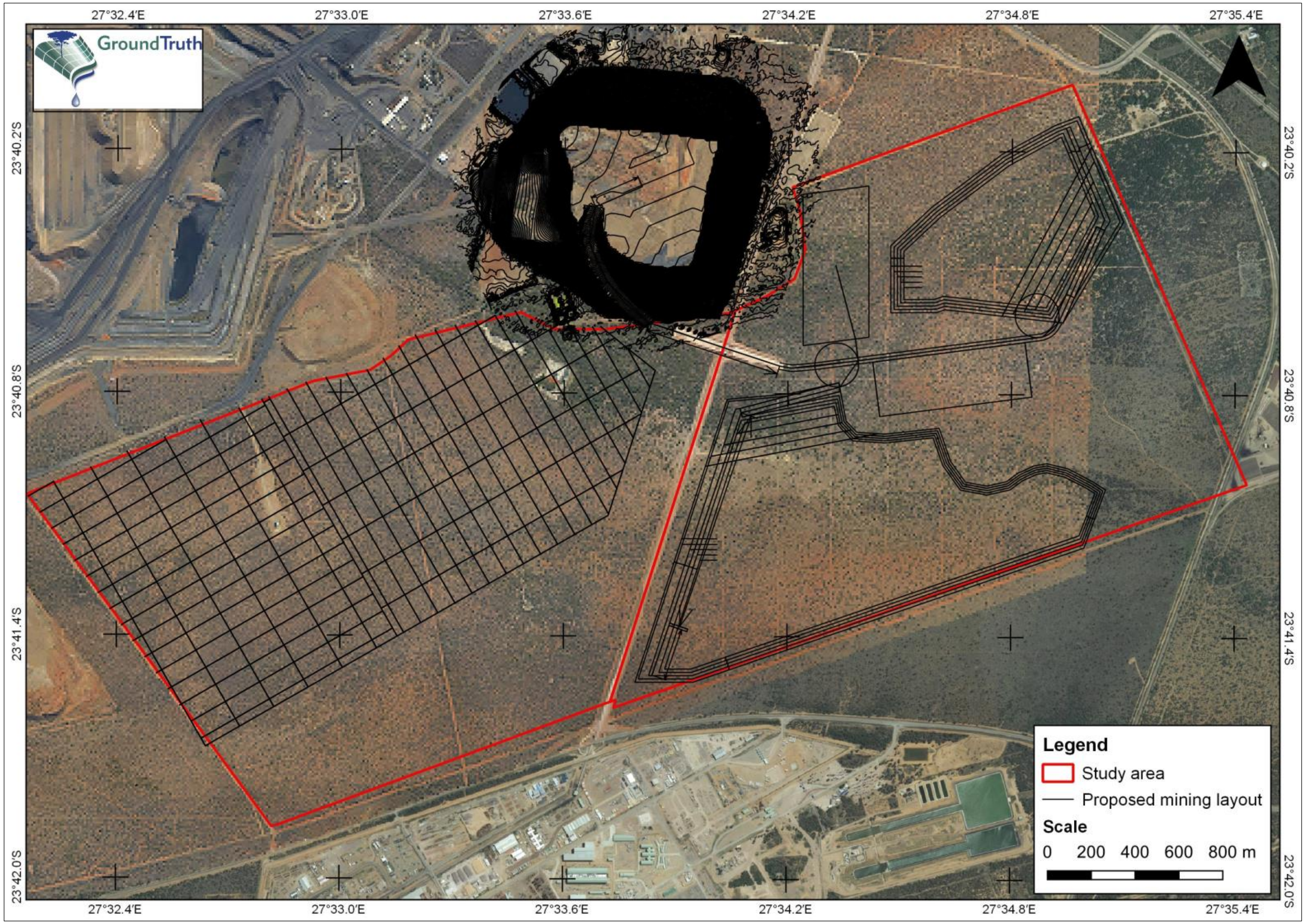


Figure 1-2 Overview of the proposed mining activities within the study area

2. KNOWLEDGE GAPS

The following sections highlight the main assumptions and limitations associated with the study.

2.1 Assumptions

Studies that focus on the potential impacts of an activity rely on various assumptions, with the following assumptions being made by the multidisciplinary team (wetland specialists and aquatic ecologist) during the assessment of these particular wetland systems:

- The reference/benchmark vegetation of the wetlands was considered to be predominantly barren soils, with only limited wetland vegetation within the larger seasonal pans/depressions.
- Due to the size of the study area, HECRAS modelling was undertaken for the site to assist with the identification of wetland habitat/low points within the landscape.
- Based on the proposed mining layout, as supplied by Exxaro in August 2019, the following wetlands located within the eastern portion of the study area will not be directly affected by the proposed mining activities and its associated infrastructure, i.e. they will not be lost in their entirety; namely wetlands 16, 17 and 19. The wetlands located within the western portion of the study area that will not be directly affected by the proposed mining activities include wetlands 6, 7, 8 and 9. Should the proposed mining layout encroach into either of these groups of wetlands, it is anticipated that a residual loss will be incurred, and as such the assessment of the wetlands will have to be revised.
- The assessment of the wetlands within the operational-mining landscape assumes that the wetlands within the footprint of the mining activities will be lost in their entirety and simultaneously, and as such has not accounted for the phased mining activities and as such represents a worst-case scenario.
- The wetlands retained to the west of the coal conveyor will be avoided to the extent that a 200m buffer will be maintained around the identified systems and/or linear features will be aligned with existing linear features e.g. roads. Should infrastructure development be planned, it will be relocated accordingly to ensure that these systems are not negatively affected by the proposed mining infrastructure.
- No food was provided to invertebrates during the inundation experiment, as it was assumed there was sufficient food in the form of algal propagules in the sediment itself. During the incubation trials algal growth was also observed to be abundant. An additional trial with feeding may have yielded a greater abundance of taxa.
- It is assumed that as part of the offset mitigation activities, wetland creation may be considered. Should this approach be adopted, wetland soils will be ‘harvested’ from the largest wetland areas that are to be lost in the landscape.

2.2 Limitations

Limitations and uncertainties often exist within the approaches and techniques used to assess the condition of natural systems, with the following limitations applying to the studies undertaken for this report:

- Two site visits were undertaken, coinciding with the dry and the wet season. The soils during the dry season were largely impregnable using a hand auger, limiting reviews of the soil profile, and as such other wetland characteristics/indicators, e.g. topography, were considered during the site visit.
- Some wetlands may have been overlooked and thus have not been included in the assessment. This would be due to the fact that these systems may have been too small to be visible from the aerial imagery and/or beneath dense tree canopy cover and/or not identified during the HECRAS modelling.
- Due to time constraints, soil descriptions are based on moist conditions, rather than the dry conditions stipulated in the DWS guidelines (DWAF 2005). Generally, the recorded Munsell colour values would increase as the soil dried and this is taken into consideration during the infield studies.
- During the wet season site visit, the identified wetlands were delineated based on the approach outlined in the DWS guidelines (DWAF 2005). The infield delineation approach included recording an appropriate number of boundary points (i.e. the edge of the temporary wetness zone) and the extent of the high-water mark. Desktop mapping then consolidated the extent of the wetland systems using the recorded information and detailed contours of the area.
- The vegetation species collected during the wet season site visit were in some instances unidentifiable due to being at the end of the flowering season.
- The wetlands were grouped according to their respective wetland complexes i.e. wetlands sharing the same characteristics were clustered together to form a wetland complex/group. This approach allowed efficient assessment of the numerous wetlands within the study area.
- For the purpose of this report, the operational-mining scenario assumes that all of the wetlands located in study area, other than pans 6, 7, 8, 9, 16, 17 and 19; will be lost in their entirety as part of the mining activities.
- The assessment of the wetland systems was based on the beta-version of the latest wetland integrity assessment technique, which is currently unpublished (Macfarlane et al. 2018). This latest assessment technique will replace the current WET-Health assessment technique (Macfarlane et al. 2007) in the near future. As such, this assessment technique was considered to be the most appropriate at the time of the compilation of the report, however, in some instances it may have shortfalls. These techniques, however, have been compiled based on international best practice to apply to South African conditions. These assessment techniques should therefore, be seen as the most appropriate tools for wetland assessments at this time.
- The assessments of the identified wetland habitat are based on two site visits, *i.e*. a 'snap-shot' in time, due to budgetary and time constraints. As such, changes in the recorded features and/or characteristics within the wetlands and their catchments, which may be subject to the influences of seasonality and/or land use changes, may not be accounted for in the assessments, particularly as the greater area has been

subjected to an extensive drought. It is anticipated that the wetlands and surrounding landscape have not had sufficient time to recover from the drought.

- The assessment of the wetland systems' ecological integrity includes catchment conditions and it should be noted that changes in the wetlands' catchments may have an adverse effect on the systems' integrity.
- WET-EcoServices assists in identifying the importance and sensitivity of specific wetlands but is recognised as having limitations in terms of quantifying specific impacts linked to development or changes within the landscape; and accounting for the size of the wetland and ecosystem services strongly associated with the size of the systems.
- The nature of the study did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified wetland habitat, offset calculations would need to be amended to account for the mitigation of impacts on the identified species.
- It is assumed that the proposed candidate wetlands for the offsetting will not be subjected to any mining activities within their catchments. Should mining take place within these systems catchments, it is anticipated that the contribution of the offset targets would be greatly reduced. Furthermore, should underground mining take place, it is essential that the systems are monitored to ensure the systems are not negatively impacted.
- As the integrity of the identified candidate wetlands is considered to be less than the wetlands that will be lost within the study area, the candidate wetlands are unable to contribute towards the functionality offset target. However, should a security of tenure of between thirty (30) and sixty (60) years in conjunction with creating wetland habitat within the greater study, be adopted, it is anticipated that the authorities may approve of the proposed offset mitigation measures.
- The invertebrate sampling could have been undertaken in more detail but it is anticipated that the derived information would not have necessarily changed the findings other than assist in an improved understanding of the systems.

The project deliverables, including the reported results, comments, recommendations and conclusions, are based on the authors' professional knowledge as well as available information. This study is based on assessment techniques and investigations that are limited by time and budgetary constraints applicable to the type and level of survey undertaken. This study is, however, considered to be the most accurate and up to date assessment of the wetland habitat associated with the study area, and should be used to inform the decision-making processes of the relevant authorities.

3. EXPERTISE OF THE SPECIALISTS

Due to the nature of the study, the project team consisted of multiple team members to ensure that the project objectives could be met. All team members have comprehensive experience in projects involving mapping, delineation, invertebrate analysis and assessment of wetland systems (**Table 3-1**).

Table 3-1 Team members, roles, and experience levels

Practitioner	Roles in the Study	Experience Levels	Qualifications
Craig Cowden	• Project management; • Conducting the dry and wet season sampling; and • Review of the project report.	18 years of experience, with input into various wetland studies, including: • Delineation; • Assessments; • Rehabilitation planning; • Monitoring and evaluation of wetland rehabilitation projects; and • Mitigation & offset requirements.	MSc (Environmental Science) Pr.Sci.Nat – Ecology
Fiona Eggers	• Conducting the dry and wet season sampling; • Desktop processing; • GIS mapping; • Conducting the wetland assessments; and • Compilation of project report.	8 years of experience, with input into various wetland studies: • Delineation, • Assessments, • Rehabilitation planning; • Monitoring and evaluation of wetland rehabilitation projects; • Mitigation & offset studies; and • Wetland creation.	MSc (Botany) Pr.Sci.Nat – Ecology
Dr Vere Ross-Gillespie	• Conducting the dry season sampling; • Invertebrate results analysis; and • Compilation of project report.	5 years of experience, with input into various freshwater ecosystem studies, including: • Biomonitoring; • Rehabilitation studies; • Reserve determinations; • Assessments; and • Monitoring and evaluation of aquatic ecosystems and water quality.	PhD (Zoology - Freshwater) Pr.Sci.Nat - Ecology
Lindelani Hlongwane	• Invertebrate identification/classification	4 years of experience as Technician with infield delineation of freshwater ecosystems and SASS surveys.	SASS 5 Accreditation

4. STUDY AREA

The following section provides an overview of the study site, focusing on the regional context, climate, wetland types and aquatic invertebrates.

4.1 Regional context

South Africa is a semi-arid country, and thus wetlands are important features within the landscape as they provide ecosystem services directly related to water quantity and quality. Approximately 300'000ha of wetlands or 2.4% of South Africa's surface area remain. It is estimated that there has been a loss of between 35% and 60% of wetlands across the major catchments in South Africa and of the remaining systems, 48% are classified as critically endangered making these systems the most threatened ecosystems (Nel and Driver 2012; Macfarlane et al. 2012).

Taking into consideration the above-mentioned degradation of wetland ecosystems, it is important that a "no-nett-loss" of wetland functioning and habitat is maintained within the broader landscape, which may include the formal protection of wetland systems and/or the creation of wetlands within the landscape not being directly influenced by the proposed mining activities.

4.2 Climate

The study site falls within the A42J quaternary catchment, as defined by Midgley et al. (1994). This quaternary catchment forms part of the Matlabas/Mokolo River catchment (Nel et al. 2011). The Mean Annual Precipitation (MAP) is 428.6mm and Potential Evapotranspiration (PET) is 2'444mm (Schulze 2007). This suggests that the wetlands/pans within the catchments would have **High** sensitivity (Macfarlane et al. 2007) to hydrological impacts within the catchment.

4.3 Vegetation types

Under natural conditions the surrounding landscape and study site would have been characterised by particular vegetation types. The historical dominant vegetation type present would have been the Limpopo Sweet Bushveld (SVcb 19) (Mucina and Rutherford 2006), which falls under the Central Bushveld Group 4 (SVcb) bioregion (Nel et al. 2011; Mucina and Rutherford 2006). The vegetation type has been classified as 'least threatened', with 0.6% receiving formal protection. Of the remaining 94.9% only a small percentage is statutorily protected in reserves including D'Nyala Nature Reserve and very little conserved in other reserves.

This vegetation extends from the lower reaches of the Crocodile and Marico Rivers, down to the Limpopo River Valley, towards the Usutu border post and Taaiboschgroet area. This vegetation type also occurs on the Botswanan side of the border. The vegetation commonly occurs between 700-1'000m above sea level. The greatest threats to this vegetation type can be attributed to cultivation (Mucina and Rutherford 2006). It should be noted, that detailed descriptions of the vegetation units and their relationships are described in more detail in the report compiled by Natural Scientific Services in 2011.

4.4 Wetland classification

To allow for the differentiation between wetland systems and the prioritisation of systems either for conservation or management purposes, the wetlands were classified in accordance with the South African National Biodiversity Institute's (SANBI) wetland classification system (2009) (Table 4-1) (Ollis et al. 2013). However, for the purpose of assessing the Hydrogeomorphic (HGM) units, Kotze et al. (2007) was used to classify the wetland systems as HGM units rather than Level 4 of the SANBI system. The HGM unit types defined by Kotze et al. (2007) differ from SANBI (2009), with the river classification being excluded and flat wetlands being grouped with the depression wetlands. The HGM units identified within the study area have been classified as pans (Table 4-1).

Table 4-1 A description of the onsite wetlands based on the SANBI (2009) classification and Kotze et al. 2007.

System (Level 1)	Bioregion (Level 2)	Landscape Unit (Level 3)	HGM Unit (Level 4)	Description of HGM Units (Kotze *et al.*, 2007)
Inland systems	Central Bushveld Group 4 (SVcb) Bioregion	Flat landscape unit	**Depressions (including Pans)**	
			Pans	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (*i.e.* it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.

4.5 Threat status of the wetlands

Globally, temporary water bodies are among some of the most threatened habitats, leading to their often unique and diverse fauna (e.g. branchiopods, arthropods, plants and other biota) being at risk (De Roeck et al 2007). Southern Africa is considered one of the world diversity hotspots for large branchiopod crustaceans. The Mediterranean type climate in the western cape and the drier climate in the northern parts of the country support temporary aquatic systems which dry out completely in summer and which often provide the only available sources of water in the regions. De Roeck et al (2007) states that these systems which are highly threatened and neglected in South Africa (Davies and Day 1998) have also likely been reduced/degraded at an alarming rate over recent decades, owing to anthropogenic impacts. These habitats vary markedly in their physical and chemical conditions (e.g. complete drying in summer, highly variable hydrological and thermal regimes) when compared to adjacent permanent water bodies, leading to the presence of specially adapted fauna and flora which can utilize available resources. The fauna are also free from fish predation in such habitats, as fish require permanent water bodies for survival and reproduction. Such habitats are therefore distinct from permanent ponds, support a diversity of fauna and flora not found elsewhere (including vascular plants, microorganisms, macroinvertebrates – some of which are endemic, rare or endangered), contribute significantly to overall regional diversity whilst being sensitive to anthropogenic impacts and climate change (Williams 1997). Furthermore, these habitats can play an important role in the landscape ecology, by providing migration corridors and isolated habitats for colonization/dispersal thereby contributing to metapopulation and metacommunity processes (De Meester et al. 2005, Zedler and Kercher 2005, Zacharias et al. 2007) in the broader region. Migratory birds utilize such habitats for feeding along with other wildlife which use the habitats for foraging, breeding and wallowing (Waterkeyn 2009).

Despite these systems being recognised as important, as previously discussed, the vast extent and number of systems within the broader landscape and bioregion needs to be considered. The wetland types fall within the Central Bushveld Group 4 (SVcb) bioregion, as described in Section 4.3. Based on the wetlands and vegetation types, and the level of protection these systems receive, the ecosystem threat status can be assessed (Nel et al. 2011). For the identified wetland vegetation group, the ecosystem threat status is considered to be 'Least Threatened', which appears to be linked to the vast extent the vegetation type/bioregion extends over. However, the ecosystem threat status for the wetland vegetation group is considered to be 'Vulnerable'[5], which may be attributed to the limited level of protection the vegetation type receives (Nel et al. 2011).

The resource quality objectives report (Government Gazette No. 42775) has been compiled by DWS (2019) to guide the management and use of freshwater ecosystems within the Mokolo, Mtalabas, Crocodile (west) and Marico catchments, and as such has been reviewed in terms of the study site as it is located within the Mokolo catchment. It should be noted though, that this document is currently still in draft format and is in the process of being finalised. Nonetheless, the Mokolo catchment has been classified as a Class II catchment, which indicates that a moderate level of protection and utilisation of the area must be considered. The Sandloop River, located to the south of the study site, however, which is not hydrologically linked to the site, has been classified as a C category system, and as such should be maintained in this category. With regards to the resource quality objectives for priority wetland clusters and systems, the Government Gazette does not refer to depression/pans systems but rather valley-bottom wetlands and hillslope seepage systems (DWS 2019). Even though, no particular reference has been made to pans, it is considered to be best practice, that there is "no-nett-loss" of wetland habitat (integrity and functioning) within the landscape, which may be addressed through appropriate mitigation activities (refer to Section 7).

4.6 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) is a tool developed to assist in the conservation and sustainable use of South Africa's freshwater ecosystems, including rivers, wetlands and estuaries. Nel et al. (2011) classified the freshwater ecosystems according to their Present Ecological State 'AB', 'C', and 'DEF' or 'Z' (Table 4-2).

[5] It should be noted that formal protection of these systems is likely to be viewed favourably by the relevant authorities.

Table 4-2 Description of NFEPA wetland condition categories
(Nel et al. 2011)

PES equivalent	NFEPA condition	Description	% of total national wetland area*
Natural or Good	AB	Percentage natural land cover ≥ 75%	47
Moderately modified	C	Percentage natural land cover 25-75%	18
Heavily to critically modified	DEF	Riverine wetland associated with a D, E, F or Z ecological category river	2
	Z1	Wetland overlaps with a 1:50 000 'artificial' inland water body from the Department of Land Affairs: Chief Directorate of Surveys and Mapping (2005-2007)	7
	Z2	Majority of the wetland unit is classified as 'artificial' in the wetland locality GIS layer	4
	Z3	Percentage natural land cover ≤ 25%	20

*this percentage excludes unmapped wetlands, including those that have been irreversibly lost

According to the available NFEPA wetlands and rivers coverage, there are no Freshwater Ecosystem Priority Areas (FEPA) within the study area (Figure 4-1). Only the Sandloop River, located to the south of the study area, is considered to be a FEPA system, however, none of the wetlands identified within the study area drain towards the south.

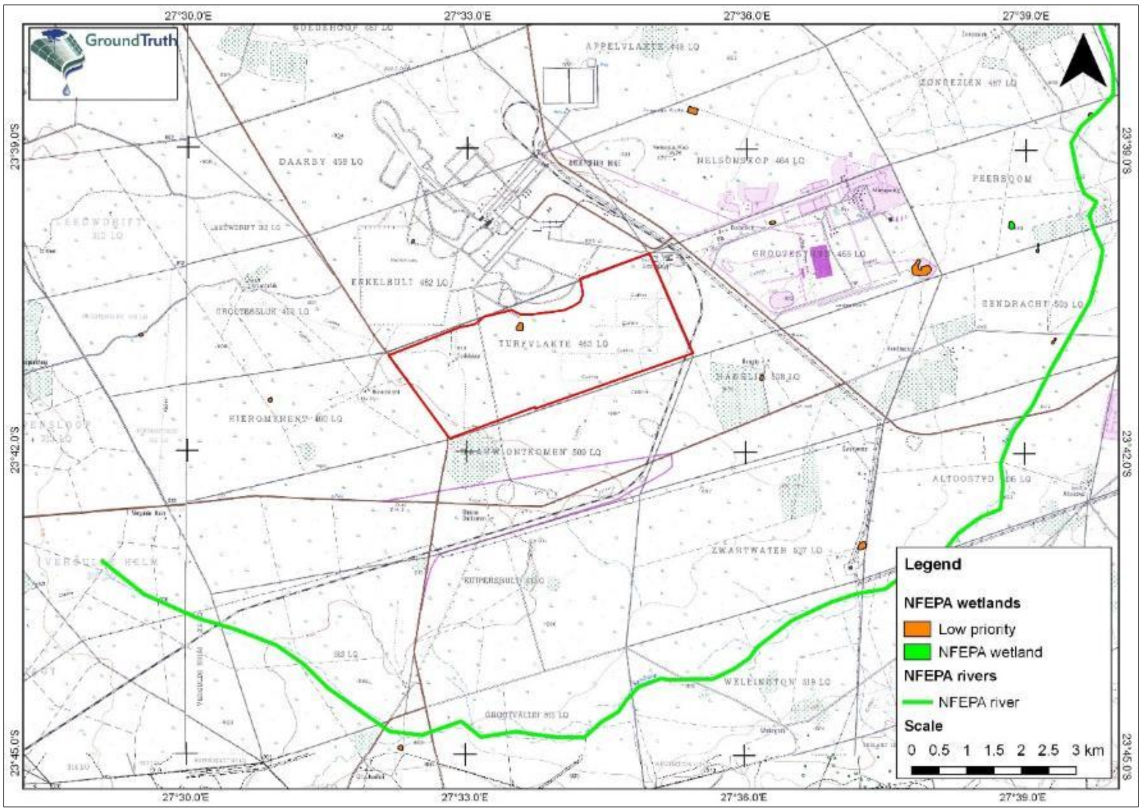


Figure 4-1 Overview of NFEPA systems (Nel et al. 2011) within the greater study area

4.7 Aquatic invertebrates

Southern Africa (bounded by the Cunene in the west and the Zambezi in the east) is predominantly a semi-arid region, with many water bodies (wetlands, vleis, pans and also rivers) being temporary in nature (i.e. they dry out completely out in the dry season and become inundated either once or repeatedly for short periods over the wet season) (Day et al. 1999, Brendonck et al. 2008, Rogers 2009; Tuytens et al 2015). Rain fed clay pans, rock pools as well natural depressional wetlands, roadside ditches and farm dams, as opposed to groundwater fed wetlands and vleis, provide ideal temporary aquatic habitats for large branchiopod crustaceans (e.g. fairy shrimp (*Anostraca*), clam shrimp (*Conchostraca*), tadpole shrimp (*Notostraca*)), macroinvertebrates (e.g. dispersing odonata, hemiptera, coleoptera and diptera) and other microinvertebrate fauna such as water fleas (*Cladocera*) and zooplankton (*Copepoda*) (Brendonck et al 2008, Rogers et al 2009, Tuytens et al 2015, Mabidi et al 2016). The large branchiopods in particular are spectacular examples of temporary wetland specialists being largely absent from permanent aquatic habitats owing to their sensitivity to fish predation (Kerfoot and Lynch 1987 as cited in Tuytens et al 2015). As such, large branchiopods can be used for the identification (Day et al 2010) and assessment of the quality and function of temporary wetlands (De Roeck et al. 2007).

While they are found in temporary aquatic habitats worldwide, most families, excepting some of the *anostraca*, are not restricted to specific latitudinal or zoogeographical zones but are however, most abundant in Mediterranean, arid and semi-arid regions with a distinct wet and dry season (Brendonck and Williams 2000, Brendonck et al 2008). Large branchiopods have unique life histories well adapted for life in disturbance driven habitats such as temporary wetlands, which experience intermittent or seasonal drying and inundation with extreme variation of physicochemical conditions. Some of the remarkable life history traits observed in large branchiopods include: rapid maturation growth and reproduction, drought resistant dormant egg banks (which remain viable for years in the sediments following drying), bet-hedging strategy whereby only a fraction of eggs in the egg bank hatch with the first inundation, dispersal by wind, water and large herbivores (Mabidi et al 2016, Brendonck et al 2017) (See also Appendix 3 for further notes).

Southern Africa is home to sixty-six (66) documented species of large branchiopod (Day et al 1999, Rogers 2013). However, given that these faunas are the still among the least well known in temporary wetland habitats this number is considered a conservative estimate which will likely increase, concurrently with distribution records/ranges, as more studies are conducted in the relatively unexplored Southern African subcontinent.

Regrettably, owing to the reduction in number and quality of temporary wetlands in South Africa and globally as a result of anthropogenic impacts, these obligatory residents are expected to be among the most threatened organisms (De Roecke et al 2007, Mabidi et al 2016). Water quality impacts in the form of diffuse or point source pollution from spills, poorly treated wastewater, chemicals as well as habitat impacts in the form of sedimentation, excavation, and draining and or total destruction form the major risks to these organisms (Mabidi et al 2016). It is for this reason that several large branchiopod species have become endangered and subsequently added to the Red Data list by the International Union for Conservation of Nature (IUCN).

For the reasons documented above, it is imperative that temporary wetlands are correctly identified (in both the wet and dry seasons) and their associated flora and fauna adequately assessed to prevent complete destruction of habitat and loss of species. To this end, a study funded by the Water Research Commission (WRC) was undertaken in 2010, which focused on the assessment of temporary wetlands during dry conditions (Day et al 2010). This document and methods described therein formed the basis of the study presented here of the temporary wetlands[6] in the study area.

[6] 'Temporary wetlands' refers to wetlands where water is not permanently present (Day et al. 2010)

5. METHODS

This section of the report provides an overview of the methodology adopted to delineate and assess the identified freshwater ecosystems associated with the study area.

5.1 Dry season sampling

5.1.1 Desktop analysis

At the outset, a desktop analysis was undertaken to identify wetland systems within the study area for delineation during the dry season fieldwork. The desktop review was undertaken in Quantum Geographic Information System (QGIS) at a fine scale of less than 1:2'000. The review mainly included the review of the data received by the client including *inter alia*, LIDAR data, aerial imagery and derived contour data. The objective of the review was to identify patterns in the landscape by:

- Distinguishing between the colour of the soils associated with terrestrial areas and possible wetland areas;
- Reviewing contours for possible indications of closed contours; and
- Distinguishing between vegetation communities, *i.e.* terrestrial versus possible wetland vegetation.

Based on the detailed review of the imagery, the identified potential wetland areas were prioritized according to the likelihood of them being wetlands. Those systems more likely to be wetlands were given a higher priority to visit during the dry season site visit in comparison to those that were considered to be more marginal systems.

5.1.2 Dry season site visit

A site visit was conducted from the 2nd – 6th October 2017 to verify all of the identified potential wetland areas. Due to the nature of the study site at the time of the site visit being particularly dry and the soils desiccated, the systems were unable to be delineated based on the soil criteria included in the DWS guideline document (DWAF 2005). Consequently, the preliminary classification of the systems was based on a review of other site characteristics, e.g. topography. The locations of the verified areas were recorded using a sub-meter accurate Global Positioning System (GPS)[7] to document the site observations.

5.1.2.1 **Collection of soil samples and visual assessment of wetlands in the dry phase**

During the dry season site visit, a total of five (5) soil samples were collected (Figure 5-1), which were identified at the desktop level as potential wetland sites. At each location the deepest point of the depression was identified and visually investigated for signs of the presence of obligate temporary wetland invertebrates. Such signs commonly included the crusts formed from the shells of Conchostraca and Copepoda, which are left behind when they die (Figure 5-2). Depressions where crusts were observed were noted.

[7] Mobile Mapper 10 handheld unit, a professional sub-meter accurate receiver

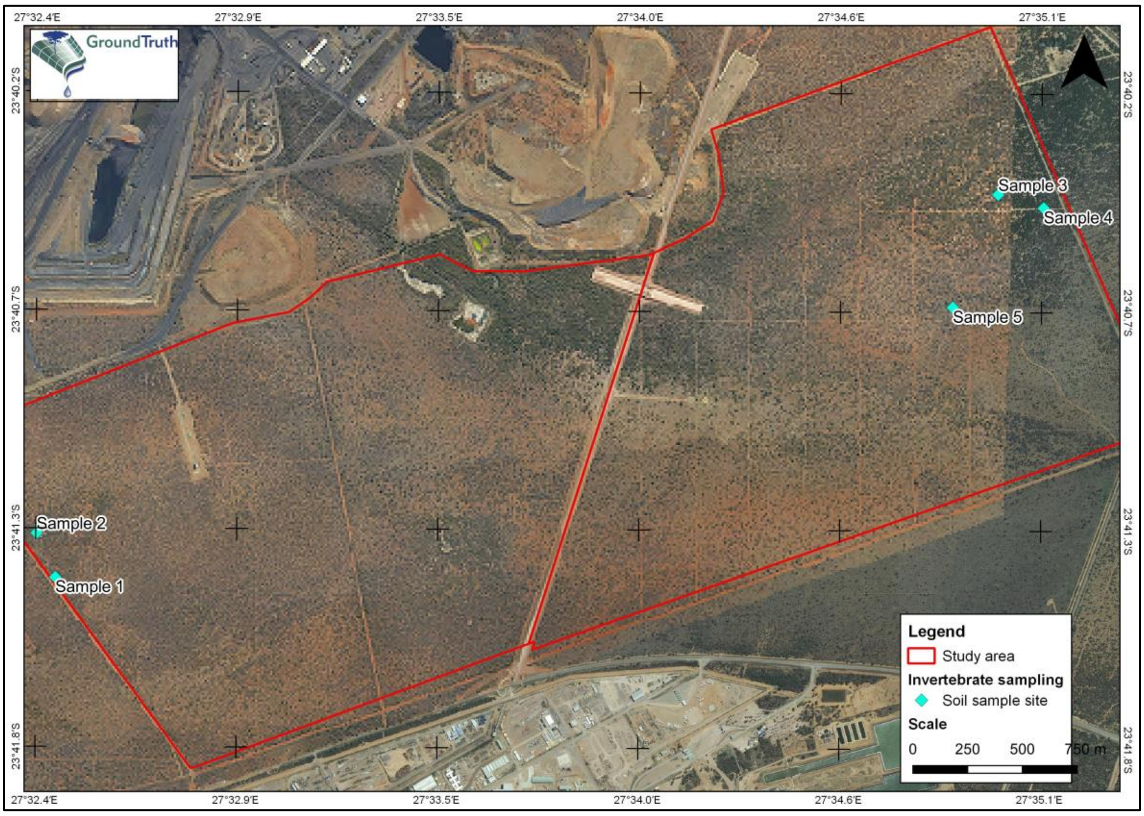


Figure 5-1 Localities of soil samples that were collected from suspected temporary wetlands at Grootegeluk for incubation and invertebrate hatching experiments

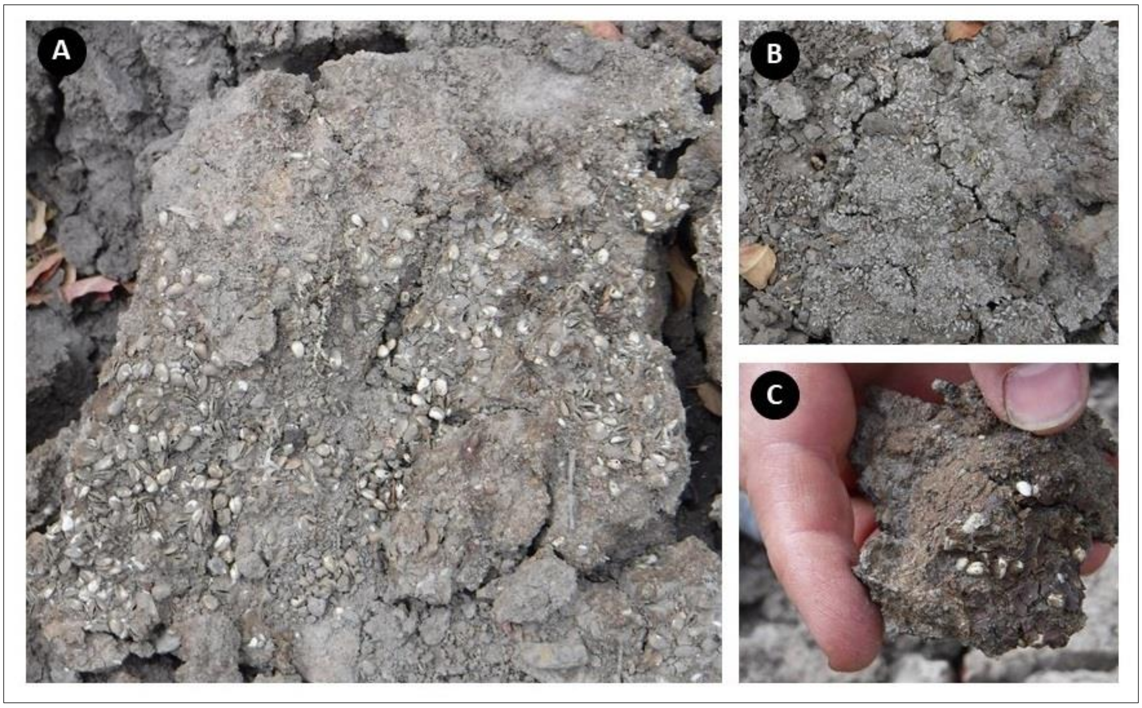


Figure 5-2 Crusts (A) comprising the shells of Copepoda (B) and Conchostraca (C) – both obligate temporary wetland invertebrates - observed on the uppermost sediments of wetlands/pans at Grootegeluk.

Following the visual recording of crusts, photographic records and GPS extents, sediment samples were collected from the deepest part of the wetlands/pans. With some minor exceptions, the field sampling protocols as described in Day et al. (2010) for the assessment of temporary wetlands during dry conditions were followed.

At the deepest point in each depression, surface crusts were hand collected and placed in a labelled sealable plastic bag. Where softer soils prevailed, dry soil samples were collected using a standard bucket auger (head diameter of 90mm) from approximately five points randomly spaced within a 20m radius from the estimated deepest part of the wetland/pan (Figure 5-3). Only the top 5-10cm of soil in each of the five auger samples was collected, homogenised and placed together with the surface crusts (if present) into the same sealable plastic bag. Where the use of the auger was prohibited, owing to the hardness of the soil layers, a standard garden pick-axe was used to loosen clumps within the top 10-15cm for collection. In all cases soil characteristics including mottling, and chroma were observed.

Figure 5-3 Collection of surface crusts and soils from the deepest parts of a temporary wetland at Grootegeluk during the dry season. Hard soils in places necessitated the need for a pick-axe to be used to collect soils instead of an auger.

Sealable plastic bags were sealed and transported to the laboratory where they were left open for 2 weeks prior to the start of the incubation experiments period. This was done in order to ensure that sediment would be dry at the commencement of the experiments.

5.1.2.2 **Invertebrate incubation**

Soil samples collected in the field at each individual site were homogenised (but not pooled) and lightly crushed to break up large clumps. Thereafter, sub-samples of approximately 50g were placed in small plastic containers (140 x 200 x 60 mm) where a single replicate was prepared for each site. Tubs were filled with distilled water to a height of 45mm which equated to a depth of approximately 25mm. Inundated tubs were incubated at approximately 20-25°C through the use of a heater fan connected to a Digital STC-1000 thermostat in a controlled environment room equipped with a full spectrum fluorescent light. Lights operated on a permanent basis.

A conservative incubation period amounting to a total of 41 days was applied during which time all tubs were inspected daily for signs of hatchlings/nauplii and water levels were topped up (maintained at 25mm depth).

Frequent photographs were taken to record changes in water quality and visual characteristics (Figure 5-4), while a Yellow Springs International 556 (YSI) handheld probe was used to record water quality parameters (pH, electrical conductivity, dissolved oxygen and Oxidation Reduction Potential, Total Dissolved Solids).

Figure 5-4 Incubation trials setup showing inundated sediment samples in a controlled environment room.

5.1.2.3 Identification of invertebrates

Upon hatching, invertebrates were counted (as nauplii initially – minute 6-limbed larvae indistinguishable from each other) and where possible identified – though normally identification to Class or Order (Cladocera, Copepoda, Ostracoda, Anostraca, Conchostraca) was only possible after 5-10 days when taxonomic characteristics begin to appear.

Naked eye identifications were carried out daily and the number of organisms representing each taxonomic group recorded. Voucher specimens were collected from each tub upon termination of the experiment and sent to Albany Museum for further identification.

5.1.2.4 Water chemistry

Water quality parameters of inundated soil samples were measured with an YSI instrument in the laboratory, once at the beginning of the experiment (one day after inundation) and again at the end of the experiment just prior to termination. These measures were taken to detect any parameters of potential concern that may be attributed to soils. Mean values for water quality parameters recorded with the YSI, were calculated from three replicate measurements taken in each tub. Following inundation.

In addition to water quality, two Hobo TidbiT v2 temperature loggers were used to record the following:

- Ambient air temperature in the controlled environment room; and
- Water temperature in the inundated tubs every 30 minutes for the duration of the experiment.

5.2 Wet season sampling

5.2.1 Desktop analysis

The data collected during the dry season site visit, was reviewed based on the observations made during the site visit and the recorded data. The aerial imagery was reviewed to confirm any anomalies, thus refining the 'points of interest' layer.

5.2.1.1 HECRAS modelling

Hydrologic Engineering Centre's River Analysis Systems (HECRAS) modelling was undertaken for the study area based on the LIDAR data received from Exxaro. The modelling included a detailed analysis of the topography, including:

- Catchment size;
- Dendritic drainage patterns;
- Flow accumulation areas; and
- Wetland size and characteristics (depth of inundation).

5.2.1.2 Refinement of points of interest

Following on from the HECRAS modelling, the results of the model in conjunction with the points of interest were further interrogated. This allowed for additional areas to be included/excluded based on the model, dry season findings and a better understanding of the landscape following on from the dry season site visit. Key aspects considered during the interrogation of the aerial imagery and HECRAS model results, included:

- A derived dendritic drainage network;
- Collection points of water/wetland areas;
- Soil colouration between terrestrial and wetland areas;
- Contours; and
- Vegetation signatures (where applicable).

The refined GIS layer was used to inform the wet season site visit.

5.2.2 Wet season site visit

The wet season site visit was undertaken from the 28th February to the 8th March 2018 to delineate and assess the current level of ecological integrity and ecosystem services provided by the wetlands within the study area. The site visit was undertaken shortly after a significant summer rainfall event, which was considered to be high in comparison to the previous years.

5.2.2.1 **Wetland habitat identification and mapping**

The preliminary identification and mapping of all freshwater ecosystems within the study area was undertaken at a desktop level (refer to above). The wetland systems that will be primarily impacted upon by the proposed mining activities were delineated infield in accordance with the DWS guideline document. Due to the size of the study area and the nature of the systems, the number of sample points collected infield varied per system. However, the water level observed at each system was mapped. Both the sample points and water levels were recorded using a mapping grade Global Positioning System (GPS)[8]. The subsequent information was used to inform the production of a Geographic Information System (GIS) spatial coverage of the boundaries of the wetland systems. In accordance with the preferences of DWS, the study also attempted to identify and/or describe the zones of wetness within the systems (**Figure 5-5**).

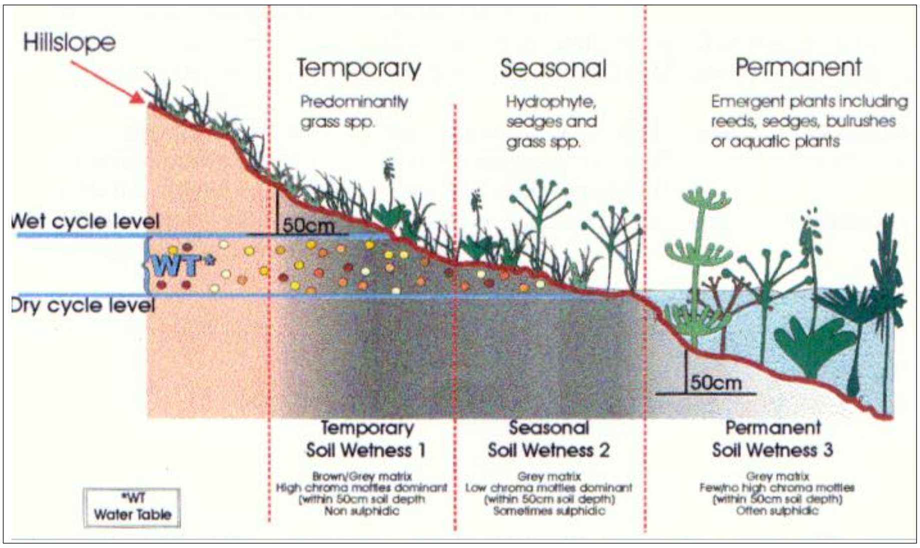


Figure 5-5 Wetness zones within wetland ecosystems
(DWAF 2005, p.6)

In accordance with best practice, representative sample plots were included (Figure 5-6 and Appendix 1) to record indicators that were used to distinguish between dryland and wetland conditions, such as:

- Vegetation Indicators;
- Soil Wetness Indicators (including descriptions of matrix and mottle colours based on a Munsell Soil Colour Chart (Year 2000 Edition); and
- Hydrological Indicators.

[8] Mobile Mapper 50 handheld unit, a professional sub-meter accurate receiver

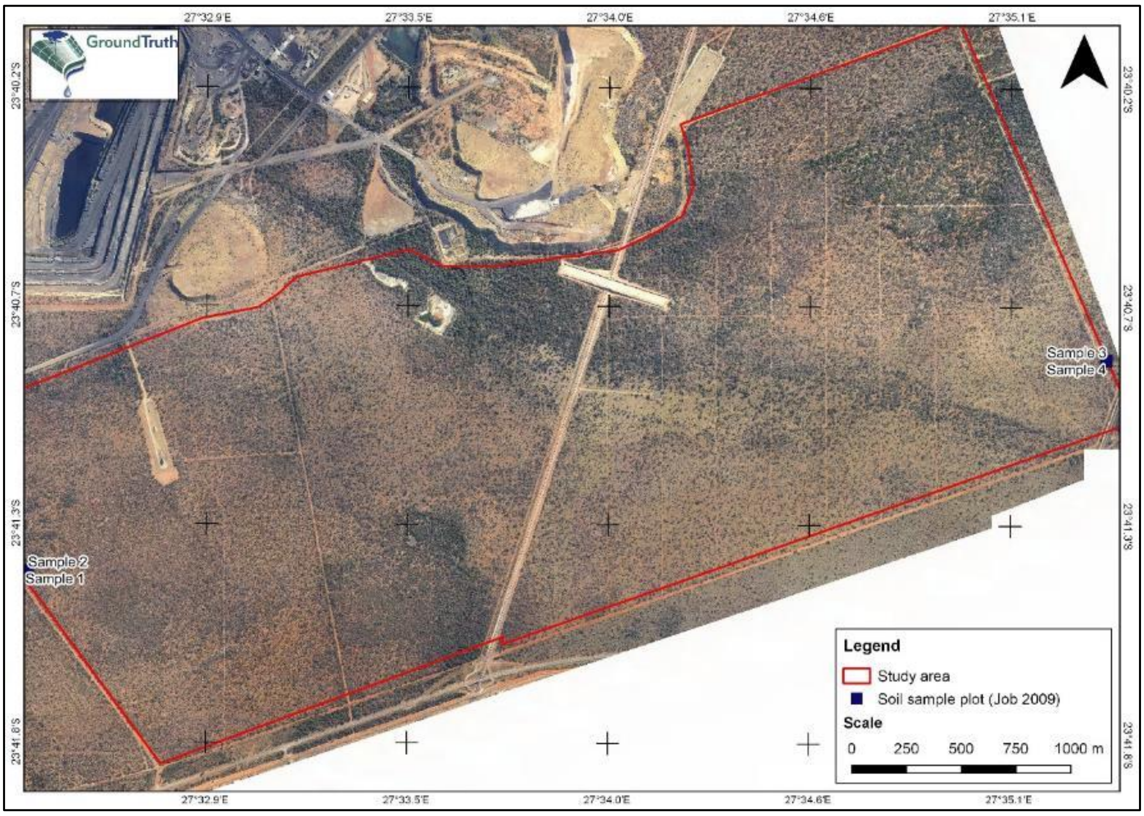


Figure 5-6 Overview of the location of the soil sample plots

5.2.2.2 **Wet Season Invertebrate sampling**

Aquatic invertebrates were collected from four (4) sites (Figure 5-1) during the wet season sampling event, with Sample Site 4 excluded from the wet season sampling, as there was no open water from which to sample during the site visit and as such no invertebrate species. Semi-qualitative sampling was undertaken using a standard SASS square frame net (250µm – catch surface 900cm^2). The water column, surrounding vegetation and the substrate were sampled using a combination of kick sampling and sweeping as well as visual observations for a period of 5-10 minutes, depending on the size of the sampled system. Collected invertebrates were preserved in 90% ethanol and identified in the laboratory to family level after which they were sent to Albany Museum for further identification.

5.2.2.3 **Water chemistry**

During the wet season sampling, four (4) wetlands as identified in Figure 5-1 were measured *in situ* for a suite of water quality parameters including: potential hydrogen (pH), temperature (Temp), electrical conductivity (EC), dissolved oxygen (DO), total suspended solids (TSS), oxidation-reduction potential (ORP) using the YSI 556 MPS Handheld probe and turbidity using a HANNA Instrument Turbidimeter (HI 98703). These *in situ* field-based measurements were then compared to laboratory measurements taken during the incubation experiments.

While once-off field and lab-based water quality data do not provide information on seasonal variation emanating from dilution, evapo-concentration as well as biological processes (e.g.

photosynthesis, respiration), such data are, however, useful for comparing wet season conditions with those in the laboratory experiments (Day et al. 2010).

5.3 Assessment of wetland functioning and condition

The assessments of the HGM units were derived by evaluating the level of ecosystem functioning and ecological integrity/condition of the identified wetlands for the **current** and **operational-mining scenarios** as outlined in the following sections. It should be noted that the operational-mining scenario only accounts for the loss of wetland habitat associated with the mining activities over the next 30 years; and does not take any form of wetland mitigation activities into account. In addition, it assumes that the loss of wetland habitat within the identified portions of the site will happen simultaneously even though the loss of habitat will follow the phasing of the proposed mining plan.

Due to the large number of wetlands within the study area, the wetlands were assessed in wetland clusters (referred to as Group 1 - 6). The clustering of the wetlands into groups was based on the following criteria:

- Wetlands type, i.e. natural versus artificial[9];
- Catchment impacts e.g. mining;
- Location in relation to the coal conveyor i.e. east or west thereof;
- Size of the wetland:
    - Less than 0.1ha; and
    - Between 0.1 and 0.5ha.

Based on these clusters the wetlands were assessed in terms of functioning and integrity.

5.3.1 Assessment of wetland functioning

To quantify the level of functioning of the wetland systems, and to highlight its relative importance in providing ecosystem benefits and services at a landscape level, a WET-EcoServices (Kotze et al. 2007) assessment was performed for the current and operational-mining scenarios. The WET-EcoServices assessment technique (Kotze et al. 2007) focuses on assessing the extent to which a benefit is being supplied by the wetland habitat, based on both:

- The opportunity for the wetland to provide the benefits; and
- The effectiveness of the particular wetland in providing the benefit.

Ecosystem services, which include direct and indirect benefits to society and the surrounding landscape, were assessed by rating various characteristics of the wetland clusters and the surrounding catchment, based on the following scale:

- Low (0);
- Moderately Low (1);
- Intermediate (2);
- Moderately High (3); and

[9] It should be noted, that none of the artificial wetlands were able to be assessed due to the fact that the origin of these systems is unnatural, i.e. created by humans and a benchmark condition does not exist.

- High (4).

The scores obtained from these ratings for the wetland clusters were then incorporated into WET-EcoServices scores for each of the fifteen ecosystem services (Table 5-1).

Table 5-1 Ecosystem services supplied by wetlands
(Kotze et al. 2007, p14)

Ecosystem services supplied by wetlands	**Indirect benefits**	**Regulating and supporting benefits**	Flood attenuation		The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream.
			Stream flow regulation		Sustaining stream flow during low flow periods.
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters.
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters.
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters.
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters.
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
			Carbon storage		The trapping of carbon by the wetland, principally as soil organic matter.
	Direct benefits	**Biodiversity maintenance**			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity.
		Provisioning benefits	Provision of water for human use		The provision of water extracted directly from the wetland for domestic, agricultural or other purposes.
			Provision of harvestable resources		The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
			Provision of cultivated foods		The provision of areas in the wetland favourable for the cultivation of foods.
		Cultural benefits	Cultural heritage		Places of special cultural significance in the wetland, e.g. for baptism or gathering of culturally significant plants.
			Tourism and recreation		Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife.
			Education and research		Sites of value in the wetland for education or research.

It should be noted that Wet-EcoServices assists in identifying the importance and sensitivity of specific wetlands, but is recognised as having limitations in terms of:

- Quantifying specific impacts linked to development or changes within the landscape; and
- Accounting for the size of the wetland and ecosystem services strongly associated with the size of the systems.

As WET-EcoServices does not provide a consolidated score that can be used as a target, the current and operational-mining assessment scores were incorporated into the Wetland Importance and Sensitivity assessment datasheets to provide an EIS score based on scores for ecological importance and sensitivity, hydro-functional importance, and direct human benefits (Rountree and Malan 2010). Table 5-2 provides an overview of the ratings used to record EIS scores.

Table 5-2 Ratings for describing the EIS of wetlands
(Rountree and Malan 2010)

Rating	Explanation
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

5.3.2 Assessment of wetland condition/integrity

For the purpose of the proposed mining activities, and determining the potential loss in hectare equivalents, the wetland complexes identified were assessed using the WET-Health (beta version of Macfarlane et al. 2007, namely Macfarlane et al. 2018) assessment technique for the current and operational-mining scenarios. To determine the level of ecological integrity, a Level 2 WET-Health (Macfarlane et al. 2018) assessment was performed for various wetland clusters across the study area. The WET-Health assessment technique gives an indication of the deviation of the system from the wetland's natural reference condition for the following biophysical drivers:

- Hydrology - defined as the distribution and movement of water through a wetland and its soils;
- Geomorphology - defined as the distribution and retention patterns of sediment within the wetland;
- Water quality –the quality of the water based on external water inputs; and
- Vegetation - defined as the vegetation structural and compositional state.

The impacts on the wetlands, determined by features of the wetlands' and their catchments were scored based on the impact scores and then represented as Present State Categories as outlined in WET-Health (Table 5-3). The identified systems were assessed for the current scenario and operational-mining scenarios. The assessment of the various scenarios would highlight the following:

- Current scenario: current state of the system based on both the in-system and catchment impacts; and
- Operational-mining scenario (30-year mining activities): assumes that all of the wetland systems other than 6, 7, 8, 9, 16, 17, and 19, will be impacted upon/lost as a result of the proposed mining activities.

Table 5-3 Impact scores and present ecological state categories for describing the integrity of wetlands[10] (MacFarlane et al. 2007, p30)

Impact Category	Description	Impact Score Range (0-10)	Present Ecological State Category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

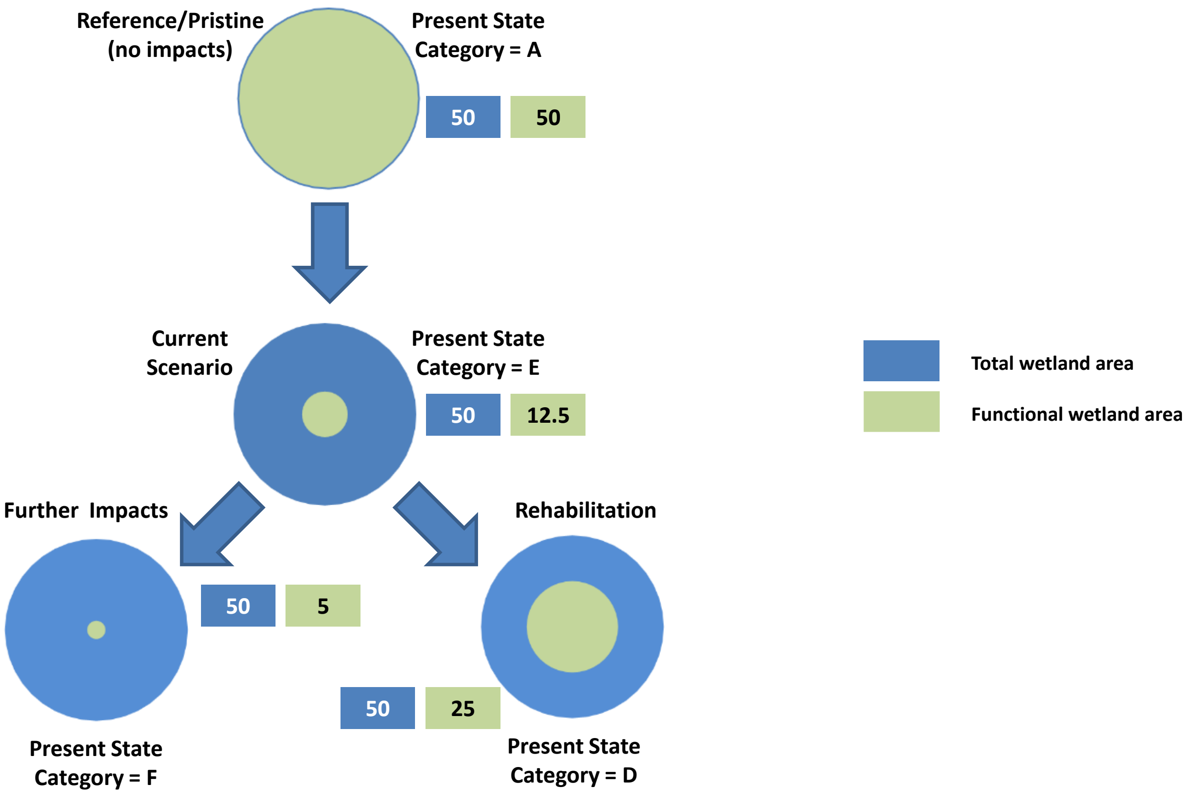
The scores for hydrology, geomorphology, water quality and vegetation were simplified into a composite impact score, using the predetermined ratio of 3:2:2:2[11] (Macfarlane et al. 2018) respectively for the three components. The composite impact score was used to derive a health score that then provided the basis for the calculation of hectare equivalents (also referred to as functional area), which can be described as the health of a wetland expressed as an area. Cowden and Kotze (2009) make use of a simple example to explain the concept of hectare equivalents conceptually illustrated in Box 5.1.

[10] It is assumed that there is no change in classes between the 2007 and 2018 integrity assessment techniques.
[11] It should be noted that if the weighting for the hydrological component is an E/F category then the hydrological weighting is doubled

Box 5.1 Example of the use of hectare equivalents to represent changes in wetland health.

The assessment of wetland health is based on comparisons to a reference state *i.e.* where the wetland's health is unmodified and the functional area of wetland is equivalent to the full extent of the system. For example, if the health of a 50ha wetland is 100% (*Present State Category=A*) this equates to 50 hectare equivalents. In many instances the current scenario for a particular system reflects some form of historical degradation. If the abovementioned wetland was *seriously* degraded, the health would be reduced from the reference state to 25% (*reflecting a wetland health score of 2.5*); a drop in hectare equivalents from 50 to 12.5 (50ha x 0.25) hectare equivalents would be recorded. The following would therefore be expected if the wetland in the above scenario was subject to the following two future options:

a) Further degradation of the wetland linked to development, with the system's health being further reduced to 10% would result in a drop in hectare equivalents to 5 hectare equivalents; and
b) Rehabilitation of the wetland habitat, with the system's health being increased to 50% would result in a gain in hectare equivalents to 25 hectare equivalents.



NOTE:
The sizes of the circles are directly related to the extent of wetland habitat and functional wetland area in the landscape

5.3.3 Freshwater ecosystem risk assessment

The risk assessment matrix (DWS 2015) assesses the likely impact the proposed expansion of the Grootegeluk mining complex may have on the freshwater ecosystems hydrologically linked to the LOM footprint. A broad outline of the criteria considered are as follows:

- Nature of the impact;
- Scale/extent of the impact;
- Duration of the impact;
- Intensity/severity of the impact; and
- Probability/likelihood of the impact occurring.

Identified impacts were evaluated according to the above-mentioned criteria. The significance of impacts was derived through a synthesis of ratings of all criteria in the following calculation:

(Severity + Spatial Extent + Duration) x Probability/Likelihood = Significance

The significance of a potential impact on decision-making was indicated through significance scores, which are described in Table 5-4.

Table 5-4 List of descriptors for the significance score of an impact.
(DWS 2015)

RATING	CLASS	MANAGEMENT DESCRIPTION	AUTHORISATION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands are excluded.	**GA**
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and requires specialist input. Wetlands may be excluded.	**WUL**
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.	**WUL**

5.4 SANBI offset calculator

The SANBI Offset Guidelines (Macfarlane et al. 2014) have been developed in conjunction with other policies and guidelines, including the national biodiversity framework and provincial biodiversity offset policies and guidelines. The SANBI guidelines serve to assess possible wetland losses due to a proposed development and to determine wetland offset targets, to ensure that wetlands receive appropriate protection and that sufficient functional area is retained within the broader landscape. The SANBI offset calculator has built on the principles of the hectare equivalents approach and incorporated additional information to inform the calculation of offset requirements for three different categories, including Water Resources and Ecosystem Services, Ecosystem Conservation and Species of Conservation Concern. These themes are all evaluated within their specific context ensuring the full range of residual impacts are addressed through each of the targets (Figure 5-7).

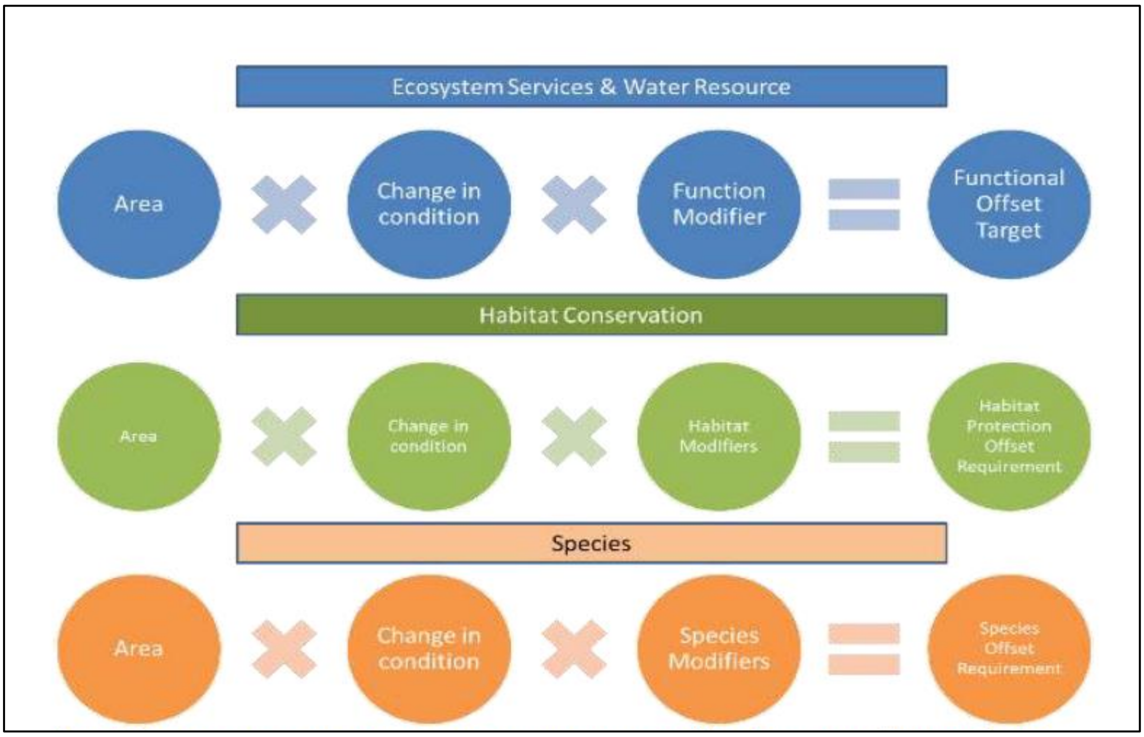


Figure 5-7 Outline of the approach used to identify the required offset for water resources and ecosystem services, habitat conservation and species of conservation concern
(Macfarlane et al. 2014, p27)

6. RESULTS

The results of the studies and investigations undertaken to inform the wetland assessments and the assessment of the potential impacts associated with the proposed mining activities, are outlined in the following sections.

6.1 Characteristics of the freshwater ecosystems

Across the study area twenty-two (22) freshwater ecosystems were identified covering an area of approximately 3.77ha (Figure 6-1). Of the twenty-two systems, three (3) were classified as artificial systems and comprised of one (1) watering hole, one (1) borrow pit and Voëltjie dam, with the latter being licenced (21b). These artificial systems cover an area of approximately 2.13ha, whilst the remaining 1.64ha are considered to be natural wetland systems. The following sections provide a description of the various freshwater ecosystems identified during the dry and wet season site visits.

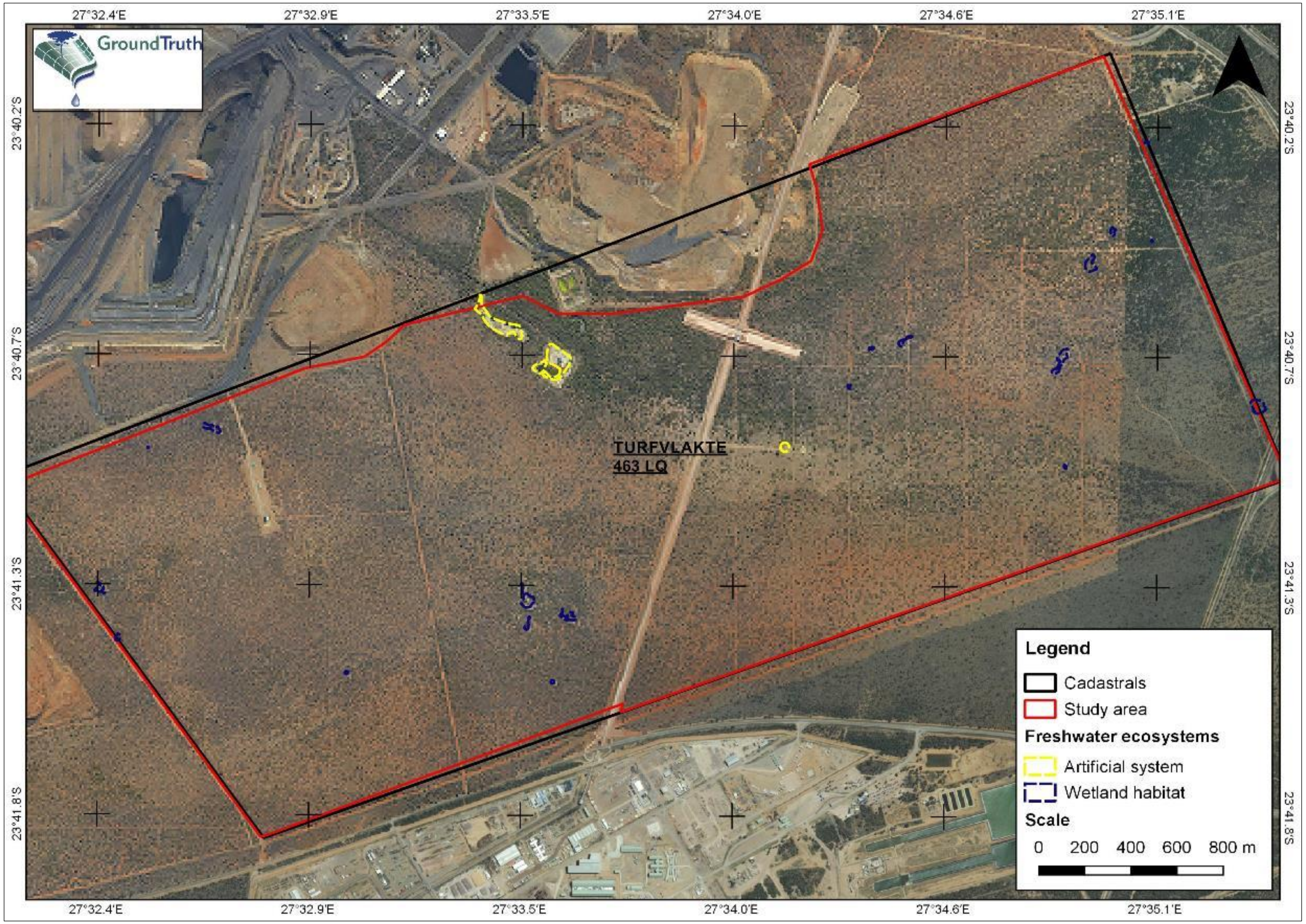


Figure 6-1 Overview of the freshwater ecosystems identified within the study area

6.1.1 Artificial systems

During the dry and wet season site visits, three (3) artificial wetland systems were identified. These systems were considered to be fundamentally different to the natural systems with some of the characteristics including the following:

- Evidence that the systems had been excavated;
- Evidence of either current water inputs into the systems via a pipe or canal;
- Retention of water throughout the year, whilst the natural systems were dry;
- Water clarity within these systems was often clear in comparison to the natural systems that had increased turbidity.

6.1.1.1 **Watering holes**

The watering hole is located to the east of the coal conveyor and is currently still being actively maintained as a source of water for the wildlife within that portion of the reserve (Figure 6-2). The system covers an area of approximately 0.12ha. This watering hole, other than the one located at the Lodge is the only source of water for the wildlife during the dry seasons, as the natural systems are considered to be seasonal in nature.

Figure 6-2 View of the watering hole during the dry season site visit (left) and the wet season site visit (right)

6.1.1.2 **Borrow pit and Dam**

The borrow pit and Voëltjie dam are located to the west of the coal conveyor and cover an area of approximately 2.01ha. As with the watering hole, the Voëltjie dam is also artificially maintained through additional water inputs (Figure 6-3), whilst the calcrete borrow pit only receives through rainwater inputs. Voëltjie dam is maintained by Mokolo water being pumped to the facility. The turbidity within the dams was recorded as zero. Voëltjie dam is currently licensed as a clean water facility and serves as a potable source of water for the wildlife within the game reserve as per to the Grootegeluk water license.

Figure 6-3 View of the dams during the dry season site visit (top left), the wet season site visit (top right),

6.1.2 Wetland habitat

The remaining nineteen (19) wetlands within the study area are considered to be wetland habitat, i.e. not artificially created and/or sustained. These systems cover an area of approximately 1.64ha, and range in size from 0.003ha to 0.275ha. However, the majority of the systems are less than 0.1ha in extent.

Formation of non-perennial pans

The functioning of wetland systems is often considered from a hydrological and biotic perspective, whilst the geomorphic and climatic setting in which these systems are located is often just briefly considered in comparison. With regards to the formation of endorheic[12] depressions/pans, there are currently three suites of controls that contribute towards the formation of such systems, either individually or in combination with one another (Thomas 2011). However, in terms of the non-perennial pans identified within the study area, the process of 'erosional control' is considered to be applicable, particularly since these systems are located within a semi-arid region. According to Goudie and Thomas (2011)[13], erosional controls refers to a process known as deflation. Deflation occurs in areas with a low MAP (≤500mm) and overgrazing around localised depressions within the landscape. Erosional controls are greatly influenced by climatic conditions, i.e. rainfall amounts and seasonality, temperature; and biotic factors including the presence and/or absence of herbivores, and the composition and structure of the vegetation within and surrounding the localised depressions. Furthermore, the underlying geology and local topography of the areas further contributes towards the formation of these systems. The underlying geology needs to be susceptible to weathering/erosion to allow for the formation of pans. The local topography is also considered to be important, in that the nature of the landscape will dictate whether there is transport of sediment into or out of the depression, i.e. the steeper the landscape the greater the opportunity for the mobilisation of sediment into the system. The combination of all of the factors results in the deflation of the depressions, i.e. a negative sediment budget, and as such the formation of a depression/pan wetland.

[12] Endorheic referring to a "Basin or region from which there is little or no outflow of water (either on the surface as rivers, or underground by flow or diffusion through rock or permeable material (Macfarlane et al. 2007, p.169)".
[13] Information sourced from Ellery (2018) MSc thesis

<u>*Catchment impacts*</u>
The wetlands are located within the Manketti game reserve and as such the impacts on the systems are considered to be limited, as the catchments are considered to be near-natural, with a handful of impacts such as the encroachment of *Dichrostachys cinerea* (site visit observation), and some alien invasive vegetation including *inter alia Agave americana* (American Agave), *Bidens pilosa* (Black jack), *Cereus jamacaru* (Queen of the night), *Flaveria bidentis* (Smelters bush), *Opuntia ficus-indica* (Prickly pear), *Pennisetum setaceum* (Fountain grass), *Solanum nigrum* (Nightshade) etc. (Natural Scientific Services 2011).

<u>*Hydrology of the wetlands*</u>
A review of the national lithology coverage highlights that the greater study area is underlain by shale, which is considered to be susceptible to weathering/erosion (Council for Geoscience n.d.). The national soil layer for the greater study area highlights that the predominant soil form in the area is dominated by the Hutton Form (Hu) (Land Type Survey Staff 1972-2006). Based on a study undertaken by Golder in 2017, the predominant soil type found within the proposed LOM footprint area is considered to be the Glenrosa Form (Gs). Both these soil forms are considered to be poorly structured soils. The Hutton Forms, as described in Red Earth cc (2004), are soils that are considered to be very permeable, whilst the Glenrosa Forms are considered to be permeable (Red Earth cc 2004). Based on Natural Scientific Services (2011), the predominant soils within the broader landscape are considered to be Kalahari sands. These soils in many instances have calcrete and surface limestone layers or are loamy clay soils in low-lying areas. The high lying areas are often shallow, gravel sandy soils (Natural Scientific Services 2011). Based on Kotze et al. (2018), the soil forms upslope of the local system's catchment can provide an indication of how water is delivered to a wetland system. Catchments characterised by soils containing E horizons e.g. Longlands, the source of water to a wetland would most likely be via lateral inputs, i.e. interflow via the E horizon (Kotze et al. 2018). However, catchments dominated by Hutton forms, which are well-drained soils, are generally characterised by the vertical movement of water and as such it is unlikely that lateral flows, i.e. interflow inputs, are a main driving factor of the wetland systems (Kotze et al. 2018). Thus, is can be broadly assumed that system's catchments that are dominated by Longlands would most likely be more sensitive to impacts within the shallow soil horizons, whilst those dominated by Hutton soils would most likely be sensitive to impacts in the deeper soil horizons (Kotze et al. 2018).

It is evident from the review of available soil information that the broader landscape lacks soils characterised by the lateral movement of water (i.e. E horizons), suggesting that the accumulation and retention of water within these depressions is strongly linked to surface runoff and the presence of an impermeable layer of clay or bedrock within the depressions, which allows for the retention of water within the landscape. Based on the observations during the dry and wet season site visits, the formation of the pans within the study area very closely mimics the aforementioned 'erosional control' process (refer to the above section '<u>*Formation of non-perennial pans*</u>'). As such, these systems are not considered to be groundwater-driven systems but rather surface water driven, i.e. fed through rainfall events. Without the impermeable layer, the infiltration rate of surface water to groundwater would be too rapid for the formation of hydromorphic soils, especially in semi-arid areas. The loss of water in these systems is predominantly associated with evaporative losses (refer to Section 4.2 for the ratio of MAP versus PET within the quaternary catchments).

Based on the dry and wet season site visits, it was evident that all of the wetlands within the study area are rainfall dependent, i.e. the systems only contained water following rainfall events. During the dry season site visit all of the wetlands, regardless of their extent, were desiccated with large cracks evident in the soil surface (Figure 6-4). However, during the wet season site visit, all of the identified wetlands contained some degree of water and/or had just recently dried up (Figure 6-5). The evaporative loss associated with the smaller wetlands was greater than the larger ones, particularly in the instances where tree canopy cover offered little protection, i.e. the wetlands under denser tree canopies retained the water for longer periods.

Figure 6-4 Examples of the desiccated soils of two of the wetlands during the dry season site visit

Figure 6-5 Examples of the some of the wetlands visited during the wet season site visit and the variable amount of water within the systems

Dendritic drainage networks

Although the wetness regime of the wetland systems is rainfall dependent, many of the wetlands within the study area are connected via a dendritic drainage network (Figure 6-6). This is particularly true for the larger wetland systems with the study area. Nonetheless, the systems are considered to be pans/depressions rather than any other hydrogeomorphic unit type. These networks are generally not visible on the aerial imagery nor infield but rather were only identified as a result of the HECRAS modelling of elevation data.

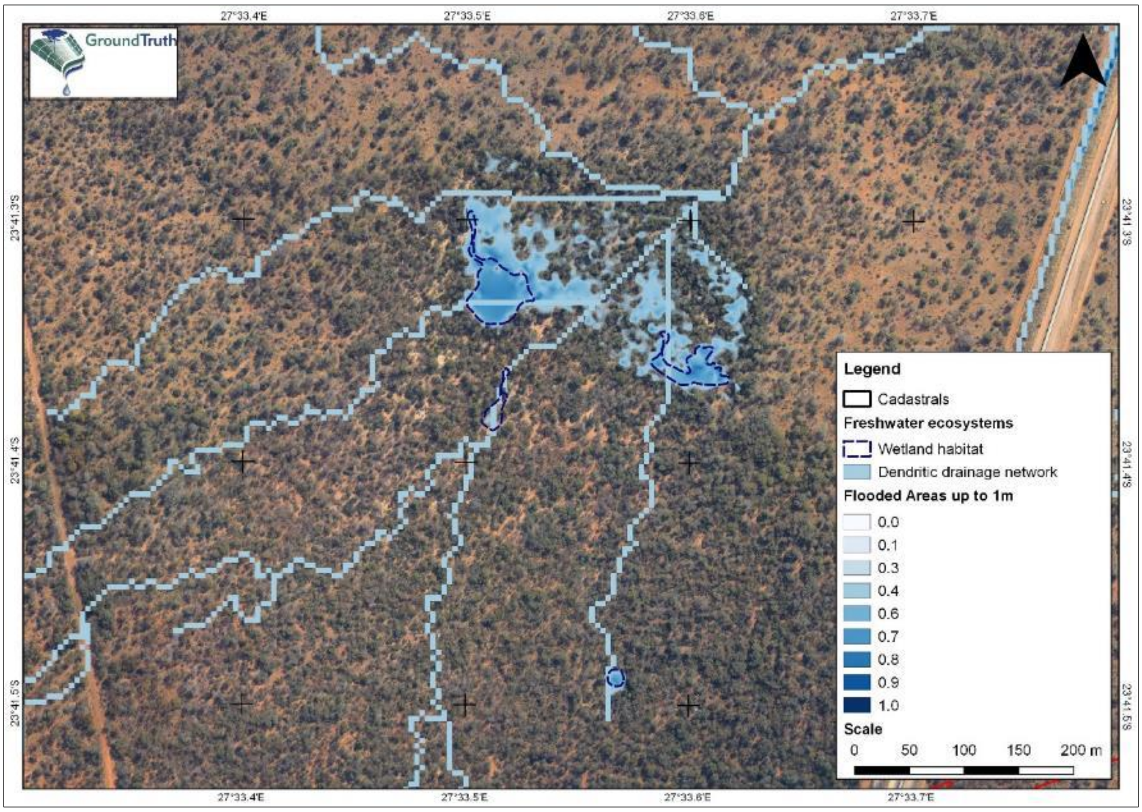


Figure 6-6 An example of a string of smaller wetlands aligned with a dendritic drainage network

Vegetation in and around the wetlands

The majority of the wetlands within the study area are surrounded by tall trees and little to no wetland vegetation within the actual wetlands themselves but in some instances, trees were located within the wetland boundary (Figure 6-7) and refer to the figures depicted above). The canopies of the trees in many instances partially encroach over the fringes of the wetland habitat even though they are considered to be terrestrial species. The seasonality of the wetlands and the temporary nature of the water within the systems seems to not affect the trees as the inundation periods are for relatively short periods of time.

Figure 6-7 An example of trees within an inundated wetland

The majority of the wetlands within the study area are bare, mud-dominated areas and did not have any form of wetland vegetation within them. However, the larger wetlands that are inundated for comparatively longer periods, did have seasonal wetland vegetation within the wettest portions of the systems (Figure 6-8). The analysis of the soil profiles within these systems supported this, as the soil profiles were those of seasonal wetness conditions (refer to Appendix 1). It is anticipated that the lack of vegetation cover within the wetlands is a result of a number of factors including the overgrazing of the vegetation within the systems, the extended drought that has affected the entire country, and the encroachment of bush species within the wetlands.

Figure 6-8 An example of two wetland systems containing seasonal wetland vegetation within the portions of the systems with sustained wet conditions

Overgrazing and bush encroachment

As described above, other than the larger wetland systems, the wetlands were considered to be predominantly mud-dominated systems. In many instances, it is anticipated that historical activities within the reserve, namely overstocking (Natural Scientific Services 2011; Digby Wells 2014), largely influenced the vegetation composition across the site. The majority of the study area is considered to be underlain by fertile soils, and as such the vegetation would most likely also be palatable to wildlife. Following the first rainfall events, the growth of new vegetation within the wetlands would attract grazers to these wetland areas. Intensive grazing of the systems would result in the reduction and/or loss of vegetation cover within these systems. This in conjunction with an extended drought would provide suitable conditions for the encroachment of shrubs into the drier portions of each system (Figure 6-9). Grass species would be easily out-competed by the shrubs, and consequently be limited in extent. Instances of bush encroachment was noted particularly in the smaller systems and/or the large shallower wetland systems.

Figure 6-9 Examples of bush encroachment into some of the wetlands identified within Turfvlakte

Invertebrates
During both the dry and wet season site visits, invertebrate samples were collected. As described in Section 5, the method of collection between the seasons differed. Even though during the wet season the collection of invertebrates was limited to the previously sampled areas, infield observations in terms of their presence, abundance and species were nonetheless made. As described above, many of the wetlands are surrounded by trees and their associated canopies. The variety of habitat surrounding the wetlands greatly favoured the presence of invertebrate species.

An interesting observation during the wet season site visit was that the wetlands located to the east of the coal conveyor, contained a larger variety and number of invertebrates in comparison to the wetlands to the west of the conveyor belt. The major difference between the two areas is that the eastern side does not have large herbivores (rhinoceros and buffalo) within its boundaries, whilst the western side does. It is anticipated that these large wildlife species may largely influence the number and diversity of the invertebrate species found within these systems.

6.2 Assessment results of the wetlands identified

The wetlands identified within the study area were assessed in terms of their functioning and condition/integrity for both the current and operational-mining[14] scenarios. The results of these assessments are described below. Figure 6-10 provides an overview of the proposed mining activities in relation to the identified wetlands with the study area.

[14] The operational-mining scenario assumes that all of the wetlands will be lost simultaneously (excluding 6, 7, 8, 9, 16, 17 and 19) due to the proposed mining activities, even though the pans will only be lost as the mining activities expand over the next 30 years.

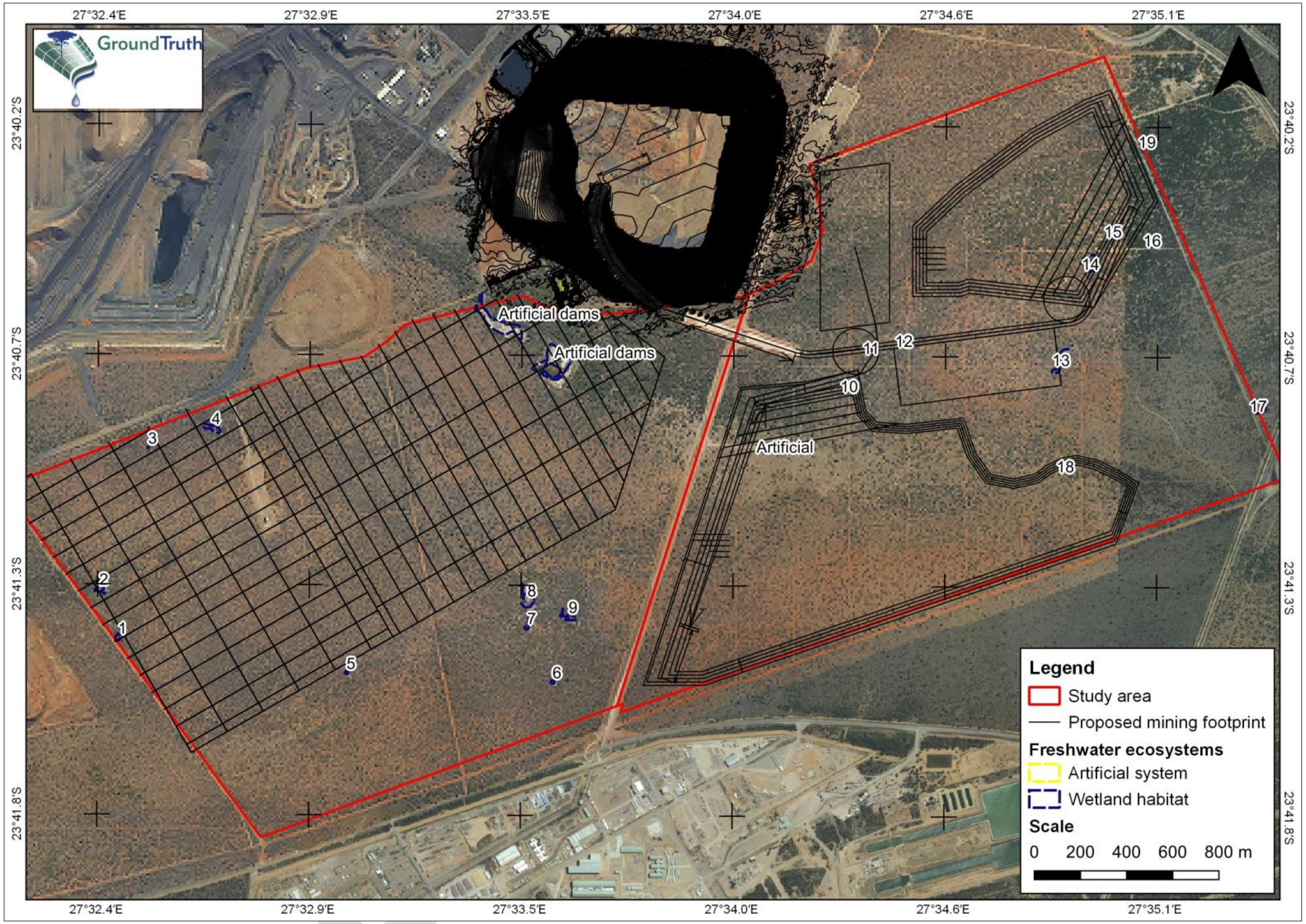


Figure 6-10 Overview of the identified freshwater ecosystems in relation to the proposed mining activities on Turfvlakte

6.2.1 Wetland clusters

Based on the criteria described in Section 5.3 all of the wetlands, excluding the artificial wetlands, were clustered/grouped as follows:

- Eastern clusters:
  - Group 1 - <0.1ha in size and will be partially lost in the operational-mining landscape;
  - Group 2 - <0.1ha in size but will be lost in the operational-mining landscape;
  - Group 3 - >0.1ha but <0.5ha in size and will be partially lost in the operational-mining landscape; and
  - Group 4 - >0.1ha but <0.5ha in size but will be lost in the operational-mining landscape.
- Western clusters:
  - Group 5 - <0.1ha in size; and will be partially lost in the operational-mining landscape; and
  - Group 6 - >0.1ha but <0.5ha in size and will be partially lost in the operational-mining landscape.

6.2.2 Wetland ecosystem functioning assessment

The general features of the wetland groups (refer to Section 6.2.1) were assessed in terms of the ecosystem functioning at a landscape level for the current and operational-mining scenarios. The score for each ecosystem service represents the likely extent to which that benefit is being supplied by the specific wetland and was interpreted based on the following rating outlined by Kotze et al. (2007):

- <0.5 Low;
- 0.5-1.2 Moderately low;
- 1.3-2.0 Intermediate;
- 2.1-2.8 Moderately high; and
- >2.8 High.

<u>*Current scenario:*</u>
Generally, the values recorded for the regulating and supporting services for the current scenario for the wetlands were ***Moderately Low*** to ***Intermediate*** (Table 6-1 and Figure 6-11 and Figure 6-12). The regulating services supplied by the smaller wetlands in Groups 1, 2 and 5 (<0.1ha) are considered to be marginally less than those wetlands within Groups 3, 4 and 6 and this can be attributed to the size of the wetlands. Biodiversity maintenance values were considered to be ***Moderately High***. This can be attributed to the fact the wetlands have been classified as pan/depressions and are located within a game reserve. The systems' provision of direct benefits and services, such as harvestable natural resources and use for education, was seen as limited due to the wetlands' location within private property.

Operational-mining scenario:
It is assumed that the wetlands to the east of the coal conveyor that fall within Groups 2 and 4 will be lost in the operational-mining landscape, and as such the ecosystems services supplied by these systems would also be lost. Some of the wetlands within the eastern clusters that will be retained within the operational-mining landscape, occur within Groups 1 and 3. Currently the proposed mining activities at the proposed eastern Turfvlakte discard dumps only partially impact Groups 1 and 3, and as such it is anticipated that there will be limited impact on the systems. Whilst, some of the wetlands within the western clusters that will be retained within the operational-mining landscape, occur within Groups 5 and 6. Should however, the proposed mining footprint change, the functioning of these systems would have to be reassessed to ensure they are not impacted by the proposed mining activities.

Table 6-1 Summary of current Ecosystem Services Scores[15] for all of the wetlands identified within the study area

Ecosystem Services	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Flood attenuation	1,7	1,7	1,7	1,6	1,7	1,6
Score for effectiveness:	1,6	1,6	1,6	1,0	1,6	1,4
Score for opportunity:	1,8	1,8	1,8	2,2	1,8	1,8
Stream flow regulation	0,0	0,0	0,2	0,0	0,0	0,2
Sediment trapping	1,7	1,9	1,9	0,9	1,7	1,4
Score for effectiveness:	0,8	1,3	1,3	0,5	0,8	0,7
Score for opportunity:	2,5	2,5	2,5	1,3	2,5	2,0
Phosphate trapping	1,1	1,1	1,3	0,3	1,1	1,0
Score for effectiveness:	1,6	1,8	2,1	0,5	1,6	1,9
Score for opportunity:	0,5	0,5	0,5	0,0	0,5	0,0
Nitrate removal	0,5	0,5	0,8	0,5	0,5	0,8
Score for effectiveness:	1,0	1,0	1,5	1,0	1,0	1,5
Score for opportunity:	0,0	0,0	0,0	0,0	0,0	0,0
Toxicant removal	1,1	1,2	1,4	0,5	1,1	0,8
Score for effectiveness:	1,2	1,3	1,8	1,0	1,2	1,7
Score for opportunity:	1,0	1,0	1,0	0,0	1,0	0,0
Erosion control	1,5	1,5	1,4	1,8	1,5	1,6
Score for effectiveness:	2,0	2,0	2,3	2,3	2,0	2,3
Score for opportunity:	0,9	0,9	0,5	1,3	0,9	0,9
Carbon storage	1,3	1,3	1,7	1,0	1,3	1,7
Biodiversity maintenance	2,3	2,3	2,3	2,0	2,3	2,7
Score for noteworthiness:	2,0	2,0	2,0	1,3	2,0	2,0
Score for integrity:	2,7	2,7	2,5	2,7	2,7	3,3
Water supply	0,0	0,0	0,6	0,5	0,0	0,6
Source of harvestable goods /resources	0,0	0,0	0,0	0,0	0,0	0,0
Source of cultivated goods /resources	0,0	0,0	0,0	0,0	0,0	0,0
Socio-cultural significance	0,0	0,0	0,0	0,0	0,0	0,0
Tourism and recreation	0,3	0,3	0,3	0,3	0,3	0,4
Education and research	1,0	1,0	1,0	1,0	1,0	1,0

[15] Where applicable the scores for opportunity and effectiveness have been presented to ensure an understanding of the effectiveness of the systems.

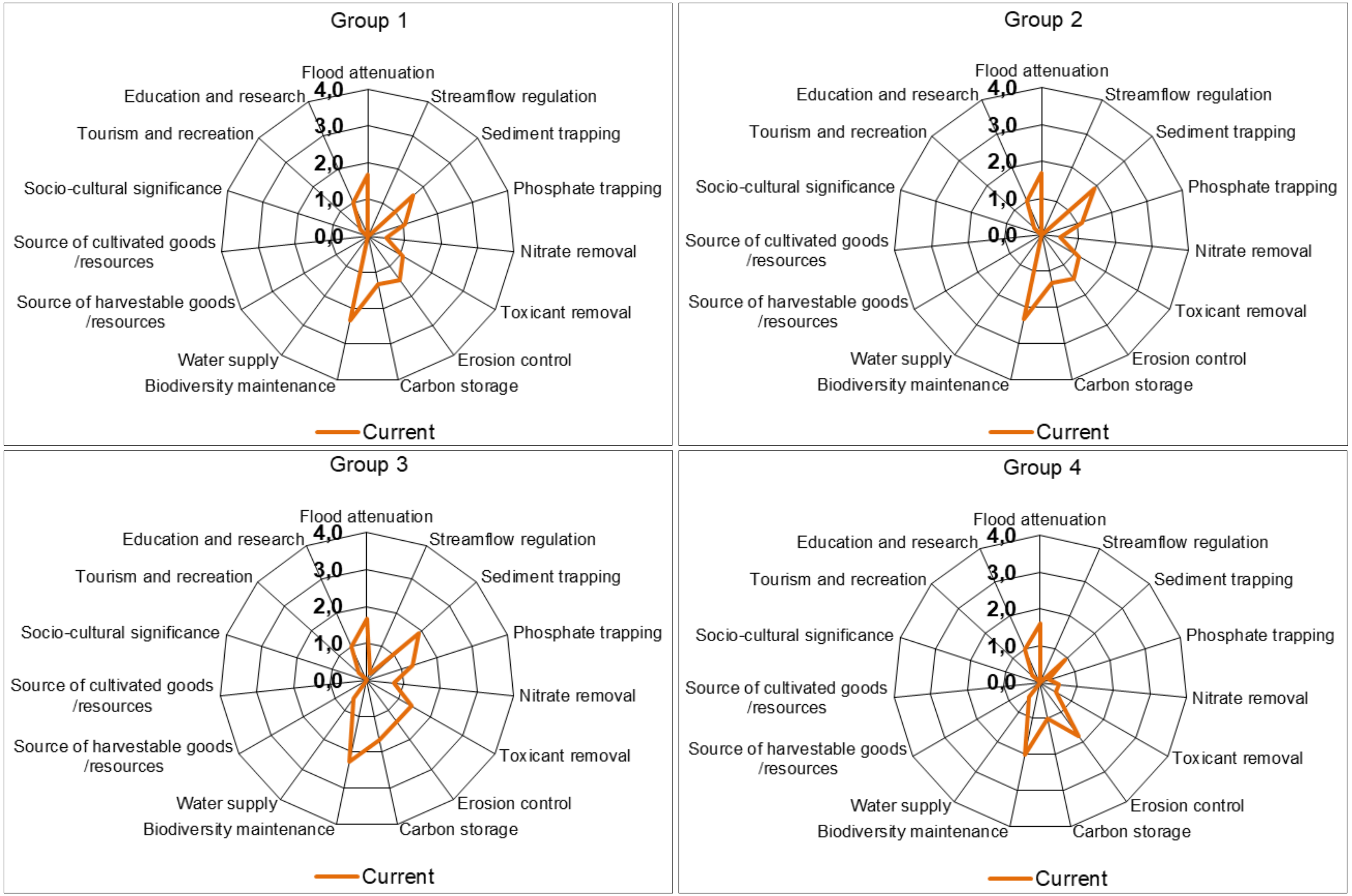


Figure 6-11 Overview of the ecosystem services provided by the wetland systems within the eastern portion of the study area for the current scenario

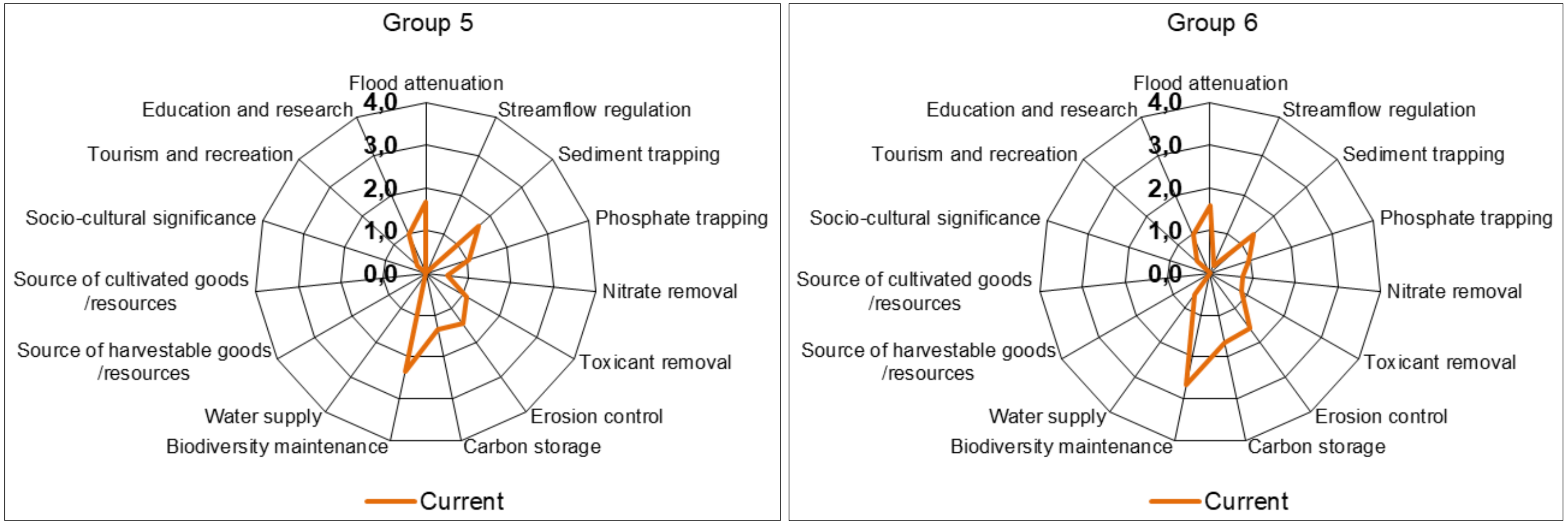


Figure 6-12 Overview of the ecosystem services provided by the wetland systems within the western portion of the study area for the current scenario

As WET-EcoServices does not provide a consolidated score that can be used as a target, the current and operational-mining assessment scores were incorporated into the Wetland Importance and Sensitivity assessment datasheets (Rountree and Malan 2010) to provide EIS scores (refer to Table 6-2 to Table 6-7). As highlighted above, it is assumed that all of the wetlands will be lost as a result of the proposed mining activities, and as such an EIS score cannot be attributed to the wetlands as they are considered to be zero for all categories.

Table 6-2 EIS scores for the Group 1 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.3	Moderate
Hydro-functional importance	1.1	Moderately Low
Direct human benefits	0.2	Low

Table 6-3 EIS scores for the Group 2 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.3	Moderate
Hydro-functional importance	1.2	Moderately Low
Direct human benefits	0.2	Low

Table 6-4 EIS scores for the Group 3 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.3	Moderate
Hydro-functional importance	1.3	Moderately Low
Direct human benefits	0.3	Low

Table 6-5 EIS scores for the Group 4 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.3	Moderate
Hydro-functional importance	0.8	Low
Direct human benefits	0.3	Low

Table 6-6 EIS scores for the Group 5 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.3	Moderate
Hydro-functional importance	1.1	Moderately Low
Direct human benefits	0.2	Low

Table 6-7 EIS scores for the Group 6 for the current scenario

Current		
Categories	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.7	Moderate
Hydro-functional importance	1.1	Moderately Low
Direct human benefits	0.3	Low

6.2.3 Wetland ecological integrity assessment[16]

The ecological integrity or Present Ecological State (PES) of the wetland clusters/groups, were assessed for the hydrology, geomorphology, water quality and vegetation components, considering the reference/benchmark conditions. The integrity of the biophysical components of the wetlands were assessed for the current and operational-mining scenarios, so as to provide an indication of the functional area lost as a result of the proposed mining activities.

It should be noted that the following assumptions were made with regards to the operational-mining scenario:

- Groups 2 and 4 located to the east of the conveyor will be lost in their entirety. Those wetlands that will be lost are considered to be lost simultaneously, even though the mining plan extends over a period of thirty (30) years;
- Groups 1, 3, 5 and 6 will primarily be lost within the operational-mining landscape. The wetlands that will be retained with minimal impact are labelled 6, 7, 8, 9, 16, 17 and 19. The catchments associated with these systems generally are located outside of the proposed mining footprint area, even though some of these systems may be within 100m of the proposed mining activities; and as such it is anticipated that the impacts on the systems will be limited. However, should the proposed mining layout be amended, the assessment of the wetlands' integrity would have to be reassessed to account for the changes within the wetlands' catchments.
- Any infrastructure requirements for the operational-mining scenario will be placed outside of the 200m buffer zone of the wetlands and/or any linear features will coincide with existing linear features within the landscape, i.e. roads Figure 6-13. Should this be unattainable, the assessments would have to be updated to account for any catchment and/or in-system modifications.

[16] Please note that the full data for the wetland ecological integrity assessment results can be made available if required.

- As such, the integrity/hectare equivalents calculated for the current scenario were considered to be lost in the operational-mining scenario i.e. if a wetland group was recorded as 1 hectare equivalent, the operational-mining scenario assumes that there will be a loss of 1 hectare equivalent within the operational-mining landscape.
- Any activities planned beyond the study site boundary have not been accounted for in the assessments unless these form part of the operational-mining scenario across the Grootegeluk site and/or are associated with existing mining activities. As such should mining activities/associated infrastructure take place beyond the study site boundary but within the 200m buffer of the wetlands, the assessments may have to be updated to account for potential impacts. However, activities within the 200m of the artificial systems would not necessarily need to be assessed as these systems do not contribute towards the hectare equivalents calculations.

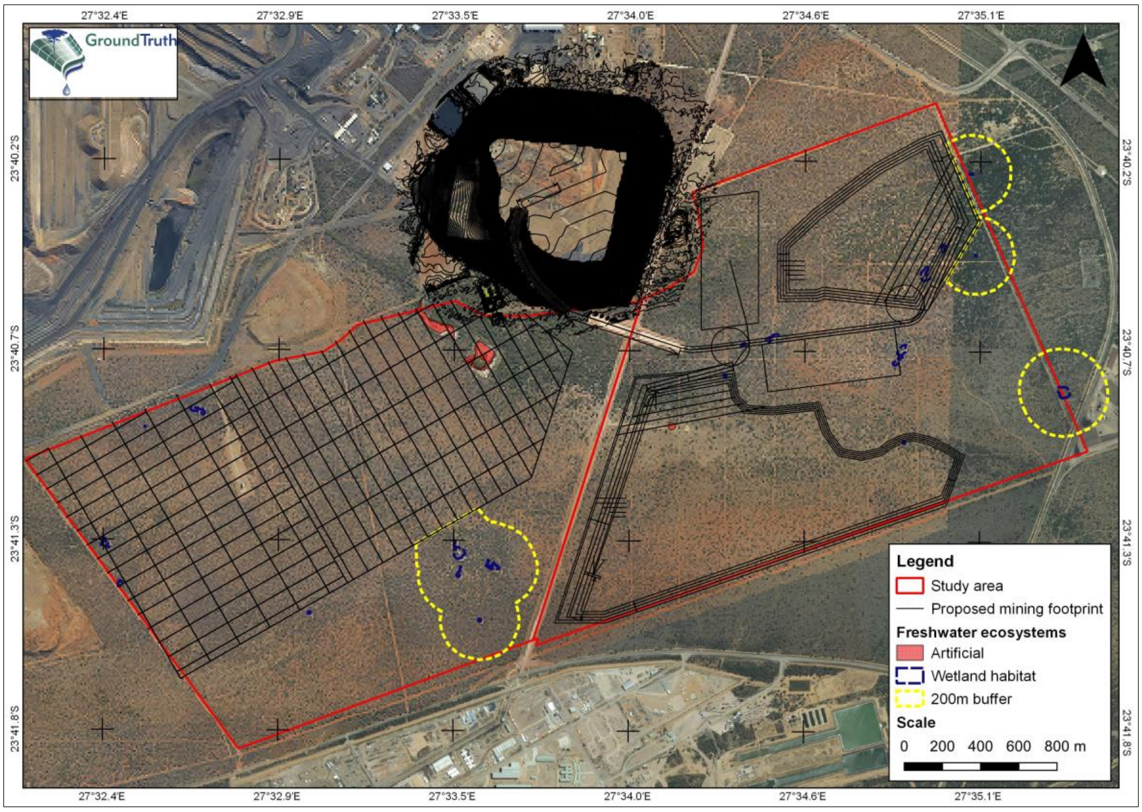


Figure 6-13 Overview of the wetlands within the study area and their associated 200m buffer zones

All of the wetlands that were assessed have been classified as pans/depressions. Even though the systems were categorised into six (6) different groups, there are some characteristics that are the same and/or similar across all of the systems. It should be noted that the assumptions adopted during the assessment of the wetland systems are largely reflected in Section 6.1.2, which described the characteristics of the wetland systems within the study area.

The catchments of the wetlands are considered to be relatively intact due to the fact that these wetlands are located within the Manketti Game Reserve and have been assessed/scored accordingly. The catchment impacts that were accounted for during the assessments include dirt roads, overgrazed vegetation due to overstocking, and in those instances where the dirt roads were in close proximity to the wetlands, additional sediment inputs into the systems.

In terms of in-system impacts, these were considered to be limited to the use of the wetlands by wildlife as the greatest ongoing system modifier. Vegetation within these systems is generally absent except for the larger wetlands that retain water for longer periods of time throughout the year. However, the absence of vegetation within the systems is considered to be associated with historical and/or current land use practices. The encroachment of woody species within the wetlands is considered to be as a result of overstocking and as such overgrazing (Natural Scientific Services 2011; Digby Wells 2014). Generally, the woodier the wetlands, the less herbaceous vegetation was seen within the systems. It is anticipated that the catchment and in-system impacts have been exacerbated by an extended drought period and as such, the recovery of the vegetation would be subject to implementation of appropriate interventions and extended rainfall.

Figure 6-14 and Figure 6-15 depict the identified wetlands within the study area and their respective PES categories. Only those impacts that are unique per group will be described separately in the following sections. A summary of the results for each of the wetland groups are outlined below (Refer to Appendix 2 providing details pertaining to the nineteen identified wetlands).

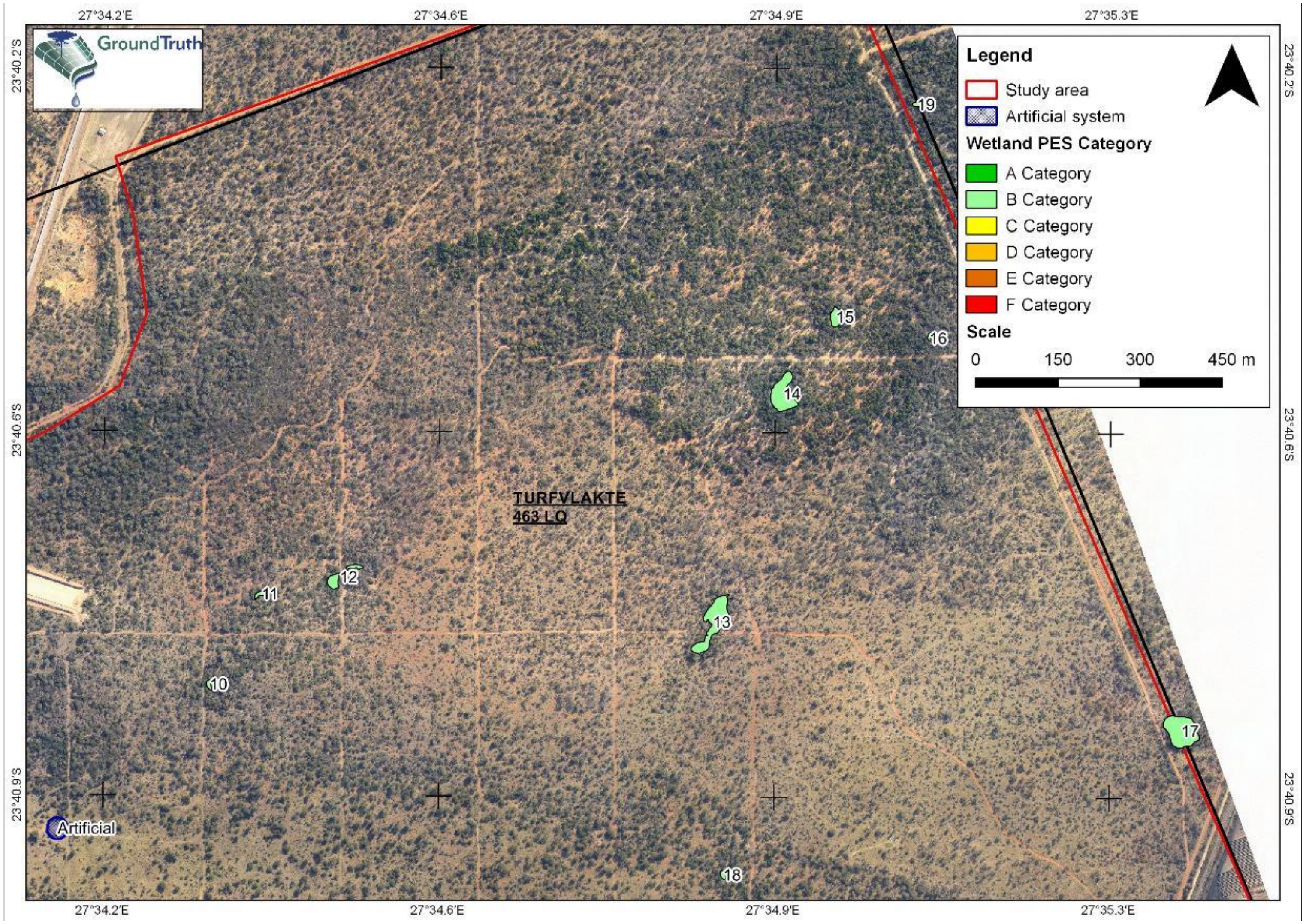


Figure 6-14 Overview of the identified wetlands located to the east of the coal conveyor, their associated numbering and PES category for the current scenario

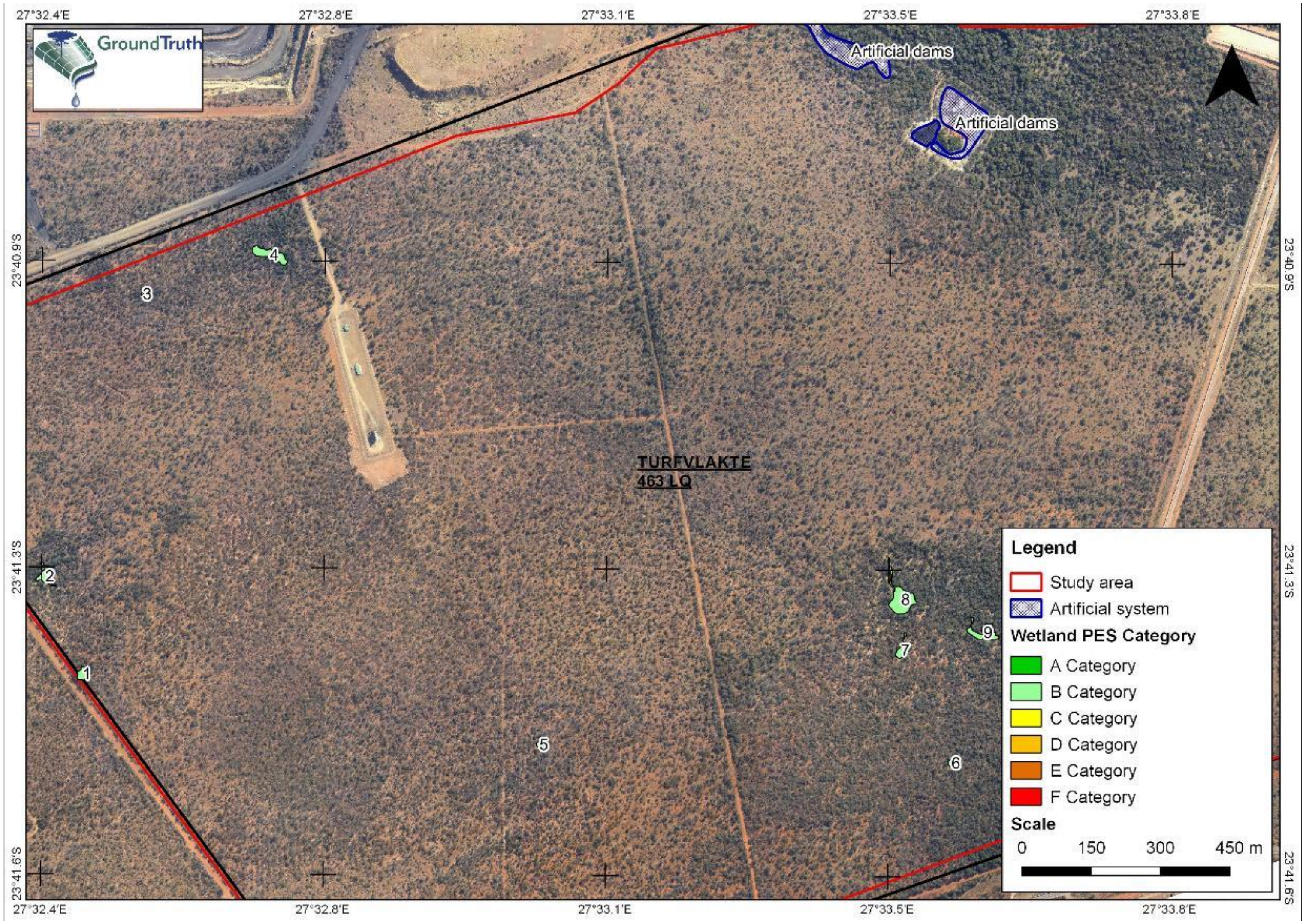


Figure 6-15 Overview of the identified wetlands located to the west of the coal conveyor, their associated numbering and PES category for the current scenario

Group 1

This group comprises of all the wetlands located to the east of coal conveyor that are less than 0.1ha in extent, and that will partially be lost within the operational-mining landscape, i.e. pan 11 will be lost. Generally, the impacts within the catchment and within the systems are uniform with the road network generally being located beyond the edge of the wetlands. These impacts have been accounted for appropriately. These smaller systems tend to be very temporary in nature and only retain water for short periods during the wet season. The assumption was made that these systems retain water for a limited period of time per annum. [17]. During the operational-mining landscape, both pans 16 and 19, will have mining activities within their catchments, which has been accounted for in the operational-mining scenario. Table 6-8 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-8 Summary of the assessment of the ecological integrity for Group 1 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.8	1.3	2.0	2.4
PES category	B	B	C	C
Composite impact score	1.9			
Combined PES score (%)	81%			
Overall PES category	B			
Hectares of wetland	0.0363			
Hectare equivalents	0.0301			
Operational-mining: hectares of wetland	0.0154			
Operational-mining: overall PES category	E			
Operational-mining: retained hectare equivalents	0.0115			
Operational-mining: loss of hectare equivalents	-0.0186			

Group 2

This group comprises of all the wetlands located to the east of coal conveyor that are less than 0.1ha in extent but that will be lost within the operational-mining landscape. Generally, the impacts within the catchment and within the systems are uniform with the road network generally being located beyond the edge of the wetlands. These impacts have been accounted for appropriately. These smaller systems tend to be very temporary in nature and only retain water for short periods during the wet season. The assumption was made that these systems

[17] It should be noted that the exact period of inundation can only be confirmed with long-term seasonal monitoring of the systems but is based on infield observations.

retain water for a limited period of time per annum[17]. Table 6-9 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-9 Summary of the assessment of the ecological integrity for Group 2 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.4	0.9	2.0	2.5
PES category	**A**	**A**	**C**	**C**
Composite impact score	1.3			
Combined PES score (%)	87%			
Overall PES category	**B**			
Hectares of wetland	0.1542			
Hectare equivalents	0.1335			
Operational-mining: hectares of wetland	0.0			
Operational-mining: overall PES category	**F**			
Operational-mining: retained hectare equivalents	0.0			
Operational-mining: loss of hectare equivalents	-0.1335			

Group 3

This group comprises of all the wetlands located to the east of coal conveyor that greater than 0.1ha but less than 0.5ha in extent and that will partially be lost within the operational-mining landscape. Generally, the impacts within the catchment and within the systems are uniform, other than one system that has a road running through the wetland, whilst other roads are located beyond the edge of the wetlands. These systems are considered to be some of the larger wetlands within the study area and as such are considered to retain water for a limited period of time per annum[17]. Table 6-10 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-10 Summary of the assessment of the ecological integrity for Group 3 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.7	0.7	1.9	2.4
PES category	**B**	**A**	**B**	**C**
Composite impact score	1.7			
Combined PES score (%)	83%			
Overall PES category	**B**			
Hectares of wetland	0.5287			
Hectare equivalents	0.4394			
Operational-mining: hectares of wetland	0.2752			
Operational-mining: overall PES category	**D**			
Operational-mining: retained hectare equivalents	0.2243			
Operational-mining: loss of hectare equivalents	-0.2151			

Group 4

This group comprises of all the wetlands located to the east of coal conveyor that greater than 0.1ha but less than 0.5ha in extent but that will be lost within the operational-mining landscape. Generally, the impacts within the catchment and within the systems are uniform with the road network generally being located beyond the edge of the wetlands. These impacts have been accounted for appropriately. These systems are considered to be some of the larger wetlands within the study area and as such are considered to retain water for a limited period of time per annum[17]. Table 6-11 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-11 Summary of the assessment of the ecological integrity for Group 4 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.7	0.7	1.9	2.5
PES category	**B**	**A**	**B**	**C**
Composite impact score	1.7			
Combined PES score (%)	83%			
Overall PES category	**B**			
Hectares of wetland	0.2056			
Hectare equivalents	0.1709			
Operational-mining: hectares of wetland	0.0			
Operational-mining: overall PES category	**F**			
Operational-mining: retained hectare equivalents	0.0			
Operational-mining: loss of hectare equivalents	-0.1709			

Group 5

This group comprises of all the wetlands located to the west of coal conveyor and that are less than 0.1ha in extent. Generally, the impacts within the catchment and within the systems are uniform, other than there being some dirt tracks in close proximity to the wetlands that are altering the sediment inputs into the system. These smaller systems tend to be very temporary in nature and only retain water for short periods during the wet season. The assumption was made that these systems retain water for a limited period of time per annum[17]. Table 6-12 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-12 Summary of the assessment of the ecological integrity for Group 5 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.3	0.7	2.0	2.6
PES category	B	A	C	C
Composite impact score	1.6			
Combined PES score (%)	84%			
Overall PES category	B			
Hectares of wetland	0.2022			
Hectare equivalents	0.1198			
Operational-mining: hectares of wetland	0.0627			
Operational-mining: overall PES category	E			
Operational-mining: retained hectare equivalents	0.0708			
Operational-mining: loss of hectare equivalents	-0.0490			

Group 6
This group comprises of all the wetlands located to the west of coal conveyor and that greater than 0.1ha but less than 0.5ha in extent. These systems are considered to be the least impacted wetlands within the study area. These systems are considered to be some of the larger wetlands within the study area and as such are considered to retain water for a limited period of time per annum[17]. Table 6-13 provides a summary of the systems' biophysical drivers for the current scenario.

Table 6-13 Summary of the assessment of the ecological integrity for Group 6 for the current scenario and the loss of hectare equivalents within the operational-mining landscape

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.9	0.5	1.7	1.9
PES category	**A**	**A**	**B**	**B**
Composite impact score	1.2			
Combined PES score (%)	88%			
Overall PES category	**B**			
Hectares of wetland	0.5126			
Hectare equivalents	0.4506			
Operational-mining: hectares of wetland	0.3745			
Operational-mining: overall PES category	**D**			
Operational-mining: retained hectare equivalents	0.2688			
Operational-mining: loss of hectare equivalents	-0.1818			

6.2.4 Summary of overall ecosystem integrity for the wetlands

For ease of interpretation the scores for hydrology, geomorphology, water quality and vegetation are able to be simplified into a composite impact score for the HGM unit by weighting the scores. This score was then used to derive hectare equivalents, which were used as the 'currency' for assessing the losses and gains in wetland integrity (Macfarlane et al. 2018, Cowden and Kotze 2009).

Based on the PES score for the current scenario, the approximately 1.64ha of natural wetland habitat is considered to be the equivalent to 1.34ha of intact wetland habitat (Table 6-14). The graphic representation of the functional wetland area versus the total extent of the wetland habitat onsite, clearly illustrates that the wetland habitat is functioning at approximately 81% (Figure 6-16).

The operational-mining scenario assumes that the proposed mining activities associated with the operational-mining scenario will result in the loss of wetland Groups 2 and 4 and portions of Groups 1, 3, 5 and 6 i.e. a loss of approximately 0.77ha of intact wetland habitat (hectare equivalents). These impacts would have to be appropriately mitigated through offsetting of the impacts (refer to **Section 6.3**).

Table 6-14 Summary of the hectare equivalents for the current and operational-mining scenarios for the identified wetland groups

HGM unit	Current ha equiv.	Operational-mining ha equiv.	Losses
Group 1	0.0301	0.0115	-0.0186
Group 2	0.1335	0.0	-0.1335
Group 3	0.4394	0.2243	-0.2151
Group 4	0.1709	0.0	-0.1709
Group 5	0.1198	0.0708	-0.0490
Group 6	0.4506	0.2688	-0.1818
		Total	-0.7689

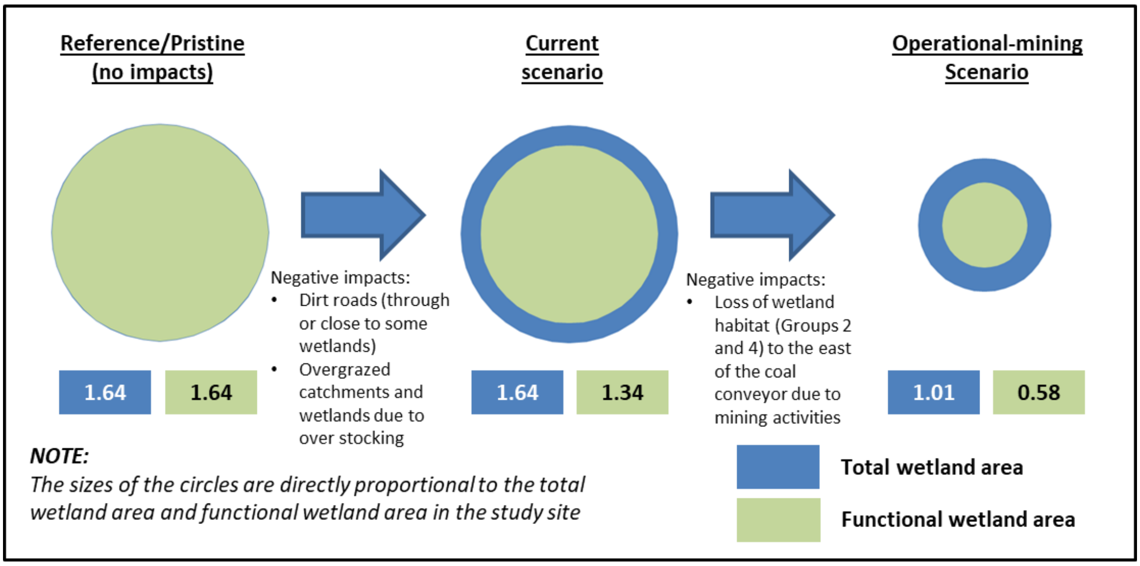


Figure 6-16 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed operational-mining scenarios without mitigation measures.

6.2.5 Freshwater ecosystem risk assessment

When assessing the risks associated with the proposed expansion of the Grootegeluk mining activities, it was assumed that the expansion and operational phases of the mining activities for the new proposed Turfvlakte pit, will extend across the eastern and western portion of the study site but limited to the supplied footprint area. Based on the proposed mine pit layout, as supplied by Exxaro in August 2019, the following wetlands located within study area will not be directly affected by the proposed mining activities, i.e. they will not be lost in their entirety; namely wetlands 6, 7, 8, 9, 16, 17 and 19. Due to the nature of the mining activities, there is no distinction between the construction and operational phases, and as such these have not been presented in Table 6-15, but rather the two operational-mining scenarios which includes 1) the pans that will be lost as a result of the proposed mining activities, and 2) the pans that will be retained within the operational-mining landscape.

Some of the key assumptions that were considered for the risk matrix assessment are documented below. It is assumed that any runoff from the mining activities will be suitably addressed to ensure that there is no contamination of the wetlands in close proximity to the mining footprint. Based on the underlying geology and soil types within the broader landscape, it is assumed that the remaining pans will not be affected by changes to interflow inputs, as Hutton soil forms are well-drained (refer to Section 6.1.2). Due to the nature of the pans being inward draining systems, with limited catchments, it is assumed that there will be limited impacts on these remaining systems associated with the proposed expansion of the mining activities. As per Section 6.2.3, the same assumptions with regards to remaining wetlands are considered to be applicable, particularly the fact that any additional/new infrastructure associated with the mining activities would be placed beyond the 200m buffer zone of the remaining wetlands (precautionary approach) and/or beyond the local catchment of these wetland systems. Any impacts associated with the current infrastructure and/or pits within the 200m buffer of the pans has been suitably assessed and accounted for during the PES assessments. The impacts of any proposed linear infrastructure e.g. pipelines, roads or conveyors; on the wetlands would be largely dependent on the local micro-topography of the site, i.e. whether the proposed infrastructure is located within the micro catchment of one of these systems. In the event, that the proposed linear infrastructure is located beyond the micro-catchments of the identified systems, the impacts on these systems are anticipated to be negligible however, this could only be determined upon review of the proposed infrastructure layouts and assessment of the wetland systems.

The pans that will be retained within the operational-mining landscape are considered to be at a **Moderate Risk** of negative impacts on system functioning and integrity (Table 6-15), whilst the pans that will be permanently lost as a consequence of the mining activities are considered to be at a **High Risk**. Consideration of the principles and approaches described in the DWS Risk Matrix (GN 1180 of 2015), highlighted that these systems are at a **High Risk** of negative impacts on system functioning and integrity, as these systems will be lost in their entirety (Table 6-15).

Table 6-15 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the operational-mining scenario[18].

Phase	Activity	Aspect	Impact	Severity	Spatial Extent	Duration	Probability/ Likelihood	Significance	Risk Rating*	Confidence Level	PES Scores	EIS Scores	Mitigation Measures	Residual Risk Rating
Operational-mining Scenario (Retained Pans)	No activity - Pans located beyond the mining footprint (any potential impacts associated with the mining activities have been accounted for). Management of these systems will remain unchanged.	In-system habitat (if present) and associated catchment habitat	The management of the remaining pans will remain unchanged; however, they will be within 100m of the mining activities. Based on the location of the pans in relation to the mine footprint, it is anticipated that any impacts associated with the mining activities will be limited to the footprint area and all efforts to address run-off from the mine will be appropriately managed.	1.5	1	5	13	97.5	M	80%	Groups 1-3 = B Category	Groups 1-3 = Moderate rating	Current management practices to be maintained	Low
		Flow regime		1.5	1	5	14	105	M					
		Water contamination / pollution		1.5	1	5	14	105	M					
		Siltation of wetland		1.5	1	5	13	97.5	M					
		Biotic indicators (invertebrate)		1.5	1	5	14	105	M					
Operational-mining Scenario (Lost Pans)	The expansion of the mining activities into the study area located to the east of the coal conveyor	In-system habitat (if present) and associated catchment habitat	The expansion of the mining activities will result in the loss of some of the identified wetlands located within the eastern portion of the study area.	5	2	5	20	240	H	100%	Group 4 = F Category	Group 4 = None	A detailed offset study to be undertaken to mitigate the impacts associated with the proposed mining activities Proof of Concept for the relocation and creation of pans within the landscape.	Moderate (this is subject to mitigating the impacts through appropriate mitigation activities, including both a detailed offset study and relocation/creation of pans within the landscape)
		Flow regime		5	2.5	5	20	250	H					
		Water contamination / pollution		5	2.5	5	20	250	H					
		Siltation of wetland		5	2	5	20	240	H					
		Biotic indicators (invertebrate)		5	2.5	5	20	250	H					

[18] Please note that Table 6.15 is a summary developed for reporting purposes. Full data can be made available if required.

6.3 SANBI offset calculator

As the impacts associated with the proposed expansion of the mining are unable to be mitigated through the rehabilitation of the wetland areas onsite, an offset requirement was 'triggered', as the residual impact associated with the proposed mining activities has not been accounted for as defined in the SANBI Offset Guidelines (Macfarlane et al. 2014). An assessment of the offset requirements was conducted for the wetlands lost.

The loss of 0.77 hectare equivalents of wetland habitat, associated with the expansion, was considered in terms of the approach specified by the SANBI Offset Guidelines. As described previously, the SANBI Offset guidelines were used to determine the offset targets. In terms of the offset targets that would be applicable, the following would need to be considered for the impacts on the wetland systems:

- Wetland functionality target – 0.75 hectare equivalents;
- Ecosystem conservation target – 0.2 hectare equivalents; and
- Species of conservation concern target – not applicable as no species of special concern[19] were identified.

6.4 Invertebrate sampling

The following sections provide a summary of the results from invertebrate sampling during the dry and wet season site visits.

6.4.1 Invertebrate incubation and wet season sampling

Water temperature for the duration of the incubation experiments was maintained at an average of 21.7°C, while air temperatures were maintained at 24.8°C with standard deviations of 2.3 and 1.7°C recorded respectively (Figure 6-17). The temperature profiles of the hatching experiments therefore closely matched that of ambient temperatures experienced in Lephalale during October/November[20], providing optimal conditions for hatching/growth.

[19] Species of special concern include Red Data Book or Red List taxa on threatened or conservation concern categories (Macfarlane et al. 2014). The nature of the study did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified wetland habitat, offset calculations would need to be amended to account for the mitigation of impacts on the identified species.

[20] Website - https://en.climate-data.org/location/26819/

Figure 6-17 Ambient air temperature and water temperature records collected for the duration of the incubation experiments

Incubation experiments conducted using a single inundation of each of the five (5) samples over a forty-one (41) day period revealed obligate temporary wetland invertebrates hatching from dormant eggs in each of the collected samples but at different temporal scales and in different abundances (Table 6-16 and Appendix 5). Incubation experiments using sediments yielded eight orders representing ten different genera and, as of yet, an unconfirmed number of species.

Table 6-16 Invertebrate taxa recorded from sediment inundation experiments and wet season sampling at Grootegeluk. Families in red represent obligate temporary wetland indicator species, while families in black represent good dispersers able to establish in any nearby water body

WET SEASON - SITES						DRY SEASON - SITES				
	5	5	3	1	2	1	2	3	4	5
Taxa/Families	**1.1**	**1.2**	**6.1**	**9.1**	**10.1**	**11.1**	**12.1**	**13.1**	**14**	**15**
Anostraca	■	■	■	■	■	■	■		■	■
Conchostraca			■	■	■			■		■
Notostraca	■	■	■		■			■	■	■
Copepoda						■		■	■	■
Cladocera								■	■	
Ostracoda								■	■	
Platyhelminthes										
Notonectidae	■	■	■							
Corixidae		■								
Nepidae										
Libellulidae		■		■	■					
Lestidae				■	■					
Dytiscidae Larvae		■	■	■	■					
Helodidae/Scirtidae			■							
Oligochaeta										
Physidae			■							
Culicidae					■					
Tabanidae										
Ceratopogonidae										■
Chironomidae										
Baetidae										

Large branchiopods (Anostraca, Conchostraca and Notostraca) were observed hatching from all five (5) dry season sediment samples. Similarly, wet season sampling revealed the presence of large branchiopods in all five (5) sites, in addition to 8 other families representing strong dispersers from the orders Hemiptera, Coleoptera, Diptera, Odonata and Ephemeroptera.

Copepods, cladocera and ostracods observed in the dry season incubation experiments were not collected in the wet season sampling, owing to the fact that they are extremely small and would have passed through the 250µm mesh size used on the SASS sampling net. They are expected to have been present at all sites sampled in the wet season.

The number of invertebrate families recorded per sample in both the wet and dry seasons are displayed in Figure 6-18 while species lists are presented in Appendix 4.

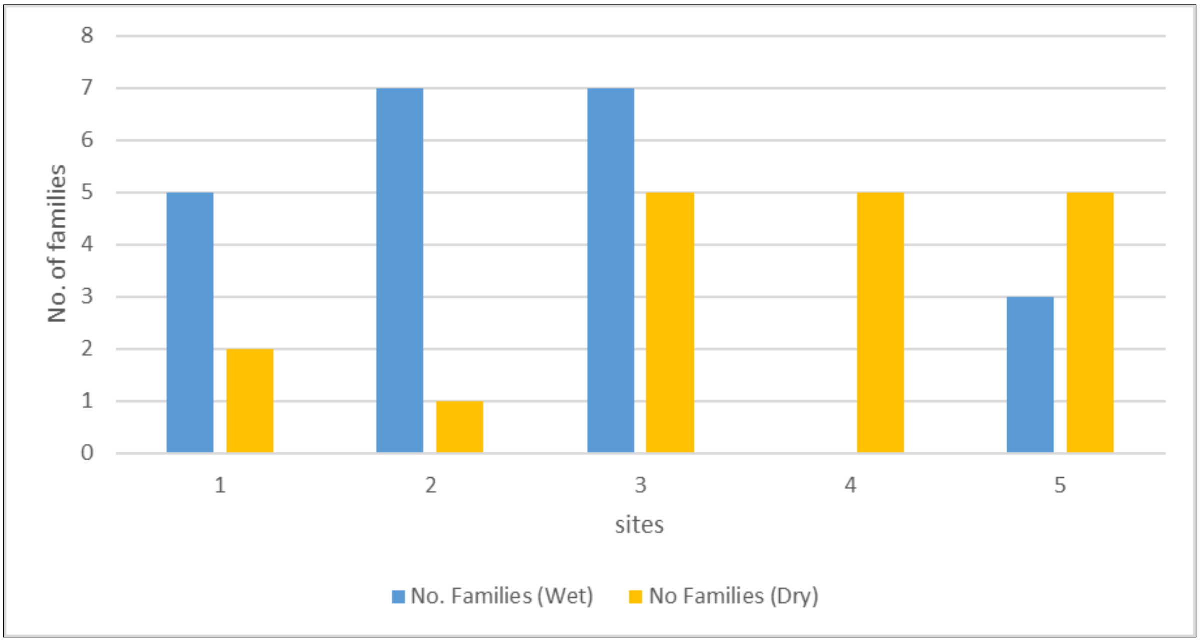


Figure 6-18 No of families recorded hatching from incubation experiments (dry season) and in-situ field sampling (wet season) of temporary wetlands located at Turfvlakte

6.4.2 Findings discussion

All 5 sites identified as potential wetlands and assessed in the current study (either through dry season incubation experiments or wet season field sampling), revealed signs of temporary wetland invertebrate indicators, thereby confirming the presence of functioning temporary wetlands. Dry season incubation experiments as per the methodology described in Day et al. (2010) with a single inundation were successful in revealing the presence of obligate temporary wetland indicator species in all samples, highlighting the value of the approach when field sampling in the wet season is not feasible or as a scoping assessment. Generally, the hatching trials provided a good representation of natural invertebrate communities and provided a low-level surrogate for wet season assessments. Large branchiopods of all three taxa (Anostraca, Conchostracha and Notostraca), hatched in all of the 5 sites soil samples collected for the incubation experiment (Anostraca were absent from site 3, Conchostrata were absent from site 1, 2 and 4; and Notostraca were absent from site 1 and 2) (See Table 6.19). Wet season sampling of the same locations revealed large branchiopods to be present at four of the five sites with fewer taxa absent in certain groups (Conchostrata were absent from site 5 and Notostraca were absent from site 1) (see table 6.19). This discrepancy is likely owing to the fact that most zooplankton including large branchiopods produce drought resistant eggs that do not all hatch at the same time after the first inundation (Brendonck et al. 2017). Instead, as part of a risk mitigation strategy, (against a highly variable hydroperiod and number of inundations) some eggs will only hatch after the second or third inundation of a season (Brendonck et al. 2017). This is because if all eggs hatched after the first inundation and the hydroperiod was too short (i.e. the pond did not remain inundated for long enough) to enable the larvae to reach maturity and reproduce the entire generation would die. As such, if time had permitted additional inundations to be performed in the laboratory, it is highly likely that increased abundances, different hatching strategies and an increased diversity of taxa would have been observed in the samples, thereby increasing the congruency of the wet and dry season sampling results. This is recommended for future dry season assessments.

Generally, water bodies that are more temporary in nature (and/or experience complete desiccation) are more likely to include organisms such as the large branchiopods (Notostraca, Anostraca and Conchostraca) (Seaman and Kok 1987). Furthermore, the shorter the inundation period, the more likely it is that within related taxa, those species with rapid life history traits (reproduction, hatching) (e.g. *Branchipodopsis* spp – Anostraca) will prevail over species with longer life cycles (*Streptocephalus* spp – Anostraca) (Anderson and Hsu 1990, Brendonck 1991, Seaman et al 1995). It is expected that the hydroperiod of the temporary wetlands in Turfvlakte, given the underlying sediments are rich clay, will be longer than those in the Western Cape (underlain by fast draining sand). Regrettably, too little is known to be able to detail what is meant by long or short inundations or life cycles.

Certain studies/authors have reported egg densities ranging from 50'000-220'000/km^2 for Anostraca in the egg banks (upper sediments – as deep as 130mm) of temporary wetlands (Brendonck and Riddoch 1997;2000, Hulsmans et al 2006). Given these remarkably high densities and the depths at which they have been found it has been suggested that

1. The invertebrates have been using the pans/temporary wetlands for as long as it has taken sediments to accumulate (possibly several thousand years);
2. Regular perturbation by animals/birds in the wet season and as result of wind during the drying stage (when cracks form) eggs can become buried at depth, and
3. Eggs in sediments can be transported by herbivores/animals (i.e. elephants, warthogs, antelope) among wetlands and shallow wallows (often created by animals), thereby aiding dispersal (see Incangone et al 2015).

6.4.2.1 Scarcity of the invertebrates collected

Sixty-six (66) large Branchiopod species have been identified in Southern Africa to date (Day et al. 1999, Rogers 2013), but large knowledge gaps relating to these fauna remain in the region. Much of the region has not been studied in detail and limited information exists for the distribution of South African species and their relationship to habitat factors (Hamer and Brendonck 1997, Brendonck et al. 2008, Mabidi et al. 2016). For some areas of South Africa information on the distribution and conservation status of large branchiopods exists namely, KwaZulu-Natal-lowlands, mountainous Drakensberg region of KwaZulu-Natal, Northern Cape, Western Cape, North West and Free State Provinces as well as Mpumalanga Highveld Region. New data has recently been collected for the semi-arid karoo basin (Eastern Cape) (Mabidi et al. 2016). Information for Limpopo however remains relatively limited (Hamer 1999). Only broad statements regarding the scarcity of fauna can therefore be made until further studies have been conducted and the phylogenetic lineages/species from the area have been described.

Notostraca - comprise only one family represented by one species *Triops granarius* – found widely in temporary wetlands throughout Africa. Not on the IUCN red list.

Anostraca – 29 species on the IUCN red list, 4 from Sub-Saharan Africa- none of which were found in the samples from Grootegeluk/Turfvlakte. *Streptocephalus proboscideus* and *Streptocephalus* *cafer* were found and are likely the two dominant species though neither of which are on the IUCN red list.

Conchostraca – none recognized by the IUCN red list. Though three families Lynceidae (*Lynceus* sp.), Leptestheriidae (*Leptestheriella sp.*, *Leptestheria sp.*) and Limnadiidae (*Eulimnadia africana*) sometimes represented in the same sample – which is quite unique.

Mollusca (wet season) – three species of Bulinus recorded from samples. One noted on the IUCN red list but as least concern *Bulinus forskalii*

Ostracoda - 3 species are on the IUCN red list, one of which is extinct, one is only known from Table Mountain and the other is a stenothermal species – unlikely to be found in Limpopo. Species collected from Grootegeluk/Turfvlakte are unidentified at this stage – but are unlikely to represent a conservation concern

Copepoda - 18 species on the IUCN red list from Sub Saharan Africa, the family Diaptomidae was collected from the site along with other unidentified specimens though these are unlikely to represent a conservation concern, but species identification is required to confirm that assertion.

Cladocera - 1 species is on the IUCN red list from Sub Saharan Africa – specimens from Grootegeluk/Turfvlakte are unidentified – conservation concern is uncertain.

Other invertebrate fauna collected represent largely mobile (e.g. Coleoptera and Hemiptera) taxa which are likely to be dispersed across the region and represented in other temporary/permanent water bodies in proximity to the mine.

While none of the invertebrate species collected and identified thus far represent a conservation concern, it should be highlighted that given their restriction to specific rainfed temporary habitats (ephemeral rock pools, natural depressional wetlands, ditches and dams/pools in riverbeds that dry out completely) – the increasing vulnerability of these specific habitats, makes them important for conservation by proxy. These specific temporary rainfed habitats are among some of the most seriously threatened habitats globally (Semlitsch and Bodie 1998, Mabidi et al. 2016), this owing to various factors including small relative volume and shallow depth. These aspects often lead to these habitats being infilled, drained and experiencing rapid pollution (Mabidi et al. 2016).

6.5 Water quality data

Key water quality measurements taken with the YSI in the laboratory (Dry 1 and Dry 2) and the field (wet) are shown in Figure 6-19. Dry season measurements were recorded from each of the samples used in the incubation trials at the beginning of the incubation experiment (Dry 1) and again at the end of the experiment forty-one days later (Dry 2).

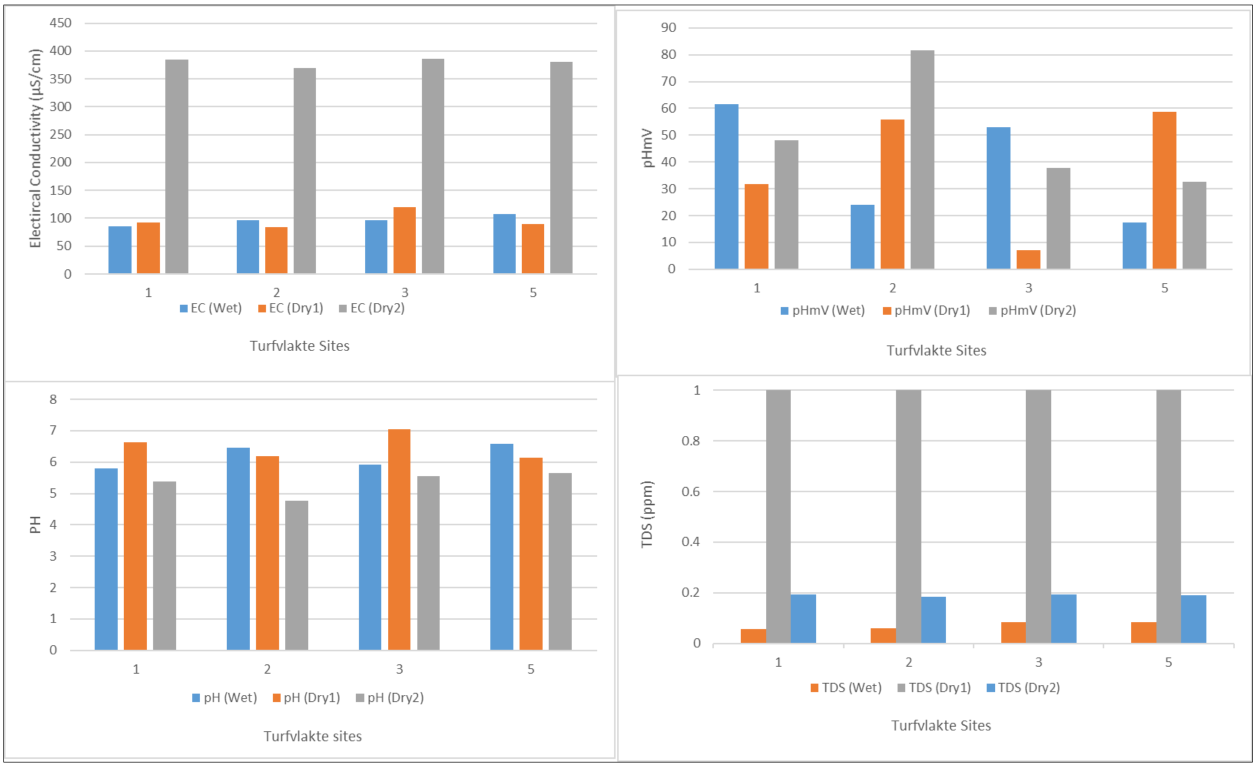


Figure 6-19 Water quality parameters measured for each sample used in the incubation experiments at the beginning of the experiment (Dry 1) at the end of the experiment 41 days later (Dry 2) as well as during the in-situ field sampling (Wet)

Water quality variables were measured both in the laboratory during the dry season and in-situ during the wet season. The variables measured in the laboratory, particularly TDS and EC varied considerably and were generally elevated when compared to in-situ measurements – this is somewhat expected as dilution factors are greatly reduced and concentration effects magnified with the small volume of water added to the samples in the laboratory. Given that the soils around Turfvlakte are comprised predominantly of fine silts and clays, these particles take time to settle when the water body/soils are initially inundated. This is reflected in high TDS values being recorded at the start of the incubation experiments (Dry 1), but which dropped considerably by the end of the experiment (Dry 2) – becoming comparable to in situ measurements. pH values were largely comparable between laboratory and in-situ measurements – with differences in temperature at the time of the recording being the likely variable responsible for variations observed. In general, pHmv values were reduced in the laboratory when compared to field conditions – in this case the field measurements give a better representation of true oxidation reduction potential – as this parameter is highly variable and is affected by temperature, length of the measurement and sampling environment.

Water quality parameters were assessed in relation to invertebrate hatching/presence and absence, but no clear trends were observed. It is likely, however, that soil particle size, organic content, soil moisture, underlying geology as well as the number of inundations in a season - none of which were looked at in great detail in this study - would reveal some relationship between the invertebrate hatching data.

7. ***RECOMMENDATIONS/CONCLUSION***

The study area is located within a more arid portion of South Africa (refer to Section 4.2), with limited large interconnected freshwater ecosystems within the landscape. The study area does not contain any perennial streams and fringe habitat wetlands within its boundaries but rather an expansive number of pans varying in size from 0.003ha to 0.28ha. The majority of the systems are under 0.1ha in extent, and in some instances are interlinked by a dendritic drainage network. However, these dendritic drainage networks are only preferential flows paths within the landscape and not actual streams (i.e. are not characterised by the presence of alluvial material and vegetation distinctly different from adjacent terrestrial vegetation).

Interestingly, the wetland delineation findings and the results from the invertebrate analysis concluded that all of the identified wetlands regardless of how temporary in nature the systems were, contained invertebrates, thus providing an additional level of evidence to the presence of wetland conditions resulting in a biotic response. Some of the artificial systems were also noted to contain some degree of invertebrates, but the numbers and diversity of the species was often limited. The limitation in the invertebrate numbers can be explained by the fact that in many instances the substrate of the artificial systems was rock versus the mud within the natural wetland systems. Therefore, the invertebrates were generally opportunistic species, such as dragonflies, who are not reliant on mud-dominated substrates for hatching purposes. Whereas, the wetland systems generally contained invertebrate species that are reliant on muddy substrates for hatching purposes.

Due to the location of the pans/depressions within the Manketti Game Reserve, the nineteen (19) identified wetlands are considered to be predominantly in good condition, i.e. 'B' category systems and cover an area of 1.64ha. Based on the integrity assessment (Macfarlane et al 2018), the wetlands were considered to be equivalent to 1.34 hectares of functional wetland habitat.

The proposed Turfvlakte mining activities within the study area will result in the loss of all of the pans and the watering hole other than pans 6, 7, 8, 9, 16, 17, and 19. The artificial systems were excluded from any assessments due to their artificial nature, and therefore, do not contribute to the offset mitigation requirements.

Based on the loss of 0.77 hectare equivalents, the SANBI Offset Guidelines were used to calculate the offset requirements of the mine. In terms of the offset targets that would be applicable, the following would need to be considered for the impacts on the wetland systems:

- Wetland functionality target – 0.75 hectare equivalents; and
- Ecosystem conservation target – 0.2 hectare equivalents.

A suitable offset receiving area and mitigation activities have not been identified for the site to date, as this would be subject to the review of areas that would not be subjected to any proposed mining activities. This would be subject to a detailed wetland offset study for this study area.

Extremely high egg densities observed in the egg bank (upper sediments of temporary wetlands), coupled with the unique hatching traits of temporary wetland fauna raises the possibility that sediments can be harvested and relocated to areas where artificial wetlands can be created. However, due to lack of research and/or preceding studies in terms of the creation of pans, the creation of pans within in the landscape is being considered by Exxaro as advancing the wetland field of practice by means of a documented experimental approach to address impacts on wetlands in the landscape and initially would not necessarily contribute towards the offset requirements. The harvesting and relocation of sediments should enable the successful recolonization of artificial temporary wetlands by associated flora and fauna, though several factors would however have to be carefully considered and planned:

- Design specifications required
  - Harvesting wetland material from the largest wetlands within the study area as the substrate for the created wetlands;
  - Surrounding trees and marginal vegetation, seeding with existing sediment and plant species if necessary;
  - Topography – consideration to be given to depth and surface area (under inundation scenario) and modelling of the hydroperiod given the underlying geology
- Invertebrate communities
  - More in depth invertebrate community analyses (wet season) and hatching studies (dry season) are recommended to better understand the ecology and dynamics of the system before offsets and sediment removal.
  - Species level identifications would need to be completed before offsets commence in the case that rare/endangered/red listed species occur in the area
  - An assessment/estimation of the density of eggs in the egg banks of wetlands earmarked for removal could prove useful for offset planning.
  - A suitable biomonitoring programme is established to gauge the ecosystem wellbeing of artificially created wetlands

Offsetting the impacts associated with the proposed mining activities, would however be subject to authorisation from the relevant authorities and a detailed offset study.

8. REFERENCES

Anderson, G. and Hsu S-Y. 1990. Growth and maturation of a North American fairy shrimp, *Streptocephalus seali* (Crustacea; Anostraca): a laboratory study. *Freshwater Biology*, 24: 429–442.

Brendonck L and Riddoch B. 2000. Egg bank dynamics in anostracan desert rock pool populations (Crustacea:Branchiopoda). *Archiv für Hydrobiologie,* 148, 71-84

Brendonck L and Riddoch B.1997. Anostracans (Branchiopoda) of Botswana: morphology, distribution, diversity, and endemicity. *Journal of Crustacean Biology,* 17, 111–134. doi: 10.2307/1549468

Brendonck L, Williams WD. 2000. Biodiversity in wetlands of dry regions (drylands). In: Gopal B, Junk WJ, Davis JA (Eds) *Biodiversity in Wetlands: Assessment, Function and Conservation*. Backhuys Publishers, Leiden, 181–194.

Brendonck L. 1991. Contributions to the study of the reproductive biology of *Streptocephalus proboscideus* (Anostraca, Streptocephalidae). *Crustaceana*, 60, 145–162.

Brendonck L. Rogers DC. Olesen J. Weeks SRH. 2008. Global diversity of large branchiopods (Crustacea: Branchiopoda) in fresh water. *Hydrobiologia* 595: 167–176. doi: 10.1007/ s10750-007-9119-9

Brendonck L., Pinceel T. and Ortells R. 2017. Dormancy and dispersal as mediators of zooplankton population and community dynamics along a hydrological disturbance gradient in inland temporary pools. *Hydrobiologia*, 796, 201-222.

Cowden C, Kotze DC. 2009. WET-RehabEvaluate: Guidelines for the monitoring and evaluation of wetland rehabilitation projects. WRC Report No TT 342/08. Pretoria: Water Research Commission.

Davies, B. and Day. J.1998. *Vanishing waters*. University of Cape Town Press, Cape Town, South Africa.

Day J. Day E. Ross-Gillespie V. and Ketley A. 2010. The assessment of temporary wetlands during dry conditions. Water Research Commission Report TT434/09, Water Research Commission, Pretoria.

Day JA. Stewart BA. de Moor IJ. Louw AE. 1999. *Guides to the Freshwater Invertebrates of Southern Africa: Crustacea I -Notostraca, Anostraca, Conchostraca and Cladocera*. WRC Report no. TT 121/00, Water Research Commission, Pretoria, South Africa, 126 pp.

De Meester L., Declerck S., Stocks R., Louette G., Van de Meutter F., De Bie T., Michels E. and Brendonck L. 2005. Ponds and pools as model systems in conservation biology, ecology and evolutionary biology. *Aquatic Conservation* 15: 715–725.

De Roeck ERM., Vanschoenwinkel B., Day JA., Xu Y., Raitt L. and Brendonck L. 2007. *Conservation status of large branchiopods in the Western Cape*, South Africa. Wetlands 27: 162-173.

Digby Wells 2014. Wetland assessment – identification of wetlands associated with the proposed Thabametsi Coal Mine, Exxaro Coal, Limpopo Province. Report Ref: EXX0564. Gauteng, South Africa.

DWAF (Department Of Water Affairs and Forestry). 2005. *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas.* Edition 1, September 2005. Pretoria: DWAF.

DWE. 2016. Wetland assessment associated with the proposed Exxaro Thabametsi Coal Mine, Limpopo Province. Project code: EXX0564. Gauteng: South Africa.

DWS 2019. Determination Of Water Resource Classes and Resource Quality Objectives for Mokolo, Matlabas, Crocodile (West) and Marico Catchments. *Government Gazette South Africa* (562) 42775.

Hamer M. 1999. Anostraca. In: Day J.A., Stewart B.A., de Moor I.J., Louw A.E. (Eds) *Guides to the Freshwater Invertebrates of Southern Africa: Crustacea I – Notostraca, Anostraca, Conchostraca and Cladocera.* WRC Report no. TT 121/00, Water Research Commission, Pretoria, 14–58.

Hamer ML. Brendonck L. 1997. *Distribution, diversity and conservation of Anostraca (Crustacea: Branchiopoda) in southern Africa*. In: Simovich M, Sassaman C, Belk D (Eds) Studies on Large Branchiopod Biology and Conservation. Springer, 1–12.

Hulsmans A. Bracke S. Moreau K. Riddoch BJ. De Meester L. and Brendonck L. 2006. Dormant egg bank characteristics and hatching pattern of the Phallocryptus spinosa (Anostraca) population in the Makgadikgadi Pans (Botswana). *Hydrobiologia*, 571, 123-132.

Incagnone G. Marrone F. Barone R. Robba L. and Naselli-Flores L. 2015. How do freshwater organisms cross the “dry ocean”? A review on passive dispersal and colonization processes with a special focus on temporary ponds. *Hydrobiologia*, 750(1), 103-123.

Job N. 2009. Report on the Application of the Department of Water Affairs and Forestry Wetland Delineation Method to Wetland Soils of the Western Cape. WRC Report No. K8-718. Pretoria: Water Research Commission.

Kerfoot WC. and Lynch M. 1987. Branchiopod communities: associations with planktivorous fish in space and time, pp. 376-382. In, W. C. Kerfoot and A. Sih (eds.), *Predation: Direct and Indirect Impacts on Aquatic Communities*. University Press of New England, Hanover, NH.

Kotze DC, Marneweck GC, Batchelor AL, Lindley DS, Collins NB. 2007. *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No TT 339/08. Pretoria: Water Research Commission.

Mabidi A. Bird MS. Perissinotto R. and Rogers DC. 2016. Ecology and distribution of large branchiopods (Crustacea, Branchiopoda, Anostraca, Notostraca, Laevicaudata, Spinicaudata) of the Eastern Cape Karoo, South Africa. *ZooKeys*, (618), 15.

Macfarlane DM, Holness SS, Von Hase A, Brownlie S, Dini J. 2014. *Wetland offsets: a best practice guideline for South Africa.* Pretoria: South African National Biodiversity Institute and the Department of Water Affairs.

Macfarlane DM, Kotze D, Walters D, Koopman V, Goodman P, Ellery W, Goge C. 2007. *WET-Health. A technique for assessing wetland health*. WRC Report No. TT340/08. Pretoria: Water Research Commission.

Macfarlane DM, Ollis D, and Kotze DC. 2018. *Draft suite of tools for assessing the present ecological ststae of wetland ecosystems.* Unpublished. WRC Project K5/2549. Pretoria: Water Research Commission.

Macfarlane DM, Walters D, Cowden C. 2012. *A wetland health assessment of KZNs priority wetlands*. Draft Unpublished Report prepared for Ezemvelo KZN Wildlife. Pietermaritzburg: EKZNW.

Midgley DC, Pitman WV, Middleton BJ. 1994. *Surface water resources of South Africa 1990, Vol I–VI*. WRC Reports No. 298/1.1/94 to 298/6.1/94. Pretoria: Water Research Commission.

Mucina L, Rutherford MC (eds). 2006. *The vegetation of South Africa, Lesotho and Swaziland.* South African National Biodiversity Institute. Pretoria: Strelitzia 19.

Natural Scientific Services. 2011. Grootegeluk coal mine: terrestrial ecological scan. Project Nr: 1295. Gauteng: South Africa.

Nel JL, Driver A. 2011. *National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component*. CSIR Report Number CSIR/ECO/IR/2012/0022/A. Stellenbosch: Council for Scientific and Industrial Research.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L, Nienaber S. 2011. *Technical report for the national freshwater ecosystem priority areas project*. WRC Report No. 1801/2/11. Pretoria: Water Research Commission.

Ollis D, Snaddon K, Job N and Mbona N. 2013. *Classification System for Wetlands and other Aquatic Ecosystems in South Africa: User manual: Inland Systems.* SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria.

Richardson JL, Vepraskas MJ. (eds.) 2001. *Wetland Soils: Genesis, Hydrology, Landscapes and Classification*. Washington, D.C: Lewis Publishers.

Rogers DC. 2009. Branchiopoda (Anostraca, Notostraca, Laevicaudata, Spinicaudata, Cy-clestherida). In: Likens GF (Ed.) Encyclopedia of *Inland Waters*. Elsevier, Boston, 242– 249. doi: 10.1016/B978-012370626-3.00157-5

Rogers DC. 2013. Anostraca Catalogus (Crustacea: Branchiopoda). *Raffles Bulletin of Zoology,* 61, 525–546.

Rountree MW, Malan H. (eds). 2010. *Rapid Ecological Reserve Determination Methods for Wetlands* (Version 2.0). Joint Department of Water Affairs and Water Research Commission Study. In preparation. Pretoria: Water Research Commission.

SANBI. 2009. *Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report*. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI). Pretoria: SANBI.

Schulze RE. (ed). 2007. *South African Atlas of climatology and agrohydrology*. WRC Report 1489/1/06. Pretoria: Water Research Commission.

Seaman MT, Kok DJ, Meintjes S. 1995. The description and preliminary prediction of the inundation pattern in a temporary habitat of Anostraca, Notostraca and Conchostraca in South Africa. *Hydrobiologia*, 298, 93–104. doi: 10.1007/BF00033804

Seaman MT. and Kok DJ. 1987. Ecological diversity in orange free state pans. Occasional Report Series No. 28, Ecosystem Programmes. Foundation for Research and Development, CSIR, Pretoria, 260–273

Semlitsch RD. Bodie JR. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12: 1129–1133. doi: 10.1046/j.1523-1739.1998.98166.x

Tuytens K, Vanschoenwinkel B, Clegg B, Nhiwatiwa T, Brendonck L. 2015. Exploring links between geology, hydroperiod, and diversity and distribution patterns of anostracans and notostracans (branchiopoda) in a tropical savannah habitat in se Zimbabwe. *Journal of Crustacean Biology,* 35, 309–318. doi: 10.1163/1937240X-00002319

Waterkeyn A. 2009. Community Structuring Processes in Mediterranean Temporary Wetlands. PhD Thesis. Katholieke Universiteit Leuven.

Zacharias I., E. Dimitriou, A. Dekker & E. Dorsman (2007) Overview of temporary ponds in the Mediterranean region: threats, management and conservation issues. Journal of Environmental Biology 28: 1-9.

Zedler JB and Kercher S. 2005. Wetlands resources: status, trends, ecosystem services and restorability. *Annual Review of Environmental Resources* 30: 39-74.

9. APPENDICES

Appendix 1: Sample plot descriptions and photographs collected during the field component of the study using a data collection sheet adapted from Job (2009).

Project/Site: Grootegeluk Complex
Sample Plot No.: 1
Date: 7 March 2018
Lat: -23.689978
Long: 27.540909

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? ~~Yes~~ No
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:

- ☐ crest
- ☐ scarp
- ☐ midslope
- ☐ footslope
- ☐ valley bottom
- ☒ flat

Local relief:

- ☐ flat
- ☒ concave
- ☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Combretum sp (canopy)	Terrestrial	5%
Bare soil		
Water		

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? ~~Yes~~ No

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	10yr 4/2	10yr 5/1	Depletion / manganese
10 – 20cm	10yr 5/1	10yr 6/1	Manganese
		5yr 5/8	Parent material
20 – 40cm	10yr 5/1	10yr 6/1	More manganese
		5yr 5/8	More parent material
40cm	Rock		

Zone of Wetness:

- ☐ Permanent Wetness Zone
- ☐ Seasonal Wetness Zone
- ☒ Temporary Wetness Zone
- ☐ Non-Wetland or Dryland

Features present within 50cm of the soil surface:

- ☐ Organic soil
- ☐ Grey/gleyed matrix
- ☐ Organic streaking
- ☐ Other
- ☐ High organic content in surface layer
- ☒ Mottle / concretions
- ☐ Sulfidic odour

Munsell colour one of the following? Yes ~~No~~

Gley 1:
☐

Gley 2:
☐

Hue 5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.

Hue l0YR:
☒ value 4 or more/chroma 2 or less OR
☒ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less

Hue 2.5Y:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 5Y:
☐ value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)

☐ Inundated
Depth of Surface Water: N/A
☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface
Depth to Saturated Soil: N/A
☐ Sediment Deposits
☒ Aquatic invertebrates within 1m of sample site
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	Yes	No
Vegetation indicators present?	Yes	No
Soil wetness indicators present?	Yes	No
Hydrology indicators present?	Yes	No
Is this sampling plot within wetland?	Yes	No

Sample Plot Photographs

Overview of the Soil Profile	**Location of Sample Site**
	

Project/Site: Grootegeluk Complex
Sample Plot No.: 2
Date: 7 March 2018
Lat: -23.689941
Long: 27.54103

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? ~~Yes~~ No
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:

☐ crest ☐ footslope
☐ scarp ☐ valley bottom \
☐ midslope ☒ flat

Local relief:

☐ flat
☐ concave
☒ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Solanum panduriforme	Terrestrial	10%
Dichrostachys cinerea (canopy)	Terrestrial	20%
Acacia nigrescens (canopy)	Terrestrial	10%
Bare soil		50%

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? ~~Yes~~ No

SOIL WETNESS INDICATORS

Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 20cm	5yr 4/6		
20 – 50cm	2.5yr	4/8	
50cm -	bedrock		

Zone of Wetness:

☐ Permanent Wetness Zone
☐ Seasonal Wetness Zone
☐ Temporary Wetness Zone
☒ Non-Wetland or Dryland

Features present within 50cm of the soil surface:

☐ Organic soil ☐ High organic content in surface layer
☐ Grey/gleyed matrix ☐ Mottle / concretions
☐ Organic streaking ☐ Sulfidic odour
☐ Other

Munsell colour one of the following? ~~Yes~~ No

Gley 1:
☐

Gley 2:
☐

Hue 5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.

Hue l0YR:
☐ value 4 or more/chroma 2 or less OR
☐ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less

Hue 2.5Y:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 5Y:
☐ value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)

☐ Inundated

Depth of Surface Water: N/A

☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface

Depth to Saturated Soil: N/A

☐ Sediment Deposits
☐ Aquatic invertebrates
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	Yes	No
Vegetation indicators present?	Yes	No
Soil wetness indicators present?	Yes	No
Hydrology indicators present?	Yes	No
Is this sampling plot within wetland?	Yes	No

Sample Plot Photographs

Overview of the Soil Profile	**Location of Sample Site**
	

Project/Site: Grootegeluk Complex
Sample Plot No.: 3
Date: 7 March 2018
Lat: -23.681156
Long: 27.589288

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? ~~Yes~~ No
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR

Position in the landscape:

- ☐ crest
- ☐ scarp
- ☐ midslope
- ☐ footslope
- ☐ valley bottom \
- ☒ flat

Local relief:

- ☐ flat
- ☒ concave
- ☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Unidentified herbs		20%
Bare soil		70%
Water		

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? ~~Yes~~ No

SOIL WETNESS INDICATORS
Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	10yr 3/1	10yr 3/6	
10 – 40cm	10yr 4/1	10yr 3./6	
40 – 60cm	10yr 5/1	10yr 4/6	
60cm -	Bedrock		

Zone of Wetness:

- ☐ Permanent Wetness Zone
- ☐ Seasonal Wetness Zone
- ☒ Temporary Wetness Zone
- ☐ Non-Wetland or Dryland

Features present within 50cm of the soil surface:

- ☐ Organic soil
- ☐ Grey/gleyed matrix
- ☐ Organic streaking
- ☐ Other
- ☐ High organic content in surface layer
- ☒ Mottle / concretions
- ☐ Sulfidic odour

Munsell colour one of the following? Yes ~~No~~

Gley 1:
☐

Gley 2:
☐

Hue 5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 7.5YR:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less.

Hue l0YR:
☒ value 4 or more/chroma 2 or less OR
☒ value 5 or more/chroma 3 or less OR
☐ value 6 or more/chroma 4 or less

Hue 2.5Y:
☐ value 5 or more/chroma 2 or less OR
☐ value 6 or more/chroma 4 or less

Hue 5Y:
☐ value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)

☐ Inundated
Depth of Surface Water: N/A
☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
☐ Saturated within 50 cm of surface
Depth to Saturated Soil: N/A
☐ Sediment Deposits
☒ Aquatic invertebrates within 0.5m of the sample site
☐ Salt Crust
☐ Oxidized Root Channels
☐ Water-Stained Leaves
☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	Yes	No
Vegetation indicators present?	N/A	
Soil wetness indicators present?	Yes	No
Hydrology indicators present?	Yes	No
Is this sampling plot within wetland?	Yes	No

Sample Plot Photographs

Overview of the Soil Profile	**Location of Sample Site**
	

Project/Site: Grootegeluk Complex
Sample Plot No.: 4
Date: 7 March 2018
Lat: -23.681202
Long: 27.589271

Do normal circumstances exist on the site? Yes ~~No~~
Is the site significantly disturbed (difficult site)? ~~Yes~~ No
Is the area a Specific Case per Appendix A of the delineation manual? ~~Yes~~ No

TERRAIN UNIT INDICATOR
Position in the landscape:
- ☐ crest
- ☐ scarp
- ☐ midslope
- ☐ footslope
- ☐ valley bottom \
- ☒ flat

Local relief:
- ☐ flat
- ☒ concave
- ☐ convex

VEGETATION INDICATOR

Dominant or indicator species within sample plot	Indicator Category	% Cover
Eragrostis lehmanniana var. lehmanniana	Terrestrial	25%
Urochloa trichopus	Facultative negative	
Bare soil		20%
Vahlia capensis	Terrestrial	20%
Terrestrial forbs	Terrestrial	10%

Are more than 50% of dominant species (> 50% cover) obligate, facultative positive or facultative? ~~Yes~~ No

SOIL WETNESS INDICATORS
Soil Profile Description:

Depth (cm)	Matrix Color (Munsell)	Mottle Colors (Munsell)	Texture, Concretions, Rhizospheres, etc.
0 – 10cm	10yr 3/1		
10 – 30cm	10yr 3/2		
30 – 40cm	10yr ¾		
40cm -	Bedrock		

Zone of Wetness:
- ☐ Permanent Wetness Zone
- ☐ Seasonal Wetness Zone
- ☐ Temporary Wetness Zone
- ☒ Non-Wetland or Dryland

Features present within 50cm of the soil surface:
- ☐ Organic soil
- ☐ Grey/gleyed matrix
- ☐ Organic streaking
- ☐ Other
- ☐ High organic content in surface layer
- ☐ Mottle / concretions
- ☐ Sulfidic odour

Munsell colour one of the following? ~~Yes~~ No
Gley 1:
☐
Gley 2:
☐
Hue 5YR:
- ☐ value 5 or more/chroma 2 or less OR
- ☐ value 6 or more/chroma 4 or less

Hue 7.5YR:
- ☐ value 5 or more/chroma 2 or less OR
- ☐ value 6 or more/chroma 4 or less.

Hue l0YR:
- ☐ value 4 or more/chroma 2 or less OR
- ☐ value 5 or more/chroma 3 or less OR
- ☐ value 6 or more/chroma 4 or less

Hue 2.5Y:
- ☐ value 5 or more/chroma 2 or less OR
- ☐ value 6 or more/chroma 4 or less

Hue 5Y:
- ☐ value 5 or more/chroma 2 or less

HYDROLOGY INDICATORS (Generally applicable to Permanent/Seasonal Zones of Wetness)
- ☐ Inundated

Depth of Surface Water: N/A
- ☐ Evidence of bedrock or other impermeable layer within 30-50 cm of the soil surface.
- ☐ Saturated within 50 cm of surface

Depth to Saturated Soil: N/A
- ☐ Sediment Deposits
- ☐ Aquatic invertebrates
- ☐ Salt Crust
- ☐ Oxidized Root Channels
- ☐ Water-Stained Leaves
- ☐ Water Marks

WETLAND DETERMINATION

Terrain unit indicators present?	Yes	No
Vegetation indicators present?	Yes	No
Soil wetness indicators present?	Yes	No
Hydrology indicators present?	Yes	No
Is this sampling plot within wetland?	Yes	No

Sample Plot Photographs

Overview of the Soil Profile	**Location of Sample Site**
	

Appendix 2: Summary of all of the identified freshwater ecosystems within the study site, including their PES category, size, and quaternary catchment

Wetland Label	Quaternary Catchment	Location (Coal Conveyor)	Wetland Group	Wetland Area (ha)	PES Category
1	A42J	West	Group 5	0.0485	B Category
2	A42J	West	Group 5	0.0748	B Category
3	A42J	West	Group 5	0.0028	B Category
4	A42J	West	Group 6	0.1381	B Category
5	A42J	West	Group 5	0.0134	B Category
6	A42J	West	Group 5	0.0185	B Category
7	A42J	West	Group 5	0.0442	B Category
8	A42J	West	Group 6	0.2454	B Category
9	A42J	West	Group 6	0.1291	B Category
10	A42J	East	Group 2	0.0147	B Category
11	A42J	East	Group 1	0.0209	B Category
12	A42J	East	Group 2	0.0689	B Category
13	A42J	East	Group 3	0.2535	B Category
14	A42J	East	Group 4	0.2056	B Category
15	A42J	East	Group 2	0.0579	B Category
16	A42J	East	Group 1	0.0045	B Category
17	A42J	East	Group 3	0.2752	B Category
18	A42J	East	Group 2	0.0127	B Category
19	A42J	East	Group 1	0.0109	B Category
Artificial	A42J	East	Artificial	0.1176	Artificial
Artificial	A42J	West	Artificial	0.9267	Artificial
Artificial	A42J	West	Artificial	1.0837	Artificial

Appendix 3: Life history/ecology notes (Excerpt from Day et al. 2010, Appendix 3, p. 109)

APPENDIX 3

BACKGROUND INFORMATION ON THE LIFE HISTORIES AND OTHER CHARACTERISTICS OF MAJOR GROUPS OF INVERTEBRATES THAT HATCHED OUT DURING LABORATORY TRIALS

A3.1 Ostracods (Crustacea, Ostracoda: seed shrimps)

Ostracods form an important part of the zoobenthos in African inland waters. Many species can survive harsh environmental conditions. Most species are relatively unselective scavengers. Ostracods are small- (<1 mm) to medium-sized (8 mm) bivalved crustaceans. Their bodies are completely enclosed by the carapace, which consists of two lateral valves. There are eight larval instars, the ninth instar being the adult. The animal no longer moults after it reaches the adult stage and matures: in other words, growth is determinate. All Cypridoidea, the superfamily to which the ostracods in this study belong, can produce drought-resistant eggs able to survive in desiccated form, sometimes for many decades (see Martens, 2001 for further details).

Megalocypris princeps (Sars 1898) is a remarkable ostracod. The subfamily to which it belongs is almost entirely endemic to Africa and the individuals of most species of the subfamily are very large. *Megalocypris princeps* is the largest non-marine ostracod in the world, reaching a length of 8 mm. It is typical of temporary vleis in the Western Cape province of South Africa.

A3.2 Phyllopods (Crustacea: Class Branchiopoda: clam and fairy shrimps)

A3.2.1 Conchostracans (clam shrimps)

The Conchostraca, commonly known as clam shrimps, are small (<20 mm), primitive freshwater crustaceans. They occur on all the continents except for Antarctica. In general conchostracans are found in temporary rainwater or snow-melt pools that regularly dry up completely or partially. Most conchostracans are laterally compressed, with a bivalved carapace that completely encloses the body and limbs. They reach between 3 mm and 18 mm in length, depending on species. The antennae are large and are used for swimming and burrowing. The trunk is generally composed of many segments, each with a pair of flattened phyllopodous limbs used for locomotion, feeding and respiration. Conchostracans are mainly benthic animals. Most burrow into the surface layers of the substratum, where they lie with their ventral surfaces pointed upwards, and feed non-selectively on detritus and algae in suspension. They produce feeding currents by beating their thoracic limbs. Some species, including some of the leptestheriids (the type found in our samples), bumble about on the bottom, often permanently *in copulo,* the male holding the female in front of and at right angles to himself.

Conchostracans breed continuously throughout the adult stage. Resting eggs within resistant cysts are usually dropped when the female moults. These cysts can survive extremely unfavourable conditions. The time of hatching is often capricious and triggered by specific environmental conditions. The hatchlings are free-swimming metanauplius larvae with three pairs of appendages and a median eye. There are about five naupliar stages. From the moment of hatching it is a race against time for the organism to reach the adult stage and produce the maximum number of cysts before the pools dry up through evaporation (see Brendonck, 2000 for more details).

The conchostracan in our samples was *Leptestheria rubidgei* (Baird 1862), which is widespread in South Africa.

A3.2.2 Anostracans (fairy and brine shrimps)

Anostracans are small (in southern Africa, <30 mm in length), primitive crustaceans, most of which live in fresh water, although the common brine shrimp, *Artemia*, lives in extremely saline inland salt pans. Fairy shrimps occur on all continents bar Antarctica and are found only in temporary pools that regularly dry up. Anostracans are mid-water animals, normally swimming on their backs and filtering particulate matter, often algae, from the water or scooping organic material from the surface. Their flattened limbs provide propulsion for swimming, currents for feeding, and a large surface area for respiration. Reproduction is usually sexual, the eggs developing to metanauplii (second-stage larvae) within the egg sac of the female. The metanauplii are retained within the 'egg' shell, more properly called a cyst, which is covered by a hard, resistant coat before being laid. The larvae within their cysts are able to survive desiccation for many months or years. The cysts of all southern African species appear to require desiccation before they will hatch (see Brendonck, 2000 for more details).

The fairy shrimps in our samples belonged to the genus *Streptocephalus*. Only adult male anostracans can be identified to species level, and none of those from the incubation experiments grew to adulthood, so we cannot be sure of the species. Both *S. dendyi* and *S. purcelli* are known from the wetlands we sampled.

A3.3 Cladocerans (Crustacea: Class Branchiopoda: Order Cladocera)

The Cladocera are commonly known as 'water fleas'. Most species are found in fresh water at more or less neutral pH values. They vary in length from <1 mm to nearly 5 mm. The head is not covered by a carapace. The antennae are large and biramous and are the primary organs of locomotion. The body is covered by a folded, unhinged carapace consisting of two valves. The five or six pairs of leaf-like thoracic limbs are greatly modified for food gathering. Most species are filter-feeders, feeding being aided by the beating of the thoracic legs. Other species are benthic scavengers. Dorsally the carapace forms a brood chamber into which eggs are laid. Reproduction is often parthenogenetic. Unfertilized eggs are laid in the brood chamber and after a few days the juveniles, which look like small adults, are released into the surrounding water. After a further two or three days, the young females produce their own eggs. Sexual reproduction generally occurs during times of stress. Males are produced and mating results in the production of fertilized ephippial eggs, which are surrounded by a hard, resistant shell and constitute the life stage that is able to resist desiccation (see Seaman *et al*., 2000 for details).

Appendix 4: Species list

It should be noted that the Albany museum did not identify all of the invertebrate taxa that was collected during the two sampling seasons. Only a selection of the temporary wetland obligate species was identified.

INVERTEBRATE SPECIES LIST	
WET SEASON	
TAXON	ABUNDANCE
Notostraca	
Triops granarius	9
Anostraca	
Streptocephalus cf. cafer	21
Conchostraca	
Eulimnadia africana	4
Lynceus sp.	7
Leptestheria sp.	5
Gastropoda	
Bulinus forskalii	1
Bulinus tropicus	3
Oligochaeta	4
Culicidae	1
Nepidae	
Dytiscidae	
Gyrinidae	
Corixidae	

DRY SEASON SEDIMENT HATCHING	
WET SEASON	
TAXON	ABUNDANCE
Notostraca	
Triops granarius	9
Anostraca	
Streptocephalus cf. proboscideus	21
Conchostraca	
Leptestheriella sp.	5
Copepoda	
Diaptomidae	1
Ostracoda	3
Cladocera	4

EXXARO GROOTEGELUK COMPLEX: Wetland Offset Study

Final Report

April 2020

GroundTruth Reference: GTW726/200220/01
Exxaro Reference: GG/G20/29/03/2017

GroundTruth
Water, Wetlands and Environmental Engineering

Head Office KwaZulu-Natal
P.O. Box 916, Hilton 3245, South Africa
Tel: +27 33 343 2229 - Fax: +27 86 599 2300
admin@groundtruth.co.za
www.groundtruth.co.za

COMPILED BY:

TITLE	SIGNATURE	DATE
Steven Ellery		21/04/2020
Fiona Eggers		14/04/2020

ACCEPTED AND APPROVED BY:

TITLE	SIGNATURE	DATE
Craig Cowden		17/02/2020
Trevor Pike		17/02/2020

DOCUMENT APPROVALS

ROLE	NAME	SIGNATURE	DATE

DISTRIBUTION LIST

AGENCY, ORGANISATION OR PERSON	NO. OF COPIES

DOCUMENT CONTROL

DOCUMENT INFORMATION

INFORMATION	
Document Owner	
Publish Date	[Publish Date]

DOCUMENT HISTORY

VERSION	DATE	CHANGES
Version 1	31/05/19	First draft
Version 2	12/07/19	Removed Thabametsi rehabilitation sites from the formal rehabilitation plan and inserted into appendices.
Version 3	17/02/20	Revised all rehabilitation work proposed in 2019. Have excluded borrow pit rehabilitation until created wetland work has been completed.
Version 4	14/04/20	Revising nomenclature of sites, reviewing Thabametsi mining rights area systems in conjunction with the new Thabametsi project layout.

COPYRIGHT

INDEMNITY

The project deliverables, including the reported results, comments, recommendations and conclusions, are based on the author's professional knowledge as well as available information. The study is based on assessment techniques and investigations that are limited by time and budgetary constraints applicable to the type and level of survey undertaken. GroundTruth therefore reserves the right to modify aspects of the project deliverables if and when new/additional information may become available from research or further work in the applicable field of practice, or pertaining to this study.

GroundTruth exercises reasonable skill, care and diligence in the provision of services, however, GroundTruth accepts no liability or consequential liability for the use of the supplied project deliverables (in part or in whole) and any information or material contained therein. The client, including their agents, by receiving these deliverables indemnifies GroundTruth (including its members, employees and sub-consultants) against any actions, claims, demands, losses, liabilities, costs, damages and expenses arising directly or indirectly from or in connection with services rendered, directly or indirectly by GroundTruth.

VALIDITY PERIOD

It should be noted that the findings of these freshwater ecosystem studies are considered to be valid for a period of five (5) years unless new/additional information warrants a change in project findings. This is based on the likelihood of changes within the systems (e.g. changes in vegetation composition or altered flow patterns) and the associated catchment areas (e.g. increased runoff or establishment of streamflow reduction activities.

[1] Project deliverables (including electronic copies) comprise *inter alia:* reports, maps, assessment and monitoring data, ESRI ArcView shapefiles, and photographs.

TABLE OF CONTENTS

1. INTRODUCTION 14
1.1 Background 15
1.2 Terms of reference 16
2. KNOWLEDGE GAPS 19
2.1 Assumptions 19
2.2 Limitations 20
3. EXPERTISE OF THE SPECIALISTS 22
4. STUDY AREA 24
4.1 Regional context 24
4.2 Climate 24
4.3 Vegetation types 24
4.4 Wetland classification 25
4.5 Threat status of the wetlands 25
4.6 National Freshwater Ecosystem Priority Areas 26
5. METHODS 29
5.1 Desktop analysis 29
5.1.1 Identification of candidate pans 29
5.1.2 Assessment of catchment impacts 30
5.1.3 Assessment of the pans 30
5.1.4 Prioritising additional rehabilitation areas 31
5.2 Rehabilitation work 31
5.2.1 Brush-packing 31
5.2.2 Road removal and rehabilitation 32
5.2.3 Reshaping and earthworks 32
5.2.4 Alien/invasive plant control 33
5.2.5 Revegetation 33
5.3 Infield assessment 33
5.4 Assessment of wetland functioning and condition 33
5.4.1 Assessment of wetland functioning 33
5.4.2 Assessment of wetland condition/integrity 35
5.5 Freshwater ecosystem risk assessment 37
5.6 SANBI offset calculator 38
5.7 Rehabilitation planning 39
6. RESULTS 41
6.1 Characteristics of the freshwater ecosystems 41
6.1.1 Depression wetland functioning 41
6.1.2 Delineation of areas of influence on wetland integrity and functioning 43

6.1.3 Factors influencing the degradation of depression wetlands 44
6.2 Rehabilitation areas 45
6.3 Assessment results of the wetlands identified 58
6.3.1 Wetland ecosystem functioning assessment 58
6.3.2 Wetland ecological integrity assessment 70
6.3.3 Summary of overall ecosystem integrity for the wetlands 78
6.4 Freshwater ecosystem risk assessment 79
6.5 SANBI offset calculator 81
7. WETLAND REHABILITATION PLAN 85
7.1 Wetland problems 86
7.2 Wetland rehabilitation aims and objective 86
7.3 Wetland rehabilitation strategy 86
7.4 Wetland rehabilitation/enhancement interventions 87
7.4.1 Brush-packs 88
7.4.2 Potholes/hollows 89
7.4.3 Road removal and rehabilitation 89
7.4.4 Alien/invasive vegetation removal and follow up activities 90
7.4.5 Re-vegetation and planting 91
7.4.6 Earthen diversion berms 91
7.5 Proposed Rehabilitation strategies for individual HGM units 91
8. SEQUENCE OF WORK AND ESTIMATED COSTS 103
8.1 Sequence of work 103
8.2 Estimated costs 103
9. WETLAND REHABILITATION MONITORING AND EVALUATION 105
9.1 Monitoring of interventions 105
9.2 Fixed point photography/site photographs 106
9.3 Wetland assessments 106
9.4 Wetland rehabilitation effectiveness 106
10. RECOMMENDATIONS/CONCLUSION 108
11. REFERENCES 110
12. APPENDICES 113
12.1 Appendix 1: Proposed Intervention Details for Manketti Sites 113
12.1.1 Intervention A41E-001 114
12.1.2 Intervention A41E-002 115
12.1.3 Intervention A41E-003 116
12.1.4 Intervention A41E-004 117
12.1.5 Intervention A41E-005 119
12.1.6 Intervention A41E-006 120
12.1.7 Intervention A42J-001 121
12.1.8 Intervention A42J-002 123

12.1.9 Intervention A42J-003 125
12.1.10 Intervention A42J-004 127
12.1.11 Intervention A42J-005 128
12.2 Appendix 2: Borrow-pit assessments 130
12.2.1 Characteristics of the freshwater ecosystems 130
12.2.2 Assessment results of the wetlands identified 134
12.2.3 Summary of overall ecosystem integrity for the wetlands 143
12.2.4 Freshwater ecosystem risk assessment 144
12.2.5 SANBI offset calculator 146
12.3 Appendix 3: Proposed rehabilitation strategies for individual borrow pits 148
12.3.1 Proposed enhancement strategy for Borrow Pit 1 148
12.3.2 Proposed enhancement strategy forBorrow Pit 2 150
12.3.3 Proposed enhancement strategy for Borrow Pit 3 151
12.3.4 Sequence of work 152
12.3.5 Estimated costs 152
12.3.6 Wetland rehabilitation monitoring 153
12.4 Appendix 4: Proposed Intervention Details for borrow pit sites 155
12.4.1 Intervention A42J-006 156
12.4.2 Intervention A42J-007 157
12.4.3 Intervention A42J-008 159

LIST OF FIGURES

Figure 1-1 Overview of the plan/study area within the specified cadastral boundaries in relation to the 30 year life of mine 17
Figure 1-2 Overview of the potential offset sites within the study area.......18
Figure 4-1 Overview of NFEPA systems (Nel et al. 2011) within the greater study area 28
Figure 5-1 Chart of useful protective measures for erosion and stabilising of slopes (Sheng, 1990) 32
Figure 5-2 Outline of the approach used to identify the required offset for water resources and ecosystem services, habitat conservation and species of conservation concern.......39
Figure 5-3 Overview of the wetland rehabilitation process 40
Figure 6-1 Overview of the rehabilitation sites across the Manketti Game Reserve and the Thabametsi site. The areas depicted only show wetland habitat – not additional hydrologically connected areas such as the sub-catchments and wider areas of hydrological influence 46
Figure 6-2 Extent of, and impacts associated with Rehabilitation Site 1. 47
Figure 6-3 Photo of the road bisecting Rehabilitation Site 1 (photo taken facing east) 48
Figure 6-4 Extent of, and impacts associated with Rehabilitation Site 2. 49
Figure 6-5 Extent of, and impacts associated with Rehabilitation Site 3. 50
Figure 6-6 Extent of, and impacts associated with Rehabilitation Site 4. 51
Figure 6-7 Extent of, and impacts associated with Rehabilitation Site 5. 52
Figure 6-8 Extent of, and impacts associated with Rehabilitation Site 6. 53
Figure 6-9 The area of erosion to the east of the seasonal zone in Rehabilitation Site 6.......53
Figure 6-10 Extent of, and impacts associated with Rehabilitation Site 7. 54
Figure 6-11 Extent of, and impacts associated with Rehabilitation Site 8. 55
Figure 6-12 Extent of, and impacts associated with Rehabilitation Site 9. 56
Figure 6-13 Extent of, and impacts associated with Rehabilitation Site 10. 57
Figure 6-14 Extent of, and impacts associated with Rehabilitation Site 11. 58
Figure 6-15 Overview of the ecosystem services provided by Rehabilitation Sites 1-4 in the current and post rehabilitation scenarios.......64
Figure 6-16 Overview of the ecosystem services provided by Rehabilitation Sites 5-8 for the current and post rehabilitation scenarios.......65
Figure 6-17 Overview of the ecosystem services provided by Rehabilitation Sites 9-11 for the current and post rehabilitation scenarios. 66

Figure 6-18 Overview of the identified wetlands within the Manketti Game Reserve and the Thabametsi areas and their associated PES category 71
Figure 6-19 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed post-rehabilitation scenarios. 78
Figure 6-20 Possible areas of expansion of Exxaro property in order to achieve the wetland offset targets 84
Figure 7-1 An example of rehabilitated wetland habitat in a landscape previously devoid of functional wetland habitat...85
Figure 7-2 Example of the effects of brush-packing on a localised area 88
Figure 7-3 Example of a road crossing within Rehabilitation Site 4 and its effect on the hydrological connectivity within the wetland. 90
Figure 7-4 Overview of the proposed rehabilitation strategy for Rehabilitation Site 1..........92
Figure 7-5 Overview of the proposed rehabilitation strategy for Rehabilitation Site 2..........93
Figure 7-6 Overview of the proposed rehabilitation strategy for Rehabilitation Site 3..........94
Figure 7-7 Overview of the proposed rehabilitation strategy for Rehabilitation Site 4..........95
Figure 7-8 Overview of the proposed rehabilitation strategy for Rehabilitation Site 5..........96
Figure 7-9 Overview of the proposed rehabilitation strategy for Rehabilitation Site 6..........97
Figure 7-10 Overview of the proposed rehabilitation strategy for Rehabilitation Site 7........98
Figure 7-11 Overview of the proposed rehabilitation strategy for Rehabilitation Site 8........99
Figure 7-12 Overview of the proposed rehabilitation strategy for Rehabilitation Site 9......100
Figure 7-13 Overview of the proposed rehabilitation strategy for Rehabilitation Site 10....101
Figure 7-14 Overview of the proposed rehabilitation strategy for Rehabilitation Site 11....102
Figure 9-1 Location of Rehabilitation Site 4 (Wetland 4) in relation to the Thabametsi Project infrastructure – specifically the IPP 145 Mt Pit. 107
Figure A12-1 Layout of A41E and A42J interventions 113
Figure A12-2 Location Photograph (A41E-001) 114
Figure A12-3 Location Photograph (A41E-006) 120
Figure A12-4 Location Photograph (A42J-001)..122
Figure A12-5 Location Photograph (A42J-002)..123
Figure A12-6 Location Photograph (A42J-003)..125
Figure A12-7 Location Photograph (A42J-005)..128
Figure 12-8 View of Borrow Pit 1. The dark area in the centre being the lowest point of the pit and the lighter areas to the right being the impermeable capped material.130

Figure 12-9 View of Borrow Pit 2. Black lines represent approximate sediment mound generated by sand washed in from the adjacent road......................................131
Figure 12-10 View of Borrow Pit 3. The large bowl is encircled in the black and the secondary smaller bowl for wetland creation is encircled in the white.............132
Figure 12-11 Overview of the borrow pits identified within the study site 133
Figure 12-12 Overview of the ecosystem services provided by the borrow pits for the current and post rehabilitation scenarios..138
Figure 12-13 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed post-rehabilitation scenarios. 143
Figure 12-14 Overview of the proposed rehabilitation strategy for Borrow Pit 1 149
Figure 12-15 Overview of the proposed rehabilitation strategy for Borrow Pit 2 150
Figure 12-16 Overview of the proposed rehabilitation strategy for Borrow Pit 3 151
Figure 12-17 Layout of borrow pit interventions 155
Figure A12-18 Location Photograph (A42J-006)..156
Figure A12-19 Location Photograph (A42J-007)..158
Figure A12-20 Location Photograph (A42J-008)..159

LIST OF TABLES

Table 3-1 Team members, roles, and experience levels 22
Table 4-1 A description of the onsite wetlands based on the SANBI (2009) classification and Kotze et al. 2007 25
Table 4-2 Description of NFEPA wetland condition categories 27
Table 5-1 Class ratings of the wetlands depending on the potential for rehabilitation 30
Table 5-2 Ecosystem services supplied by wetlands 34
Table 5-3 Ratings for describing the EIS of wetlands 35
Table 5-4 Impact scores and present ecological state categories for describing the integrity of wetlands 36
Table 5-5 List of descriptors for the significance score of an impact. 38
Table 6-1 Summary of current Ecosystem Services Scores for Rehabilitation Sites 1-8 60
Table 6-2 Summary of current Ecosystem Services Scores for Rehabilitation Sites 9-11 61
Table 6-3 Summary of post-rehabilitation Ecosystem Services Scores for Rehabilitation Sites 1-8 62
Table 6-4 Summary of post-rehabilitation Ecosystem Services Scores for Rehabilitation Sites 9-11 63
Table 6-5 EIS scores for the Rehabilitation Site 1 in the current and post-rehabilitation scenario 67
Table 6-6 EIS scores for the Rehabilitation Site 2 in the current and post-rehabilitation scenario 67
Table 6-7 EIS scores for the Rehabilitation Site 3 in the current and post-rehabilitation scenario 67
Table 6-8 EIS scores for the Rehabilitation Site 4 in the current and post-rehabilitation scenario 68
Table 6-9 EIS scores for the Rehabilitation Site 5 in the current and post-rehabilitation scenario 68
Table 6-10 EIS scores for the Rehabilitation Site 6 in the current and post-rehabilitation scenario 68
Table 6-11 EIS scores for the Rehabilitation Site 7 in the current and post-rehabilitation scenario 68
Table 6-12 EIS scores for the Rehabilitation Site 8 in the current and post-rehabilitation scenario 69
Table 6-13 EIS scores for the Rehabilitation Site 9 in the current and post-rehabilitation scenario 69

Table 6-14 EIS scores for the Rehabilitation Site 10 in the current and post-rehabilitation scenario 69
Table 6-15 EIS scores for the Rehabilitation Site 11 in the current and post-rehabilitation scenario 69
Table 6-16 Summary of the assessment of the ecological integrity for Rehabilitation Site 1 for the current and post-rehabilitation scenarios 72
Table 6-17 Summary of the assessment of the ecological integrity for Rehabilitation Site 2 for the current and post-rehabilitation scenarios 73
Table 6-18 Summary of the assessment of the ecological integrity for Rehabilitation Site 3 for the current and post-rehabilitation scenarios 73
Table 6-19 Summary of the assessment of the ecological integrity for Rehabilitation Site 4 for the current and post-rehabilitation scenarios 74
Table 6-20 Summary of the assessment of the ecological integrity for Rehabilitation Site 5 for the current and post-rehabilitation scenarios 74
Table 6-21 Summary of the assessment of the ecological integrity for Rehabilitation Site 6 for the current and post-rehabilitation scenarios 75
Table 6-22 Summary of the assessment of the ecological integrity for Rehabilitation Site 7 for the current and post-rehabilitation scenarios 75
Table 6-23 Summary of the assessment of the ecological integrity for Rehabilitation Site 8 for the current and post-rehabilitation scenarios 76
Table 6-24 Summary of the assessment of the ecological integrity for Rehabilitation Site 9 for the current and post-rehabilitation scenarios 76
Table 6-25 Summary of the assessment of the ecological integrity for Rehabilitation Site 10 for the current and post-rehabilitation scenarios 77
Table 6-26 Summary of the assessment of the ecological integrity for Rehabilitation Site 11 for the current and post-rehabilitation scenarios 77
Table 6-27 Summary of the hectare equivalents for the current and post-rehabilitation scenarios for the identified wetland groups 78
Table 6-28 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the rehabilitation activities for the natural systems 80
Table 6-29 Wetland offset targets and the contribution of the identified candidate wetlands towards the wetland functionality and ecosystem conservation targets 81
Table 8-1 Cost summary of offset works 103
Table 8-2 Summary of quantities for offset works (earthmoving) 104
Table 8-3 Summary of quantities for offset works (brush-packing/erosion control) 104

Table 9-1 Criteria used for monitoring earthen structural integrity of wetland rehabilitation interventions 105
Table 12-1 Summary of current Ecosystem Services Scores for the borrow-pit rehabilitation sites 136
Table 12-2 Summary of post-rehabilitation Ecosystem Services Scores for the borrow-pit rehabilitation sites 137
Table 12-3 EIS scores for the Borrow pit 1 in the current and post-rehabilitation scenario 139
Table 12-4 EIS scores for the Borrow pit 2 in the current and post-rehabilitation scenario 139
Table 12-5 EIS scores for the Borrow pit 3 in the current and post-rehabilitation scenario 139
Table 12-6 Summary of the assessment of the ecological integrity for Borrow Pit 1 for the current and post-rehabilitation scenarios 141
Table 12-7 Summary of the assessment of the ecological integrity for Borrow Pit 2 for the current and post-rehabilitation scenarios 141
Table 12-8 Summary of the assessment of the ecological integrity for Borrow Pit 3 for the current and post-rehabilitation scenarios 142
Table 12-9 Summary of the hectare equivalents for the current and post-rehabilitation scenarios for the identified wetland groups 143
Table 12-10 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the rehabilitation activities for the borrow-pits 145
Table 12-11 Wetland offset targets and the contribution of the identified candidate wetlands towards the wetland functionality and ecosystem conservation targets 146
Table 12-12 Cost summary of offset works 152
Table 12-13 Summary of quantities for offset works (earthmoving) 152
Table 12-14 Summary of quantities for offset works (brush-packing/erosion control) 153
Table 12-15 Criteria used for monitoring earthen structural integrity of wetland rehabilitation interventions 153

LIST OF ACRONYMS

Acronym	Explanation
DWE	Digby Wells Environmental
DHSWS	Department of Human Settlements, Water and Sanitation
EIS	Ecological Importance and Sensitivity
FEPA	Freshwater Ecosystem Priority Area
GIS	Geographic Information System
GPS	Global Positioning System
Ha equiv	Hectare Equivalents
HECRAS	Hydrologic Engineering Centres River Analysis System
HGM	Hydrogeomorphic
IUCN	International Union for Conservation of Nature
LiDAR	Light Detection and Ranging
LOM	Life Of Mine
MAP	Mean Annual Precipitation
MDD	Maximum Dry Density
MOD AASHTO	Modified AASHTO Test
MOD Proctor	Modified Proctor Test
NFEPA	National Freshwater Ecosystem Priority Areas
OMC	Optimum Moisture Content
PES	Present Ecological State
PET	Potential Evapotranspiration
QGIS	Quantum Geographic Information System
SANBI	South African National Biodiversity Institute
SVcb	Central Bushveld
SVcb 19	Limpopo Sweet Bushveld
Temp	Temperature
TLB	Tractor-Loader-Backhoe
WRC	Water Research Commission

1. INTRODUCTION

The loss of wetland habitat associated with the expansion of Exxaro's Grootegeluk mine, located approximately 20km to the west of the town of Lephalale within the Limpopo Province of South Africa, were unable to be mitigated onsite. Therefore, suitable candidate sites had to be identified and assessed within portions of Exxaro's landholdings that do not have any proposed opencast mining activities planned (**Figure 1-1**). In accordance with best practice, the Department of Human Settlements, Water and Sanitation (DHSWS) require that the loss of wetland habitat should be offset utilising the SANBI Offset Guidelines (Macfarlane et al. 2014) as a means of ensuring that at a minimum there is 'no-nett-loss' of functional wetland habitat.

Consequently, GroundTruth were appointed to undertake a wetland offset study and rehabilitation plan to mitigate the impacts associated with the proposed expansion of the Grootegeluk mining activities. As part of the wetland offset study, candidate wetland systems/pans were assessed in terms of rehabilitation opportunities in order to address the offset targets. According to the assessments undertaken by GroundTruth (GroundTruth 2018a; GroundTruth 2018b), the proposed expansion of the Grootegeluk mine will result in the loss of 5.86hectare equivalents, with 5.56ha equivalents and 0.30ha equivalents being within the Grootegeluk and Turfvlakte areas, respectively. In terms of the offset targets that would be applicable, the following would need to be considered to mitigate the impacts on the pan systems for the combined areas:

- Wetland functionality target – 5.85hectare equivalents;
- Ecosystem conservation target – 1.31hectare equivalents; and
- Species of conservation concern target – not applicable as no species of concern[2] were identified.

It should be noted that this report includes details from previous studies undertaken by GroundTruth in 2018, and the Digby Wells Environmental (hereafter referred to as Digby Wells or DWE) study in 2018 that focused on the assessment of wetlands associated with the proposed expansion of Exxaro's Thabametsi Coal Mine and potential candidate offset wetlands (DWE 2018). In consultation with Exxaro, the following landholdings (hereafter referred to as the study area) were considered during the selection of suitable candidate wetlands for offsetting (**Figure 1-1**):

- Appelvlakte 448R;
- Appelvlakte 448 (1);
- Gelykebult 450R;
- Gelykebult 455R;
- Goedehoop 457R;
- Graaffwater 456 (1);
- Graaffwater 456R;
- Graaffwater 456 (2);

[2] Species of special concern include Red Data Book or Red List taxa on threatened or conservation concern categories (Macfarlane et al. 2014). The nature of the wetland study (GroundTruth 2018) did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified wetland habitat, offset calculations would need to be amended to account for the mitigation of impacts on the identified species.

- Mc Cabesley 311
- Nelsonskop 464R;
- Nelsonskop 464(1);
- Onbelyk 257R;
- Van der Waltspan 310R;
- Vooruit 449R;
- Zaagput 307R.

Additionally, the rehabilitation planning undertaken for the identified candidate wetland systems[3] is outlined in this report, and has been undertaken in accordance with the approach outlined in WET-RehabPlan (Kotze et al. 2009).

1.1 Background

The Grootegeluk coal mine operation is an opencast mining operation and is located within the Waterberg coalfield of the Limpopo province and is currently the largest of Exxaro's coal mines. The coal reserves associated with the expansion of the Grootegeluk mining activities are considered to be relatively shallow, and as such opencast mining is considered the most desirable option to access these coal reserves. The coal reserves are considered to include A-grade export-quality coal and power station coal, with both of Eskom's Medupi and Matimba power stations being beneficiaries of the coal.

Opencast coal mining is an operation which results in the excavation of a large pit, the associated infrastructure and the overburden dumps. A suite of potential risks and impacts on water resources are associated with these activities and includes not only the direct loss of freshwater ecosystems due to the mining activities, but also the contamination of these freshwater resources.

Currently it is proposed that the areas immediately to the north and the west of the current open-cast mine will be mined – which will be rolled out over a thirty (30) year period (**Figure 1-1**). In order to mitigate the impacts associated with these proposed mining activities, pans located to the north-east of the mine, located in the Manketti Game Reserve, were considered for offsetting purposes (**Figure 1-2**). In addition, a number of wetland systems located in the Thabametsi mining rights area, previously specified for offsetting by Digby Wells (Digby Wells Environmental 2018), were assessed for rehabilitation potential (as seen in **Figure 1-2**). The search for additional offsetting areas in the Thabametsi mining rights area was necessary as many of the systems assessed in the northern section (above the D2001 provincial road) of the Manketti Game Reserve alone were not sufficiently degraded to warrant large-scale rehabilitation. As such, the 'value' of their offsetting potential would not have been sufficient to satisfy the offset requirements for the wetland loss associated with both the Grootegeluk and the Turfvlakte

[3] It should be noted that the wetlands identified within the study area are considered to be non-perennial depression wetlands that only contain water during the rainy season and are commonly referred to as pans. Furthermore, these systems are not sustained by subsurface water inputs and as such are considered to be ephemeral in nature, which is further exacerbated by the low rainfall and high evaporative rates for this area. The formation of these systems coincides with depressions in the landscape that are underlain by suitable substrate, e.g. clay layers. These depressions in the landscape are often formed through a combination of animal wallowing and deflation through aeolian means. The combination of these factors has resulted in the formation of these non-perennial pan systems within the landscape, which are considered to be the only wetlands identified within the study area.

portions, and additional areas had to be considered. It is GroundTruth's understanding that the plans for the Thabametsi mining rights area have changed significantly since the Digby Wells assessment and as such, some of the systems within Thabametsi area can contribute to the Grootegeluk and Turfvlakte offset targets. In addition, it was communicated to GroundTruth that the mining activities associated with the Thabametsi area were only going to commence after 30 years. The Thabametsi systems have already been assigned for offsetting targets by Digby Wells to offset Exxaro's impact in the Thabametsi mining rights area. However, it is GroundTruth's understanding that the impact to wetland systems in the Thabametsi mining rights area will no longer be as extensive and drastic as initially calculated by Digby Wells as the mining and infrastructural plans have changed subsequent to the submission of the Digby Wells report. In addition, no formal detailed rehabilitation plan for the Thabametsi systems has ever been presented, hence they were visited during the site visit and were added to the detailed rehabilitation plan.

1.2 Terms of reference

The study area is located to the north of the Grootegeluk mine and falls under the management of the Manketti Game Reserve (which incorporates the Thabametsi mining rights area), which is an Exxaro-owned entity and operates under Ferroland. Digby Wells undertook a brief review of the wetland systems within the study area, and identified a number of potential candidate pans for offsetting (DWE 2018). Prior to undertaking any onsite pan rehabilitation planning, it is considered to be essential to ascertain the extent of any freshwater ecosystems within the study area. The identification of these systems allows for appropriate planning to be undertaken in order to ascertain whether opportunity exists within the landscape to mitigate the impacts associated with the proposed mining activities. The terms of reference for this study included the following:

- Review of all of the existing freshwater ecosystem studies that have been undertaken to date, which includes all digital data, and would comprise of the following tasks:
    - Desktop collation and review of potential candidate wetlands;
    - Desktop review of wetland impacts; and
    - Mapping of wetland areas at an appropriate scale;
- Site visit/detailed rehabilitation planning;
- Functional assessment of the wetland habitat within the study area for the current and post-rehabilitation scenarios;
- Description of the current state/integrity of the wetland systems within the study area;
- Assessment of the potential gains in hectare equivalents;
- Calculations to determine whether the proposed rehabilitation activities will suitably improve the integrity of the systems, thereby achieving the offset targets; and
- Estimation of costs associated with the agreed wetland rehabilitation activities.

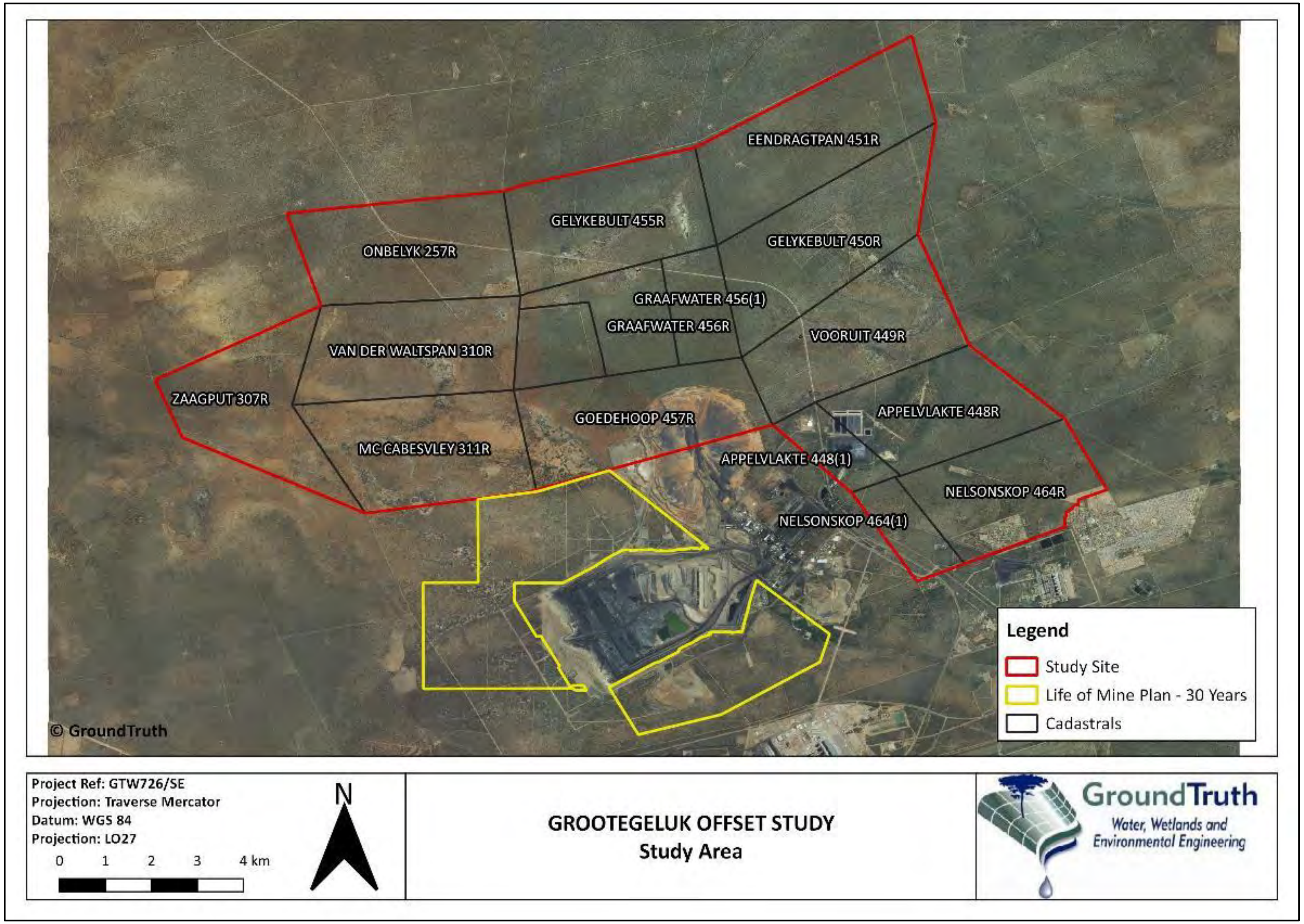


Figure 1-1 Overview of the plan/study area within the specified cadastral boundaries in relation to the 30 year life of mine

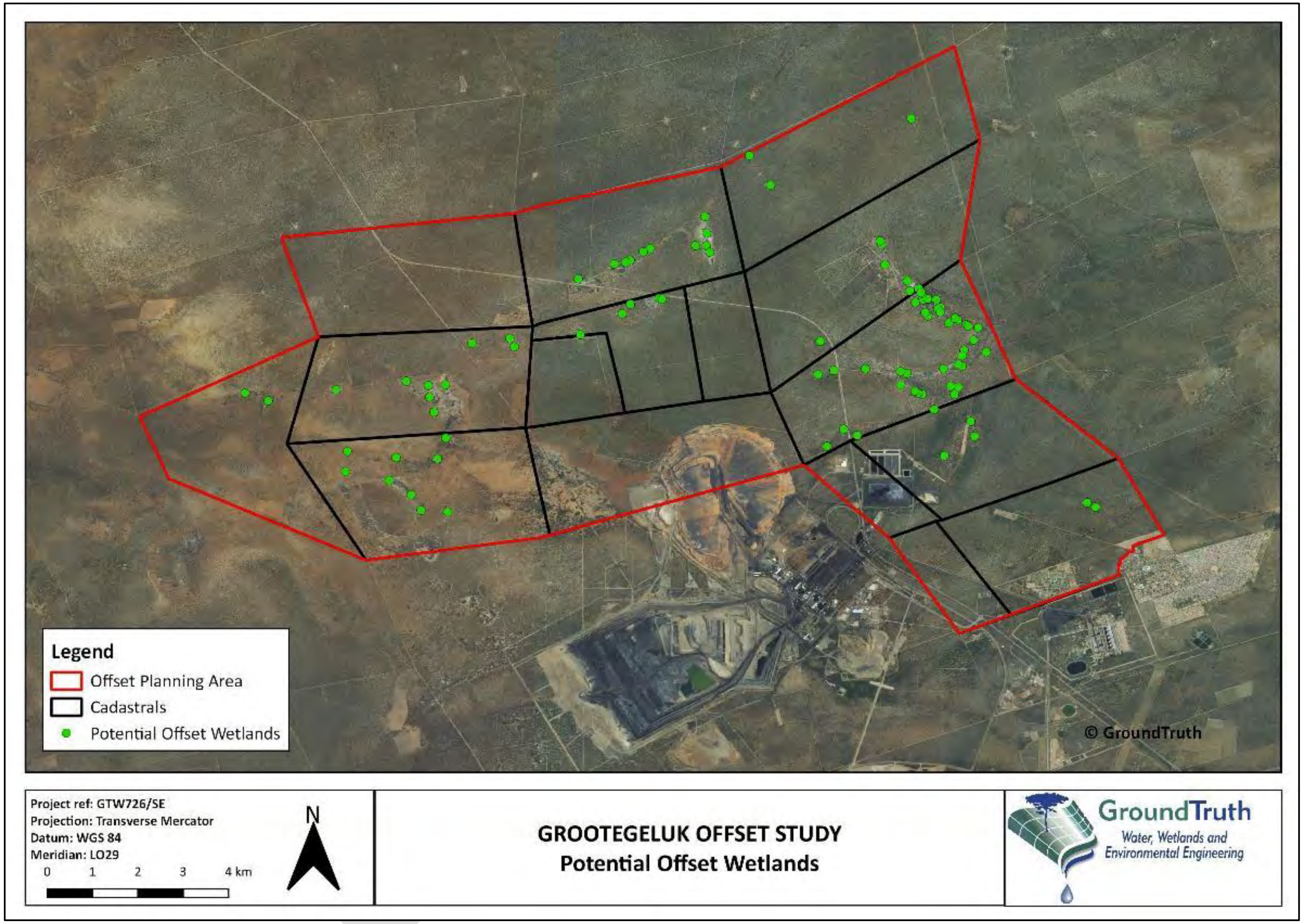


Figure 1-2 Overview of the potential offset sites within the study area

2. KNOWLEDGE GAPS

The following sections highlight the main assumptions and limitations associated with the study.

2.1 Assumptions

Studies that focus on the potential impacts of an activity rely on various assumptions, with the following assumptions being made by the multidisciplinary team (wetland specialists, environmental engineers, terrestrial ecologists and aquatic ecologist) during the assessment of these particular wetland systems:

- The reference/benchmark vegetation of the wetlands was considered to be predominantly barren soils, with only limited wetland vegetation within the larger seasonal pans/depressions.
- The analysis of the areas showed that the catchments yield minimal runoff into the depression areas unless there is a significant rain event.
- For quantifying the brush-packing at the rehabilitation sites, it is assumed that the material is sourced from the clearing of the future mining areas; the haulage distances are calculated from the future LOM areas to each rehabilitation site.
- It is assumed that a large portion of the rehabilitation work will be carried out and implemented by Ferroland - a satellite organisation of Exxaro. Therefore, the majority of the plant hire requirements for the project will be borne by Exxaro. In addition, it is assumed that the majority of the labour will be sourced locally and will already be in the employment of Ferroland or Exxaro.
- A number of the positions and extents of the rehabilitation sites are based on the Digby Wells Environmental study (DWE 2018) and were used to inform the wetland offset calculations as well. However, the DWE delineation and assessment report did not include all the systems present in the Manketti and Thabametsi sites and as such, a number of them were delineated by GroundTruth using a combination of aerial imagery (current and historic), an assessment of dendritic drainage line networks and infield verification.
- The integrity and functional assessments conducted by DWE were acknowledged and used to inform the assessments conducted in this report, but it is assumed that the results presented in this study are the most up-to-date assessments of these systems.
- While the majority of the wetland systems assessed in this study are deemed to be hydrologically isolated from one another (or only connected during very heavy rainfall events), a number of the smaller systems that fall closely together are thought to be hydrologically connected given an average year's rainfall. As such, these smaller systems were grouped together and delineated as a larger complex of wetlands or 'string-of-pearls' configuration[4].

[4] The string-of-pearls configuration is defined by a number of wetland systems that are located in close proximity to one another and become hydrologically linked during the wet season. During the wet season, these systems become hydrologically linked and coalesce into large singular surficial features for a short period of time after

- It assumed that the proposed rehabilitation sites will not be subjected to any mining activities within their catchments. Should mining take place within these systems' catchments, it is anticipated that the contribution of the offset targets would be greatly reduced. Furthermore, should underground mining take place, it is essential that the systems are monitored to ensure the systems are not negatively affected.

2.2 Limitations

Limitations and uncertainties often exist within the approaches and techniques used to assess the condition of natural systems, with the following limitations applying to the studies undertaken for this report:

- The vegetation species collected during the wet season site visit were unidentifiable in some instances due to being at the end of the flowering season.
- The assessment of the wetland systems was based on the beta-version of the latest wetland integrity assessment technique, which is currently unpublished (Macfarlane et al. 2018). This latest assessment technique will replace the current WET-Health assessment technique (Macfarlane et al. 2007) in the near future. As such, this assessment technique was considered to be the most appropriate at the time of the compilation of the report, however, in some instances it may have shortfalls. These techniques, however, have been compiled based on international best practice to apply to South African conditions. These assessment techniques should therefore, be seen as the most appropriate tools for wetland assessments at this time.
- The assessments of the identified wetland habitat are based on two site visits, *i.e*. a 'snap-shot' in time, due to budgetary and time constraints. As such, changes in the recorded features and/or characteristics within the wetlands and their catchments, which may be subject to the influences of seasonality and/or land use changes, may not be accounted for in the assessments.
- The assessment of the wetland systems' ecological integrity includes catchment conditions and it should be noted that changes in the wetlands' catchments may have an adverse effect on the systems' integrity.
- WET-EcoServices assists in identifying the importance and sensitivity of specific wetlands but is recognised as having limitations in terms of quantifying specific impacts linked to development or changes within the landscape; and accounting for the size of the wetland and ecosystem services strongly associated with the size of the systems.
- The nature of the study did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified wetland habitat, offset calculations

---

rainfall. As these larger wetlands dry, the extent of each smaller system retreats into their more 'permanent' depressions which is where the typical wallow pit and clay substrates are located. The connection of these systems during the wet season cannot be ignored and disturbances in the space between the wallow pits may affect the structure and functioning of the more permanent wetland areas. Therefore, these smaller permanent wetlands have been grouped and delineated to include the areas that become temporarily inundated during the wet season.

would need to be amended to account for the mitigation of impacts on the identified species.

- Due to the gentle terrain, surrounding free-draining soils, and high evaporation to precipitation ratio, it was difficult to identify what area of the catchment impacts the wetland functioning and water inflows in wetland systems.
- The LiDAR data provided was not fine enough to calculate the gradients surrounding the offset sites. Therefore, some assumptions were made during this study. Any discrepancies that may arise in these areas can be rectified with a tachometry surveying or additional LiDAR data, as a result flows could not be accurately quantified or traced with missing data.
- In addition to the sparse LiDAR data, there were areas with missing data within the boundaries of Graafwater and Van Der Waltspan farms. In addition, the LiDAR data was clipped to the extent of the study area. Therefore, the mapping of catchments that extend beyond the study area boundary was done based on 5m contour data.
- As the integrity and functionality of the identified candidate wetlands in the Manketti Game Reserve and the Thabametsi mining rights area is considered to be generally less than the wetlands that will be lost within the study area, the candidate wetlands are unable to contribute fully towards the functionality offset target. It should be noted, that the integrity of the offset receiving systems was generally considered to be ‘near natural’ to ‘minimally modified’ (scores ranging between health classes A and C) and as such, rehabilitation options were limited. As such the overall improvement of systems’ integrity will not be drastic as the majority of systems have been managed and maintained in a healthy state. In addition, should a security of tenure of between thirty (30) and sixty (60) years be adopted on Exxaro owned land, in conjunction with the created wetland habitat trial within the greater study area; it is anticipated that the authorities may consider the proposed mitigation measures appropriate.
- It should be noted that this report only includes the offset targets required to offset the wetland losses associated with Grootegeluk and Turfvlakte. The offset requirements for the Thabametsi mining rights area were calculated by DWE (2018) using a different method to those that were employed in GroundTruth (2018a & 2018b) and are therefore not comparable.

The project deliverables, including the reported results, comments, recommendations and conclusions, are based on the authors’ professional knowledge as well as available information. This study is based on assessment techniques and investigations that are limited by time and budgetary constraints applicable to the type and level of survey undertaken. This study is, however, considered to be the most accurate and up to date assessment of the wetland habitat associated with the study area, and should be used to inform the decision-making processes of the relevant authorities.

3. EXPERTISE OF THE SPECIALISTS

Due to the nature of the study, the project team consisted of multiple team members to ensure that the project objectives could be met. All team members have comprehensive experience in projects involving mapping, delineation, invertebrate analysis and assessment of wetland systems (**Table 3-1**).

Table 3-1 Team members, roles, and experience levels

Practitioner	Roles in the Study	Experience Levels	Qualifications
Craig Cowden	• Project management; • Conducting the wet season sampling; and • Review of the project report.	20 years' of experience, with input into various wetland studies, including: • Delineation; • Assessments; • Rehabilitation planning; • Monitoring and evaluation of wetland rehabilitation projects; and • Mitigation & offset requirements.	MSc (Environmental Science) Pr.Sci.Nat – Ecology
Fiona Eggers	• Conducting the wet season site visit; and • Review of project report.	9 years' of experience with input into various wetland studies: • Delineation, • Assessments, • Rehabilitation planning; • Monitoring and evaluation of wetland rehabilitation projects; • Mitigation & offset studies; and • Wetland creation.	MSc (Botany) Pr.Sci.Nat – Ecology
Gary De Winnaar	• Conducting wet season sampling; • Invertebrate results analysis; and • Conducting biodiversity surveys.	10 years' experience, with input into biodiversity studies and assessments of aquatic and terrestrial ecosystems, including: • Aquatic biomonitoring and assessments; • Desktop assessments and GIS mapping; and Impact assessments, rehabilitation planning and mitigation measures.	M.Sc. (Hydrology) Pr.Sci.Nat. (Ecology)

Dr Vere Ross-Gillespie	• Conducting the dry and wet season sampling; • Invertebrate results analysis; and • Conducting biodiversity surveys.	5 years' experience, with input into various freshwater ecosystem studies, including: • Biomonitoring; • Rehabilitation studies; • Reserve determinations; • Assessments; and • Monitoring and evaluation of aquatic ecosystems and water quality.	PhD (Zoology - Freshwater) Pr.Sci.Nat - Ecology
Trevor Pike	• Conducting the infield rehabilitation and enhancement planning (Engineering); • Material analysis; and • Review of the project report.	20 years' experience, with input into various environmental engineering studies, focussing on: • Wetland rehabilitation planning; • Wetland rehabilitation implementation support; and • Stormwater management.	BSc (Civil Engineering) Pr.Eng
Keaton Parker	• Conducting the infield rehabilitation and enhancement planning (Engineering); and • Material analysis	3 years' experience, with input into various geotechnical, structural and environmental studies, including: • Construction Management • Engineering design • Assessments; and • Material analysis and reporting	BSc.Eng (Civil Engineering)
Steven Ellery	• Conducting wet season sampling; • Assisting with biodiversity surveys; • Wetland delineation and assessments; • Wetland rehabilitation plan; and • Compilation of project report	1 years' experience, with input into various freshwater ecosystem studies, including: • Infield research studies; • Rehabilitation planning; • Delineation; and • Assessments	MSc (Geomorphology)

4. STUDY AREA

The following section provides an overview of the study site, focusing on the regional context, climate, wetland types and aquatic invertebrates.

4.1 Regional context

South Africa is a semi-arid country, and thus wetlands are important features within the landscape as they provide ecosystem services directly related to water quantity and quality. Approximately 300'000ha of wetlands or 2.4% of South Africa's surface area remain. It is estimated that there has been a loss of between 35% and 60% of wetlands across the major catchments in South Africa and of the remaining systems, 48% are classified as critically endangered making these systems the most threatened ecosystems (Nel and Driver 2012).

Taking into consideration the above-mentioned degradation of wetland ecosystems, it is important that a "no-nett-loss" of wetland functioning and habitat is maintained within the broader landscape, which may include the formal protection of wetland systems and/or the creation of wetlands within the landscape not being directly influenced by the proposed mining activities.

4.2 Climate

The study site falls across the A41E and A42J quaternary catchments, as defined by Midgley et al. (1994). These quaternary catchments form part of the Matlabas/Mokolo River catchment. The Mean Annual Precipitation (MAP) for A41E is 439.4mm and Potential Evapotranspiration (PET) is 2'407mm (Schulze 2007). The MAP for A42J is 428.6mm and PET is 2'444mm (Schulze 2007). This suggests that the wetlands/non-perennial pans within the catchments would have **High** sensitivity (Macfarlane et al. 2007) to hydrological impacts within the catchment.

4.3 Vegetation types

Under natural conditions the surrounding landscape and study site would have been characterised by particular vegetation types. The historical dominant vegetation type present would have been the Limpopo Sweet Bushveld (SVcb 19) (Mucina and Rutherford 2006), which falls under the Central Bushveld Group 4 (SVcb) bioregion (Nel et al. 2011; Mucina and Rutherford 2006). The vegetation type has been classified as 'least threatened', with 0.6% receiving formal protection. Of the remaining 94.9% only a small percentage is statutorily protected in reserves including D'Nyala Nature Reserve and very little conserved in other reserves.

This vegetation extends from the lower reaches of the Crocodile and Marico Rivers, down to the Limpopo River Valley, towards the Usutu border post and Taaiboschgroet area. This vegetation type also occurs on the Botswanan side of the border. The vegetation commonly occurs between 700-1'000m above sea level. The greatest threats to this vegetation type can be attributed to cultivation (Mucina and Rutherford 2006). It should be noted, that detailed descriptions of the vegetation units and their relationships are described in more detail in the report compiled by Natural Scientific Services in 2011.

4.4 Wetland classification

To allow for the differentiation between wetland systems and the prioritisation of systems either for conservation or management purposes, the wetlands were classified in accordance with the South African National Biodiversity Institute's (SANBI) wetland classification system (2009) (**Table 4-1**) (Ollis et al. 2013). However, for the purpose of assessing the Hydrogeomorphic (HGM) units, Kotze et al. (2007) was used to classify the wetland systems as HGM units rather than Level 4 of the SANBI system. The HGM unit types defined by Kotze et al. (2007) differ from SANBI (2009), with the river classification being excluded and flat wetlands being grouped with the depression wetlands. The HGM units identified within the study area have been classified as pans.

Table 4-1 A description of the onsite wetlands based on the SANBI (2009) classification and Kotze et al. 2007.

System (Level 1)	Bioregion (Level 2)	Landscape Unit (Level 3)	HGM Unit (Level 4)	Description of HGM Units (Kotze *et al.*, 2007)
Inland systems	Central Bushveld Group 4 (SVcb) Bioregion	Flat landscape unit	**Depressions (including Pans)**	
			Pans	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (*i.e.* it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.

4.5 Threat status of the wetlands

Globally, temporary water bodies are among some of the most threatened habitats, leading to their often unique and diverse fauna (e.g. branchiopods, arthropods, plants and other biota) being at risk (De Roeck et al 2007). Southern Africa is considered one of the world diversity hotspots for large branchiopod crustaceans. The Mediterranean type climate in the Western Cape and the drier climate in the northern parts of the country support temporary aquatic systems which dry out completely in the dry season and which often provide the only available sources of water in the regions. De Roeck et al (2007) states that these systems which are highly threatened and neglected in South Africa (Davies and Day 1998) have also likely been reduced/degraded at an alarming rate over recent decades, owing to anthropogenic impacts. These habitats vary markedly in their physical and chemical conditions (e.g. complete drying in the dry season, highly variable hydrological and thermal regimes) when compared to permanent water bodies, leading to the presence of specially adapted fauna and flora which can utilize available resources. The fauna are also free from fish predation in such habitats, as fish require permanent water bodies for survival and reproduction. Such habitats are therefore distinct from permanent ponds, support a diversity of fauna and flora not found elsewhere (including vascular plants, microorganisms, macroinvertebrates – some of which are endemic, rare or endangered), contribute significantly to overall regional diversity whilst being sensitive to anthropogenic impacts and climate change (Williams 1997). Furthermore, these habitats can play an important role in the landscape ecology, by providing migration corridors and isolated habitats for colonization/dispersal thereby contributing to metapopulation and metacommunity processes (De Meester et al. 2005, Zedler and Kercher 2005, Zacharias et al. 2007) in the broader region. Migratory birds utilize such habitats for feeding along with other wildlife which use the habitats for foraging, breeding and wallowing (Waterkeyn 2009).

Despite these systems being recognised as important, as previously discussed, the vast extent and number of systems within the broader landscape and bioregion needs to be considered. The wetland types fall within the Central Bushveld Group 4 (SVcb) bioregion, as described in **Section 4.3**. Based on the wetlands and vegetation types, and the level of protection these systems receive, the ecosystem threat status can be assessed (Nel et al. 2011). For the identified wetland vegetation group, the ecosystem threat status is considered to be 'Least Threatened', which appears to be linked to the vast extent the vegetation type/bioregion extends over. However, the ecosystem threat status for the wetland vegetation group is considered to be 'Vulnerable'[5], which may be attributed to the limited level of protection the vegetation type receives (Nel et al. 2011).

The draft resource quality objectives report (Government Gazette No. 41310) has been compiled by DHSWS (2017) to guide the management and use of freshwater ecosystems within the Mokolo, Mtalabas, Crocodile (west) and Marico catchments, and as such has been reviewed in terms of the study site as it is located within the Mokolo catchment. It should be noted though, that this document is currently still in draft format and is in the process of being finalised. Nonetheless, the Mokolo catchment has been classified as a Class II catchment, which indicates that a moderate level of protection and utilisation of the area must be considered. The Sandloop River, located to the south of the study site, however, which is not hydrologically linked to the site, has been classified as a C category system, and as such should be maintained in this category. With regards to the resource quality objectives for priority wetland clusters and systems, the Government Gazette does not refer to depression/pans systems but rather valley-bottom wetlands and hillslope seepage systems (DHSWS 2017). Even though, no particular reference has been made to pans, it is considered to be best practice, that there is "no-nett-loss" of wetland habitat (integrity and functioning) within the landscape, which may be addressed through appropriate rehabilitation and enhancement activities (refer to **Section 7**).

4.6 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) is a tool developed to assist in the conservation and sustainable use of South Africa's freshwater ecosystems, including rivers, wetlands and estuaries. Nel et al. (2011) classified the freshwater ecosystems according to their Present Ecological State 'AB', 'C', and 'DEF' or 'Z' (**Table 4-2**).

[5] It should be noted that formal protection of these systems is likely to be viewed favourably by the relevant authorities.

Table 4-2 Description of NFEPA wetland condition categories
(Nel et al. 2011)

PES equivalent	NFEPA condition	Description	% of total national wetland area*
Natural or Good	AB	Percentage natural land cover ≥ 75%	47
Moderately modified	C	Percentage natural land cover 25-75%	18
Heavily to critically modified	DEF	Riverine wetland associated with a D, E, F or Z ecological category river	2
	Z1	Wetland overlaps with a 1:50 000 'artificial' inland water body from the Department of Land Affairs: Chief Directorate of Surveys and Mapping (2005-2007)	7
	Z2	Majority of the wetland unit is classified as 'artificial' in the wetland locality GIS layer	4
	Z3	Percentage natural land cover ≤ 25%	20

*this percentage excludes unmapped wetlands, including those that have been irreversibly lost

According to the available NFEPA wetlands and rivers coverage, there are no Freshwater Ecosystem Priority Areas (FEPA) within the study area (**Figure 4-1**). Only the Sandloop River, located to the south and south east of the study area, is considered to be a FEPA system. The Sandloop River is not hydrologically connected to any of the wetland systems within the study area, but there is a shallow and flat valley bottom feature that runs from the study site in an easterly direction and eventually flows into the Sandloop River. While the Sandloop River may not derive any surface flows that originate from the Manketti site, this may be deemed as an important landscape connection as there may be important genetic flows that occur between the two sites. In addition, there are a number of low priority NFEPA wetlands within the study area that have possibly been prioritised for their rarity and unique origin.

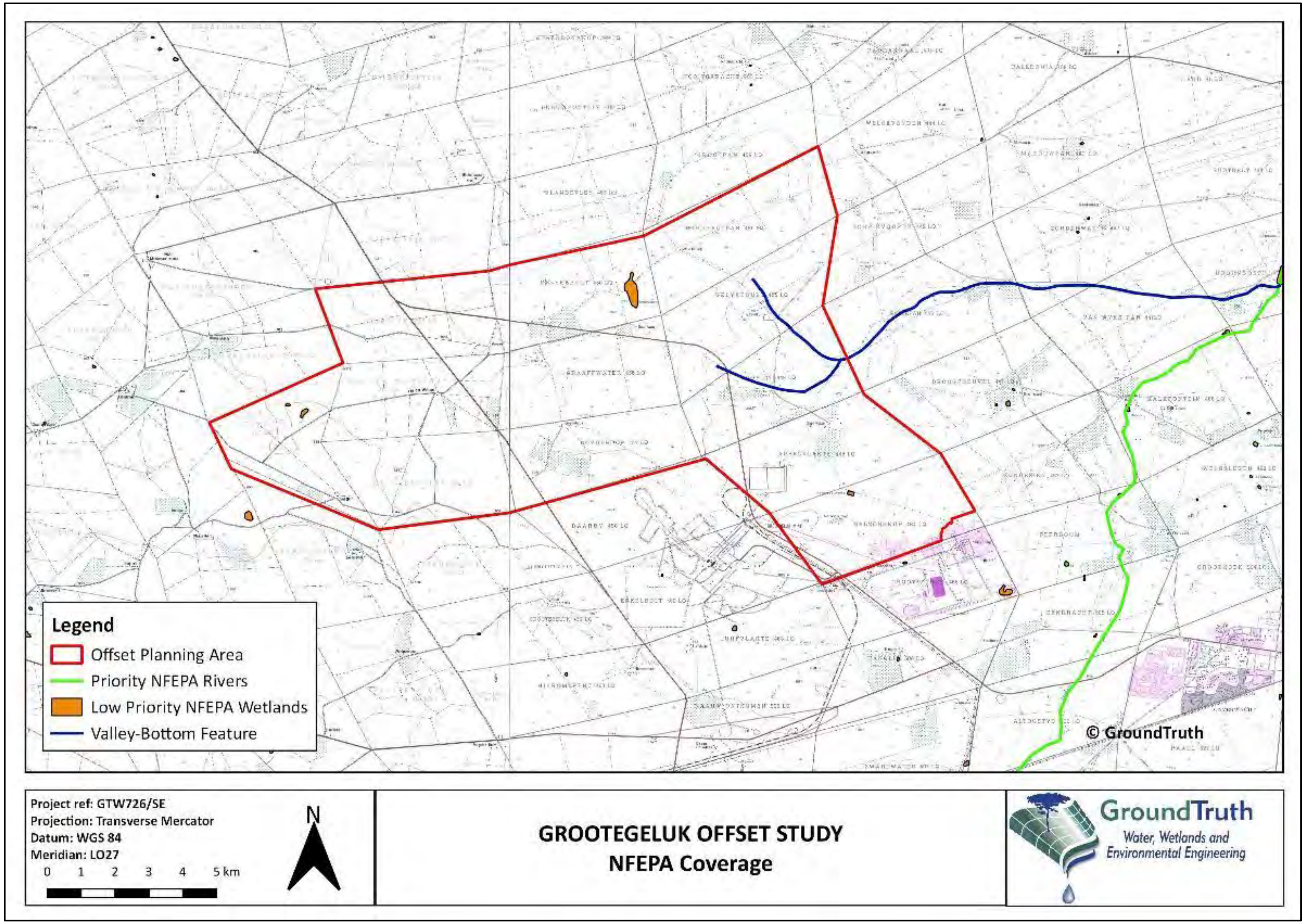


Figure 4-1 Overview of NFEPA systems (Nel et al. 2011) within the greater study area

5. METHODS

This section of the report provides an overview of the methods adopted to for the determination of losses associated with the expansion of the proposed Grootegeluk mining activities, the targets to be achieved through an offset approach and the contribution of the identified candidate systems towards offset targets, which includes the proposed rehabilitation activities.

5.1 Desktop analysis

At the outset, a desktop analysis of the study area was undertaken (refer to **Figure 1-1** and **Figure 1-2**) to identify potential candidate pans for rehabilitation, in order to address the SANBI offset targets. It should be noted that the desktop review of the candidate systems was informed by the Digby Wells (DWE 2018) study however, this study was considered to be a high-level study. The desktop analysis further served to inform the overall wetland rehabilitation planning process with the objectives to:

- Review existing data supplied by Exxaro;
- Identify potential candidate pans and/or borrow pits for rehabilitation/creation and protection;
- Preliminarily evaluate the pans based on:
  - Area;
  - Level of transformation;
  - Visible problem areas;
  - Catchment land use activities;
  - Location;
  - Future land use activities[6];
- Prioritise those pans that may warrant rehabilitation;
- Establish the nature of problem within the pans that may require rehabilitation;
- Determine the possible level of rehabilitation required; and
- Determine whether the creation of wetland habitat within the disused borrow pits would be a feasible option to contribute towards the offset targets.

5.1.1 Identification of candidate pans

The identification of suitable pans for rehabilitation purposes was undertaken at a desktop level utilising available satellite and aerial imagery, the Digby Wells (DWE 2018) proposed candidate wetlands spatial coverage, and contour data. It should be noted that additional pans, beyond the Digby Wells candidate pans were identified following a detailed review of the aerial imagery and were mapped at a desktop level, with limited infield verification. The desktop mapping relied largely on changes in vegetation cover and colouration of the soils

[6] Currently the landholdings/study area is owned by Exxaro and any pans identified for rehabilitation/protection will be maintained and protected to ensure that the offset targets are achieved and maintained. Should the ownership of the landholdings change, it is anticipated that the new landowners would be responsible for the management and maintenance of these systems.

and dense radial animal tracks. The desktop level mapping/analysis was performed in Quantum GIS at a scale of 1:5'000 to create a Geographical Information System (GIS) spatial coverage of the wetland ecosystems within the study area.

5.1.2 Assessment of catchment impacts

The catchment and sub-catchments areas of the identified pans were interrogated using available satellite and aerial imagery in order to determine the various land use practices and/or impacts within the catchments. The extent and possible intensity of the activities were broadly assessed, provisionally highlighting the extent of the impacts on the pans. The greater the transformations within the landscape and/or the proximity of the impacts to the pans, the more likely the pan will be substantially altered and therefore, require rehabilitation. In the majority of the instances the sub-catchments are characterised by land use practices associated with the Manketti Game Reserve, and as such the impacts are limited to historical land use practices, e.g. overgrazing by livestock, road networks, and/or overutilization of an area due to a pan being a permanent artificial source of water. As such, in some instances there are limited in-system impacts but rather catchment related impacts, which can be attributed to and should be rectified by the management of the veld in an appropriate manner.

5.1.3 Assessment of the pans

Following the assessment of the catchment impacts, the pans were reviewed for rehabilitation opportunities. The aerial imagery was interrogated for erosion associated with animal paths, sedimentation and/or encroachment of invasive vegetation surrounding the pans and/or within the temporary zone of the pans. The extents of the impacts were considered in comparison to the size of the pan in question, to determine the potential costs of rehabilitating the system to eliminate "lost causes".

A spatial coverage of the pans in the study area was created, indicating the identified problem areas, and rating the systems according to rehabilitation potential. These ratings were based on the rehabilitation objectives, catchment impacts, the pan extent, and potential problems to be addressed by rehabilitation efforts (**Table 5-1**).

Table 5-1 Class ratings of the wetlands depending on the potential for rehabilitation
(Cowden and Kotze 2009)

Rank	Description of the class based on the score rating
0	Very low rehabilitation potential – very low returns or rehabilitation costs are considered to be too high.
1	Low rehabilitation potential – identified threats within the system however; return on rehabilitation investment potentially low or uncertain.
2	Moderate rehabilitation potential – identified threats within the system with the return on rehabilitation investment moderate.
3	High rehabilitation potential – identified threats within the system with the return on rehabilitation investment being high.

5.1.4 Prioritising additional rehabilitation areas

Following the desktop assessment of the offset sites, it was uncertain as to whether there were a sufficient number of rehabilitation-worthy[7] wetland areas within the Greater Manketti study site to meet the wetland functionality target of 5.85hectare equivalents. Therefore, additional wetlands within the Thabametsi mining rights area were also assessed for rehabilitation purposes. In addition to the Thabametsi sites, it may be necessary for Exxaro to consider purchasing the Ganzepan 446 farm to the east of Manketti that is host to the valley-bottom feature that connects the Manketti systems to the Sandloop River. Exxaro already owns the land to the east of Ganzepan 446R (Zonderwater 442R farm portion) and it may provide Exxaro with ample offsetting opportunity from both wetland and landscape connectivity points of views.

5.2 Rehabilitation work

Of the eleven (11) offset rehabilitation sites, totalling an area of 47.19ha, seven (7) are depression wetlands across the Thabametsi mining rights area, and four (4) more depression wetlands within the Manketti Game Reserve Area. The following rehabilitation work will be undertaken.

5.2.1 *Brush-packing*

Packing brush on bare patches of earth has been known to increase water infiltration, reduces the temperature of the soil surface, allows a seed bank to build up and adds organic material to the soil. This method is both low-cost and effective at trapping aeolian and alluvial deposits of seed and sediment, as well as shading and preventing any animals from grazing the area (**Figure 5-1**).

The quantifying of brush-packs has been included in **Appendix 1**, however the costing for this is dependent on Exxaro's labour force, haulage lengths and availability of materials. This will need to be reviewed and recalculated closer to implementation.

[7] Rehabilitation-worthiness was assessed based on a number of landscape and wetland characteristics which included; the extent of direct disturbance by man (roads, dam walls, infilling, excavation etc.), the nature of the water source (natural/artificial) and the extent of catchment derived impacts associated with poor veld condition.

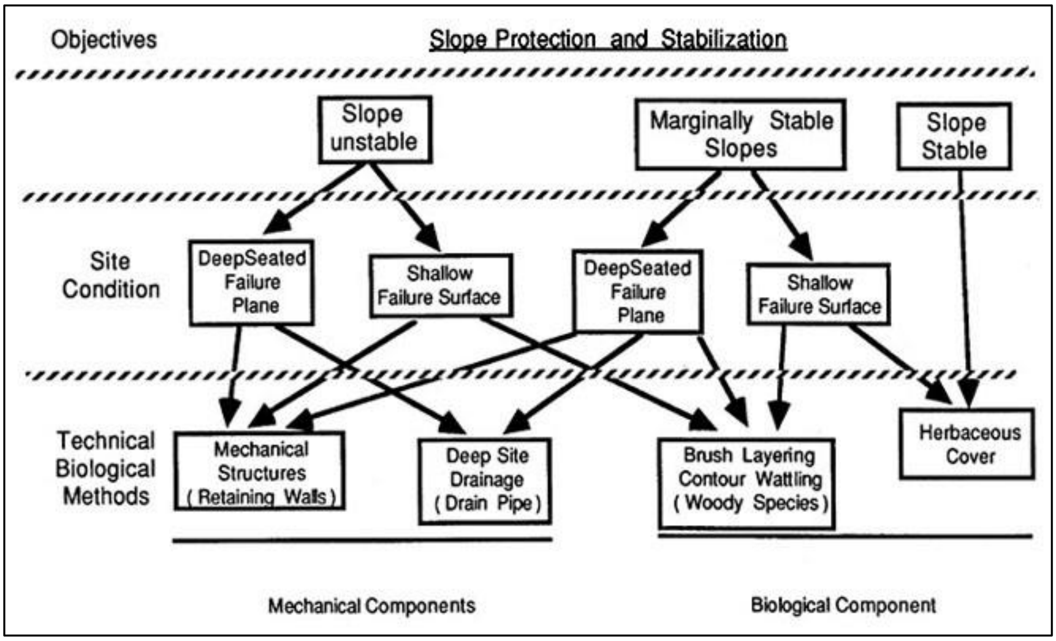


Figure 5-1 Chart of useful protective measures for erosion and stabilising of slopes (Sheng, 1990)

5.2.2 Road removal and rehabilitation

Various roads have been identified as passing through wetlands or running adjacent to the rehabilitation areas. Where drainage has not been controlled across roads, there is gully erosion which will need to be repaired, as well as structures to control water flow in these areas. The roads that will need to be removed will need to be appropriately levelled and revegetated, if the road needs to pass through the area it can be rerouted around the wetland and brush-packs to be installed next to the roads to prevent any erosion. When shaping the roads, it is imperative that the material is bladed to the middle of the road and not to the sides, as observed during the site visits. If material is bladed to the edges of the road during road levelling it forms windrows, which stops any water from flowing and creates a loose soil that is prone to silting up the rehabilitation sites.

5.2.3 Reshaping and earthworks

Areas around the rehabilitation sites will be reshaped to shallower slopes, and compacted to reduce the likelihood of any loose soil silting up the bottom of the depressions. Brush-packing around the sites will be accompanied with ponding areas to further reduce any sediment from mobilising into the rehabilitated areas. A few earthen berms are to be removed to allow water to flow freely, whereas other places berms are to be constructed to divert water flow or to stop vehicles from travelling on roads. The material created from the removal of berms must be taken offsite so that the sediment does not affect any surrounding areas; this will be accounted for as a haulage item in the costing.

5.2.4 Alien/invasive plant control

Dense stands of woody invasive species were identified in the sub-catchment and within two (2) of the rehabilitation sites. The removal of these species would improve both the hydrological and vegetative integrity of these wetland areas. The invasive vegetation removal should be done by a hand team and five (5) follow up treatments have been specified to eradicate any regrowth that is likely to occur.

5.2.5 Revegetation

Any damaged or reshaped areas will require revegetation, along with brush-packs to allow the vegetation to germinate. Prior to revegetation, there should be a suitable top soil, of which should be scarified and then seeded during the wet season.

5.3 Infield assessment

A site visit was conducted from the 25th of February till the 1st of March 2019, to identify suitable wetlands for rehabilitation, and assess the current level of ecological integrity, and ecosystem services provided by the wetlands. An additional field visit was conducted between the 4th and the 6th of December 2019 for additional rehabilitation planning.

5.4 Assessment of wetland functioning and condition

The expansion of the proposed Grootegeluk mining activities will result in the loss of wetland habitat and therefore, a residual impact (refer to **Section 1**). To be able to proceed with the expansion of the mining activities, Exxaro needs to ensure that the impacts of the proposed activities are mitigated through the rehabilitation of candidate pans and/or creation of wetland habitat within borrow pits, to meet offset targets. The assessment of the candidate systems was undertaken for both the current and post-rehabilitation scenarios, to ascertain whether the proposed activities will assist in attaining the offset targets (refer to **Section 1**). The approach undertaken is outlined in the following sections.

5.4.1 Assessment of wetland functioning

To quantify the level of functioning of the wetland systems, and to highlight its relative importance in providing ecosystem benefits and services at a landscape level, a WET-EcoServices (Kotze et al. 2007) assessment was performed for the current and post-rehabilitation scenarios. The WET-EcoServices assessment technique (Kotze et al. 2007) focuses on assessing the extent to which a benefit is being supplied by the wetland habitat, based on both:

- The opportunity for the wetland to provide the benefits; and
- The effectiveness of the particular wetland in providing the benefit.

Ecosystem services, which include direct and indirect benefits to society and the surrounding landscape, were assessed by rating various characteristics of the wetland clusters and the surrounding catchment, based on the following scale:

- Low (0);

- Moderately Low (1);
- Intermediate (2);
- Moderately High (3); and
- High (4).

The scores obtained from these ratings for the wetland clusters were then incorporated into WET-EcoServices scores for each of the fifteen ecosystem services (**Table 5-2**).

Table 5-2 Ecosystem services supplied by wetlands
(Kotze et al. 2007, p14)

<table>
<tr><td rowspan="15">Ecosystem services supplied by wetlands</td><td rowspan="8">Indirect benefits</td><td rowspan="8">Regulating and supporting benefits</td><td colspan="2">Flood attenuation</td><td>The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream.</td></tr>
<tr><td colspan="2">Stream flow regulation</td><td>Sustaining stream flow during low flow periods.</td></tr>
<tr><td rowspan="5">Water quality enhancement benefits</td><td>Sediment trapping</td><td>The trapping and retention in the wetland of sediment carried by runoff waters.</td></tr>
<tr><td>Phosphate assimilation</td><td>Removal by the wetland of phosphates carried by runoff waters.</td></tr>
<tr><td>Nitrate assimilation</td><td>Removal by the wetland of nitrates carried by runoff waters.</td></tr>
<tr><td>Toxicant assimilation</td><td>Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters.</td></tr>
<tr><td>Erosion control</td><td>Controlling of erosion at the wetland site, principally through the protection provided by vegetation.</td></tr>
<tr><td colspan="2">Carbon storage</td><td>The trapping of carbon by the wetland, principally as soil organic matter.</td></tr>
<tr><td rowspan="7">Direct benefits</td><td colspan="3">Biodiversity maintenance</td><td>Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity.</td></tr>
<tr><td rowspan="3">Provisioning benefits</td><td colspan="2">Provision of water for human use</td><td>The provision of water extracted directly from the wetland for domestic, agricultural or other purposes.</td></tr>
<tr><td colspan="2">Provision of harvestable resources</td><td>The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.</td></tr>
<tr><td colspan="2">Provision of cultivated foods</td><td>The provision of areas in the wetland favourable for the cultivation of foods.</td></tr>
<tr><td rowspan="3">Cultural benefits</td><td colspan="2">Cultural heritage</td><td>Places of special cultural significance in the wetland, e.g. for baptism or gathering of culturally significant plants.</td></tr>
<tr><td colspan="2">Tourism and recreation</td><td>Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife.</td></tr>
<tr><td colspan="2">Education and research</td><td>Sites of value in the wetland for education or research.</td></tr>
</table>

It should be noted that Wet-EcoServices assists in identifying the importance and sensitivity of specific wetlands, but is recognised as having limitations in terms of:

- Quantifying specific impacts linked to development or changes within the landscape; and

- Accounting for the size of the wetland and ecosystem services strongly associated with the size of the systems.

As WET-EcoServices does not provide a consolidated score that can be used as a target, the current and post-rehabilitation assessment scores were incorporated into the Wetland Importance and Sensitivity assessment datasheets to provide an EIS score based on scores for ecological importance and sensitivity, hydro-functional importance, and direct human benefits (Rountree and Malan 2010). **Table 5-3** provides an overview of the ratings used to record EIS scores.

Table 5-3 Ratings for describing the EIS of wetlands
(Rountree and Malan 2010)

Rating	Explanation
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

5.4.2 Assessment of wetland condition/integrity

For the purpose of the rehabilitation planning, and determining the potential gain in hectare equivalents, the systems identified for rehabilitation were assessed using the WET-Health (beta version of Macfarlane et al. 2007, namely Macfarlane et al. 2018) assessment technique for the current and post-rehabilitation scenarios. To determine the level of ecological integrity, a Level 2 WET-Health (Macfarlane et al. 2018) assessment was performed for various pans across the study area. The WET-Health assessment technique gives an indication of the deviation of the system from the wetland's natural reference condition for the following biophysical drivers:

- Hydrology - defined as the distribution and movement of water through a wetland and its soils;
- Geomorphology - defined as the distribution and retention patterns of sediment within the wetland;
- Water quality –the quality of the water based on external water inputs; and
- Vegetation - defined as the vegetation structural and compositional state.

The impacts on the wetlands, determined by features of the wetlands' and their catchments were scored based on the impact scores and then represented as Present State Categories as outlined in WET-Health (**Table 5-4**). The identified systems were assessed for the current scenario and post-rehabilitation scenarios. The assessment of the various scenarios would highlight the following:

- Current scenario: current state of the system based on both the in-system and catchment impacts; and
- Post-rehabilitation/enhancement scenario: the projected state of the system after rehabilitation work has been conducted within the system and its catchment.

Table 5-4 Impact scores and present ecological state categories for describing the integrity of wetlands[8] (MacFarlane et al. 2007, p30)

Impact Category	Description	Impact Score Range (0-10)	Present Ecological State Category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

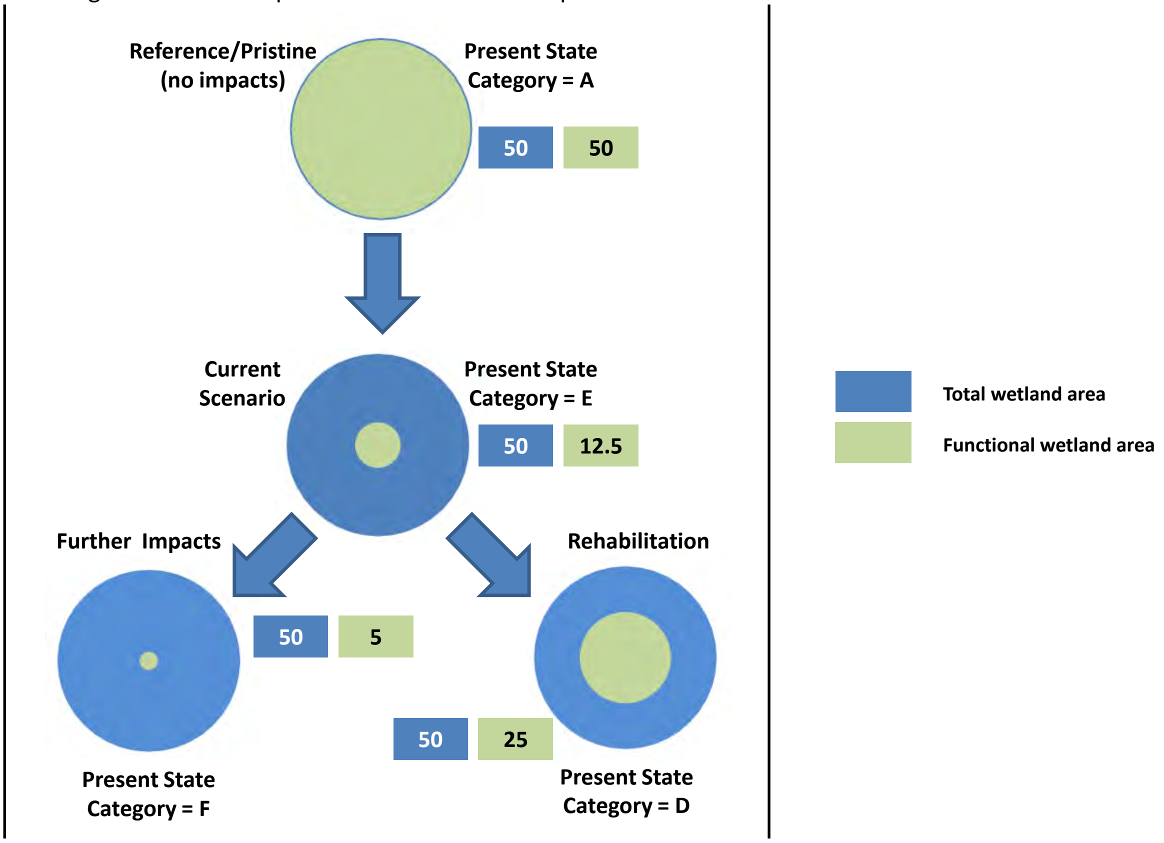
The scores for hydrology, geomorphology, water quality and vegetation were simplified into a composite impact score, using the predetermined ratio of 3:2:2:2[9] (Macfarlane et al. 2018) respectively for the three components. The composite impact score was used to derive a health score that then provided the basis for the calculation of hectare equivalents (also referred to as functional area), which can be described as the health of a wetland expressed as an area. Cowden and Kotze (2009) make use of a simple example to explain the concept of hectare equivalents conceptually illustrated in **Box 5-1**.

[8] It is assumed that there is no change in classes between the 2007 and 2018 integrity assessment technique.
[9] It should be noted that if the weighting for the hydrological component is an E/F category then the hydrological weighting is doubled

Box 5-1 Example of the use of hectare equivalents to represent changes in wetland health.

The assessment of wetland health is based on comparisons to a reference state *i.e.* where the wetland's health is unmodified and the functional area of wetland is equivalent to the full extent of the system. For example, if the health of a 50ha wetland is 100% (*Present State Category=A*) this equates to 50-hectare equivalents. In many instances the current scenario for a particular system reflects some form of historical degradation. If the abovementioned wetland was *seriously* degraded, the health would be reduced from the reference state to 25% (*reflecting a wetland health score of 2.5*); a drop in hectare equivalents from 50 to 12.5 (50ha x 0.25) hectare equivalents would be recorded. The following would therefore be expected if the wetland in the above scenario was subject to the following two future options:

a) Further degradation of the wetland linked to development, with the system's health being further reduced to 10% would result in a drop in hectare equivalents to 5-hectare equivalents; and
b) Rehabilitation of the wetland habitat, with the system's health being increased to 50% would result in a gain in hectare equivalents to 25-hectare equivalents.



NOTE:
The sizes of the circles are directly related to the extent of wetland habitat and functional wetland area in the landscape

5.5 Freshwater ecosystem risk assessment

The risk assessment matrix (DHSWS 2015) assesses the likely impact the proposed rehabilitation activities may have on the pans that have been identified as candidate offset systems. A broad outline of the criteria considered are as follows:

- Nature of the impact;
- Scale/extent of the impact;

- Duration of the impact;
- Intensity/severity of the impact; and
- Probability/likelihood of the impact occurring.

Identified impacts were evaluated according to the above-mentioned criteria. The significance of impacts was derived through a synthesis of ratings of all criteria in the following calculation:

(Severity + Spatial Extent + Duration) x Probability/Likelihood = Significance

The significance of a potential impact on decision-making was indicated through significance points, which are described in **Table 5-5**.

Table 5-5 List of descriptors for the significance score of an impact.
(DHSWS 2015)

RATING	CLASS	MANAGEMENT DESCRIPTION	AUTHORISATION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands are excluded.	GA
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and requires specialist input. Wetlands may be excluded.	WUL
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.	WUL

In order to reduce the significance of negative impacts and/or increase the significance of positive impacts, recommendations have been provided in **Section 7**.

5.6 SANBI offset calculator

The SANBI Offset Guidelines (Macfarlane et al. 2014) have been developed in conjunction with other policies and guidelines, including the national biodiversity framework and provincial biodiversity offset policies and guidelines. The SANBI guidelines serve to assess possible wetland losses due to a proposed development and to determine wetland offset targets, to ensure that wetlands receive appropriate protection and that sufficient functional area is retained within the broader landscape. The SANBI offset calculator has built on the principles of the hectare equivalents approach and incorporated additional information to inform the calculation of offset requirements for three different categories, including Water Resources and Ecosystem Services, Ecosystem Conservation and Species of Conservation Concern. These themes are all evaluated within their specific context ensuring the full range of residual impacts are addressed through each of the targets (**Figure 5-2**).

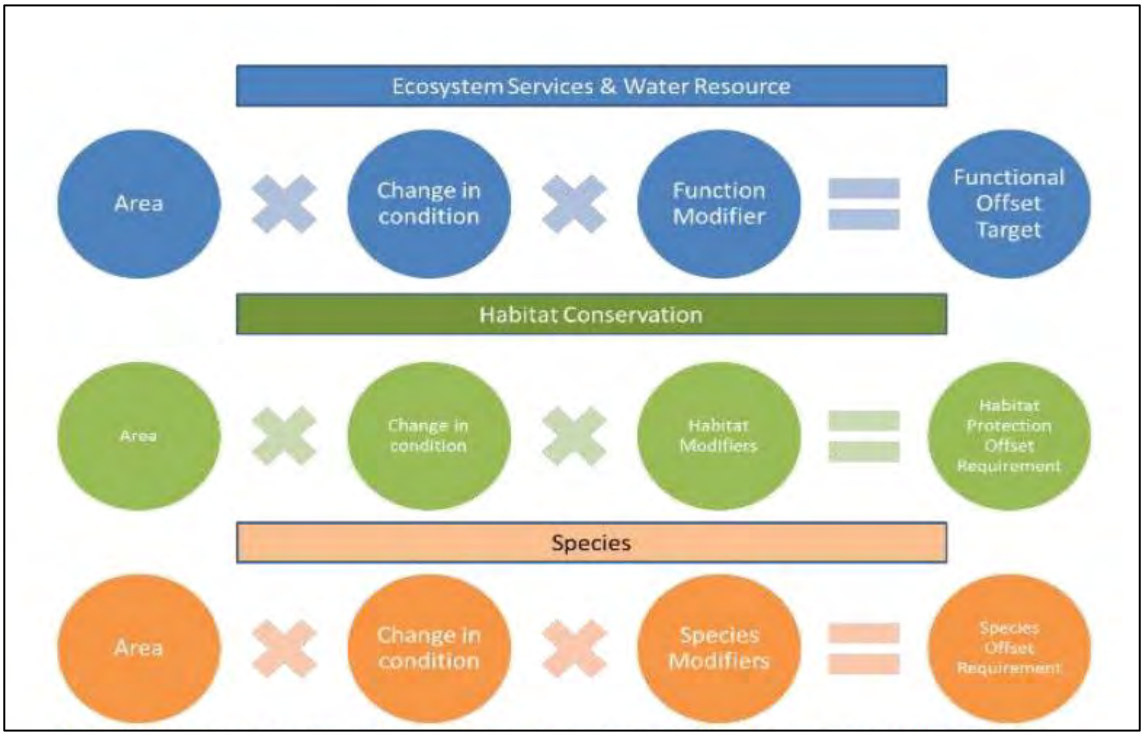


Figure 5-2 Outline of the approach used to identify the required offset for water resources and ecosystem services, habitat conservation and species of conservation concern
(Macfarlane et al. 2014, p27)

5.7 Rehabilitation planning

The rehabilitation of freshwater ecosystems is considered to be a complex undertaking and the planning process involves multiple disciplines. The initial steps of the following methodology were adopted for the project and comprised multiple steps (**Figure 5-3**), using existing information from previous studies and infield observations. A rehabilitation plan was compiled to achieve desired levels of functioning and integrity in the identified candidate systems within the study area. The compilation of the rehabilitation plan was based on two site visits, one undertaken between the 25th of February and the 1st of March 2019, and the other undertaken between the 4th and 6th of December 2019 by the relevant specialists, including:

- Wetland specialists responsible for highlighting those problems identified as undermining the hydrological, geomorphic and vegetation integrity of the pans within the site and providing a rehabilitation strategy and objectives to achieve improvements in system functioning and integrity in order to achieve the offset targets;
- Environmental/soil conservation engineers responsible for identifying appropriate earthen, gabion and/or concrete interventions to achieve the rehabilitation objectives outlined by the ecologist; and
- Biodiversity specialists responsible for identifying any rare or endangered faunal or floral species in close proximity to the wetlands that may be detrimentally affected by the rehabilitation of the wetland systems, and suggesting ways in which these impacts could be mitigated.

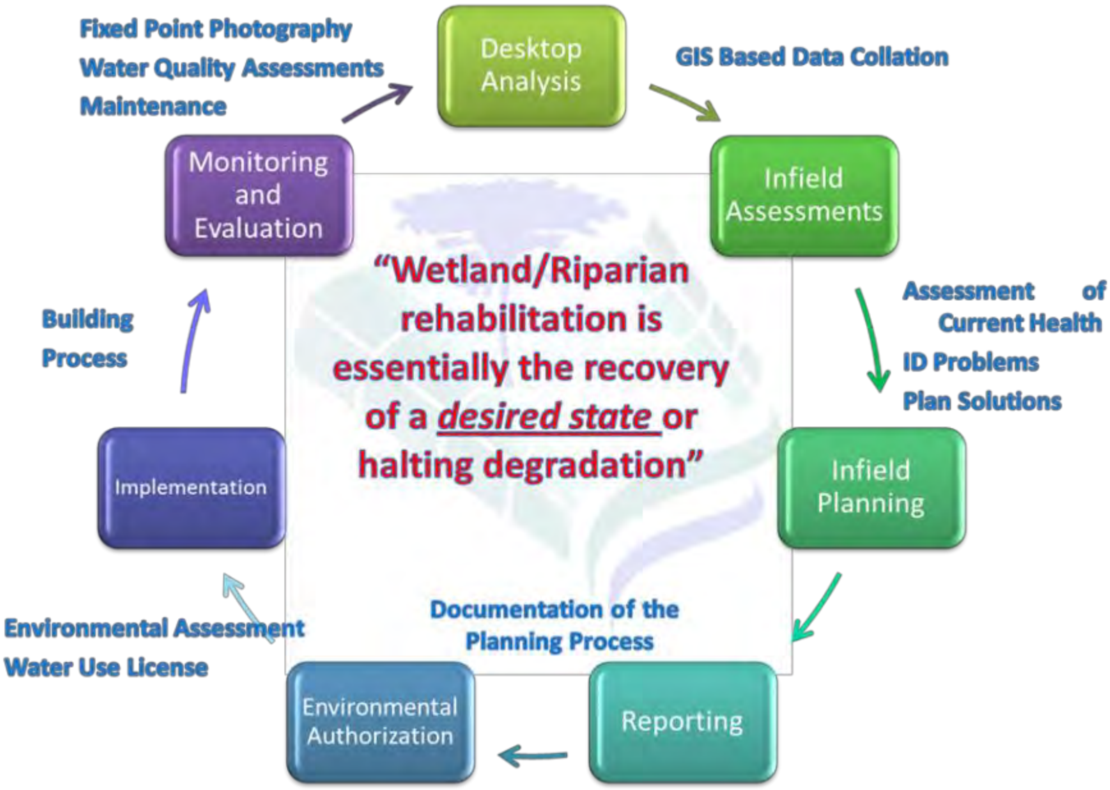


Figure 5-3 Overview of the wetland rehabilitation process

6. RESULTS

The results of the studies and investigations undertaken to inform the wetland assessments and the assessment of the potential improvements associated with the proposed wetland rehabilitation activities, are outlined in the following sections.

6.1 Characteristics of the freshwater ecosystems

GroundTruth (2018) undertook a literature review on the formation and functioning of wetlands within semi-arid climates (refer to GroundTruth 2018 and 2020 for a detailed description of the formation and functioning of these systems). However, with repeated site visits and new data available, a brief description of the updated understanding of the structure and functioning of these depression wetlands is provided below.

6.1.1 *Depression wetland functioning*

The majority of the wetland systems specified for rehabilitation are considered to be non-perennial depression wetlands that only contain water during the rainy season and are commonly referred to as pans. The formation of these systems coincides with depressions in the landscape that are underlain by suitable substrate, e.g. clay layers. These depressions in the landscape are often formed and expanded as a result of sediment export through a combination of animal wallowing and deflation through aeolian means. The combination of these factors has resulted in the formation of these non-perennial pan systems within the landscape, which are considered to be the only wetlands identified within the study area.

Furthermore, these systems are not sustained by subsurface water inputs and as such are considered to be ephemeral in nature, which is further exacerbated by the low rainfall and high evaporative rates for this area. It is evident from the review of available soil information of the surrounding areas, that the broader landscape lacks soils characterised by lateral movement of water which suggests the accumulation and retention of water in these depression wetlands is strongly linked to surface runoff and the presence of an impermeable layer of clay or bedrock within these depressions (GroundTruth 2018). A detailed review of the topography in the broader landscape revealed a series of dendritic drainage networks that connect many of the wetlands via surface flow in the wet season and are thought to be responsible for conveying large proportions of the annual precipitation into these depressional areas. These dendritic drainage features are considered to be of vital importance to the sustenance of many of these systems in the landscape and have been included within the rehabilitation plans as catchment related rehabilitation work. A number of the depression wetlands fall into what has been termed a 'string-of-pearls configuration'[10],

[10] The extent of these systems were mapped at a desktop level using a combination of topographic data, vegetation signatures, soil signatures and understanding gained from infield observations. It should be noted that therefore, the rehabilitation strategy for a single string-of-pearls configuration or for a series of depression wetlands linked by a smaller drainage network will contain several wetland systems within the larger

whereby there are a series of depression wetlands that are interconnected by a series of dendritic drainage networks. The string-of-pearls configuration can be defined by a number of wetland systems that are located in relatively close proximity to one another and become hydrologically linked during the wet season. During the wet season, these systems can often coalesce into large singular surficial features for a short period of time after rainfall. As these larger bodies of water desiccate, the extent of each system retreats into the smaller, more 'permanent' depressions which is where the typical wetland and clay substrates are located. The connection of these systems during the wet season cannot be ignored and disturbances in the space between the seasonal wetland areas may affect the structure and functioning of the systems. Therefore, these smaller permanent wetlands have been grouped and delineated to include the areas that become temporarily wet during the wet season. Whilst portions of the area included within the mapping of these string-of-pearls configurations cannot be defined as true wetland areas as per the DHSWS (2005) wetland delineation guideline document, these in-between areas are considered to be vital to the functioning of the true wetland areas which are located sporadically within the larger string-of-pearls configurations. These areas that lie in-between the delineated wetland areas will be delineated and categorised according to specific characteristics. See **Section 6.1.2** for a detailed description of the different designations of the catchment areas.

With the PET being so high in the area, these systems are ephemeral in nature and generally hold water for no longer than six (6) months at a time. However, natural variation in the water retention capacity of the systems was observed during the site visit. This variability can be attributed to a number of different factors such as size, rainfall variability, substrate type, human related impacts and connection to a wider dendritic drainage network. An observation was made that the wetlands with good grass cover in the central wallow section of the depression desiccated at a much faster rate than those without grass cover. Upon closer inspection, it appeared that the grassed wetlands contained significantly loamier and silty soils, which are much more permeable than the heavily clayed unvegetated systems. As such, it is thought that these grassed systems are more susceptible to subsurface water loss than the un-grassed systems. Natural rainfall variability within the area is another factor that may affect the length of time over which a wetland would retain water as some systems may receive more rain in a given year than others. A number of wetland systems displayed very temporary signs of wetness which indicated that some areas in larger wetland areas only receive and retain water in years with very high rainfall as the majority of the water will drain from the temporary zones into the more seasonal wetland areas in lower rainfall years. In these more temporary systems, the layer of characteristically heavy clays was much thinner and less well developed which indicates less frequent inundation. Connection to a wider dendritic drainage network is another factor that influences the ability of a wetland system to retain water into the drier months of the year. Catchment and in-system impacts related to human activity (current and historical) in the landscape is a major driver in the variability observed in the water retention ability of depression wetlands.

---

configuration despite the possibility that not all wetland areas within the wider drainage area will receive rehabilitation interventions.

6.1.2 *Delineation of areas of influence on wetland integrity and functioning*

In a landscape with high levels of connectivity, it would be short-sighted to ignore the influence of the broader landscape on the functioning and integrity of the identified wetland systems. As such, these additional areas will be included in the offset requirements to different degrees. The adopted definitions for these separate areas are outlined below.

Seasonal wetland area
This is a seasonal wetland zone that is defined primarily using soil indicators and characteristics in accordance with the DHSWS guidelines for wetland delineation. These areas generally coincide with the lowest points in the landscape and will therefore naturally accumulate water from surrounding areas.

Temporary wetland area
The temporary wetland zones are also defined primarily using soil indicators and characteristics in accordance with the DHSWS guidelines for wetland delineation. Generally, temporary wetland areas are defined by redoximorphic soil characteristics at a depth of 50cm below ground level. However, in the wetland delineation carried out by DWE (2017) the temporary zone of the wetland areas in this landscape were defined by redoximorphic soil characteristics to a depth of 70cm. During the wet season, these temporary wetland areas are temporarily flooded and are hydrologically linked to the seasonal wetland areas. As the water evaporates from these wetland areas, the temporary wetland areas are the first to desiccate as the water line retreats into the more seasonal wetland areas.

Sub-catchment area
The sub-catchment area refers to the area immediately surrounding the wetland that has a distinctive impact on the hydrology of the wetland – even during small rainfall events. The catchments of these systems are so large that it is necessary to be able to distinguish between the parts of the catchment that have a distinct effect on wetlands and the parts of the catchment that have negligible impacts on the wetland. It is assumed that the sub-catchment does not extend more than 50m beyond the wetland boundary.

Wider area of hydrological influence
This area is defined primarily by topography and resembles a shallow valley line. During large rain events, water is mobilised into these areas and flows down these features in an event that resembles a flood. The string-of-pearls configurations are often located within these features, and such as these and their presence in the landscape is important to the functioning of many of the smaller temporary and seasonal wetlands. With the increased presence of water in these particular areas, these wider areas of hydrological influence display a biotic response as well – similar to that of riparian areas as defined by the DHSWS guidelines for riparian delineation. The presence of the wetlands within the landscape elicits a strong biotic response in the areas surrounding the wetland areas as a result of water availability in an otherwise dry landscape. As such, shifts in vegetation composition and structure can be observed along with shifts in soil texture, colour and composition. These areas of biotic influence fall within the catchments of wetland areas and can have a biotic impact on the functioning of these wetland areas as well. Therefore, these wider areas of

hydrological influence can also be defined by vegetative and soil signatures in the absence of topographical data.

6.1.3 *Factors influencing the degradation of depression wetlands*

The degradation of these depression wetland systems is predominantly related to historical land use practices and the extensive presence of dirt tracks and roads within the broader landscape. The wider landscape was historically utilised for cattle grazing and small-scale crop farming before it was purchased by Exxaro Coal Pty (Ltd) and managed by Ferroland. Many portions of these landholdings were severely overgrazed for many years, which resulted in a shift in vegetative species composition as cattle preferentially graze on specific grass species. Large tracts of land were also cleared by these farmers either to plant more appropriate grass species for their cattle to graze or to grow agricultural crops. These cleared portions of land have never fully recovered to their natural climax vegetation and are often characterised by dense stands of invasive vegetation such as *Senegalia mellifera*, which is a small to medium sized tree. These areas that are invaded by invasive species are also often characterised by poor undergrowth coverage which in turn can result in sediment mobilisation during heavy rains. Degraded lands within wetland catchments can therefore, have negative impacts on the functioning of the wetland systems, especially if they are responsible for the mobilisation of sediment into the wetlands themselves.

In addition to the historical grazing pressures, the Manketti Game Reserve (which includes the Thabametsi mining rights area) were consistently overstocked for a long period of time which resulted in heavy grazing and browsing pressure in these areas as well. Because these depression wetlands are the primary source of water for many of the wild animals on the game reserves, the herbivorous animals often spend more time in and around these systems. As such, the vegetation cover and vegetation diversity in the areas adjacent to the wetland systems have been reduced which in turn can result in the mobilisation of sediment into the wetlands which can shift these natural systems away from a completely natural state. In many instances the understory has been reduced due to increased grazing and hoof action which has allowed for the encroachment of trees around some of these systems – which also results in reduced surface roughness in the areas directly surrounding the depression wetlands. In order to offset this particular grazing pressure on the wetland systems and the surrounding vegetation, a number of the wetland systems were fitted with artificial water supplies such that they were full of water all year round. The addition of water to a number of these systems serves also to provide a vital source of water to the fauna that are kept in the area. This strategy is still utilised to some degree in the Manketti Game Reserve which includes the Thabametsi site. While this strategy does relieve some of the pressure on the surrounding sites, it alters the natural hydrological cycle in the artificially supplied wetland systems.

Possibly the most significant impact to the wetland systems is associated with the network of roads that traverse the Manketti and Thabametsi sites. While a number of these roads are no longer operational, a large number of them are still being used by Ferroland personnel. Many of these roads pass through the immediate catchments of wetland areas while a number of them pass directly through the depression wetlands themselves. The impact that roads have on the functioning of these wetlands vary depending on the proximity of the road to the wetland system, the nature of the surrounding topography and the ability of the road to intercept flows from wider areas of hydrological influence. Some roads are located in close proximity to wetland systems which could result in additional sediment being mobilised from the road into the wetland as well as preventing complete hydrological connectivity between a wetlands catchment and the wetland itself. Additionally, if a road passes across or through one of the dendritic drainage lines that is responsible for conveying water to a depression wetland in a string-of-pearls configuration, the road could potentially divert or interrupt the supply of runoff to a given wetland system, thereby changing the hydrology of that wetland. Some roads run directly through depression wetlands which have impacted on the hydrology of these systems. In some cases, the deep tyre tracks created by vehicles passing through these systems during the wet season remain imprinted in the ground as a result of the high clay content in the soils. This often leads to ponding and pooling of water within the tyre ruts – preventing water from flowing along its natural path. In addition, many of these roads running through the wetlands will also contribute to unnatural sediment deposition within the wetland during heavy rains.

6.2 Rehabilitation areas

Across the Manketti Game Reserve study area, four (4) wetland systems were identified and specified for rehabilitation covering an area of approximately 10.90ha[11][12]. In addition to these sites, seven (7) more depression wetlands covering an area of 36.29ha[13] were identified and specified for rehabilitation in the Thabametsi mining right area (**Figure 6-1**). A description of the systems specified for rehabilitation is provided below.

---

[11] Three disused borrow pits were also identified and specified for rehabilitation within the Manketti Reserve. These borrow pits will be utilised as wetland creation sites to contribute towards the wetland functionality offset target. However, until the created wetlands described in GroundTruth 2020 have been successful, these systems will be excluded from the offset calculations until such a time that the wetland creation concept has been tried and tested. The descriptions and rehabilitation plans for these borrow pits are included in Appendix 4.

[12] It should be noted that these hectare calculations only include areas that can be defined as true wetlands as per the DHSWS (2005) delineation manual. It does not include the sub-catchment and wider areas of hydrological influence.

[13] It should be noted that Rehabilitation Site 4 (Wetland 4 in **Figure 6-1** below) in the Thabametsi mining rights area fall within the Thabametsi Project layout plan (as per TIPP 1 in the drawing ECG-T01-IGN-SP-SP-00002) and could potentially be negatively impacted upon by construction and operational activities. However, this system falls approximately 320m away from any infrastructure and as such, should not be directly impacted. However, it is recommended that this system is monitored closely when the Thabametsi Project is implemented in the next 30+ years. Refer to **Section 9.3** for a detailed explanation.

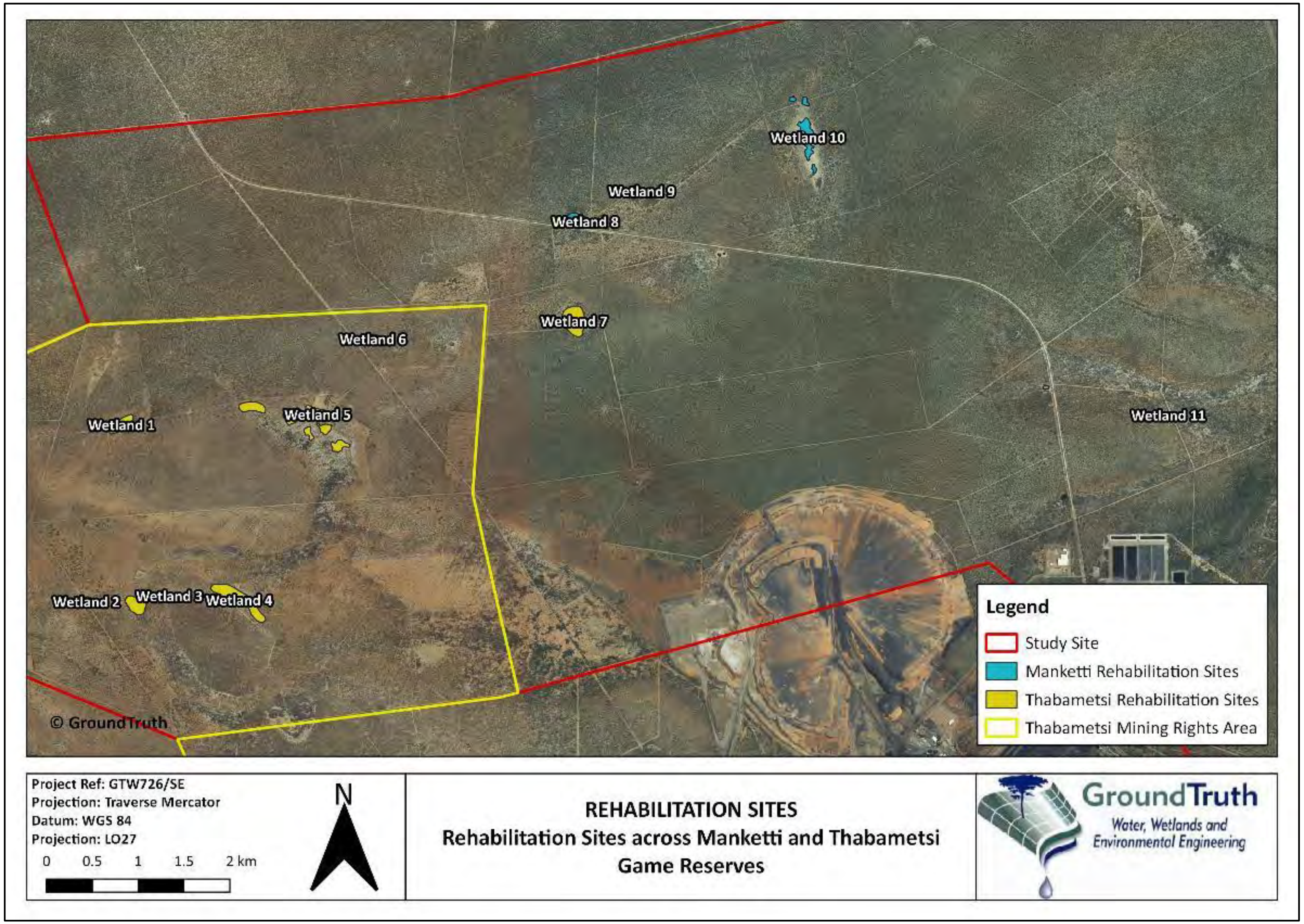


Figure 6-1 Overview of the rehabilitation sites across the Manketti Game Reserve and the Thabametsi site. The areas depicted only show wetland habitat – not additional hydrologically connected areas such as the sub-catchments and wider areas of hydrological influence

Rehabilitation Site 1 (Wetland 1)

Rehabilitation Site 1 is located within the Thabametsi mining right area of the Exxaro property and spans a total length of approximately 340m with an area of 2.61ha. This wetland is divided up into distinctive seasonal and temporary zones, with the seasonal zones being confined to the northern and southern-most sections of the wetland and the temporary zone covering the remainder of the delineated area (**Figure 6-2**). This wetland can therefore be defined as a series of seasonal wetlands within a larger drainage network as there is hydrological connectivity between the seasonal wetlands within the overall system. The HGM unit was in a relatively degraded state as evidence of heavy grazing was observed within the wetland extent itself. Old construction material was also observed in the wetland, and it was assumed that this material was left behind after the construction of the road that runs directly through the middle of the wetland, bisecting it (**Figure 6-3**). Based on the location of the road, it is anticipated that the road is having a negative impact on the drainage patterns and distribution of water within and through the system.

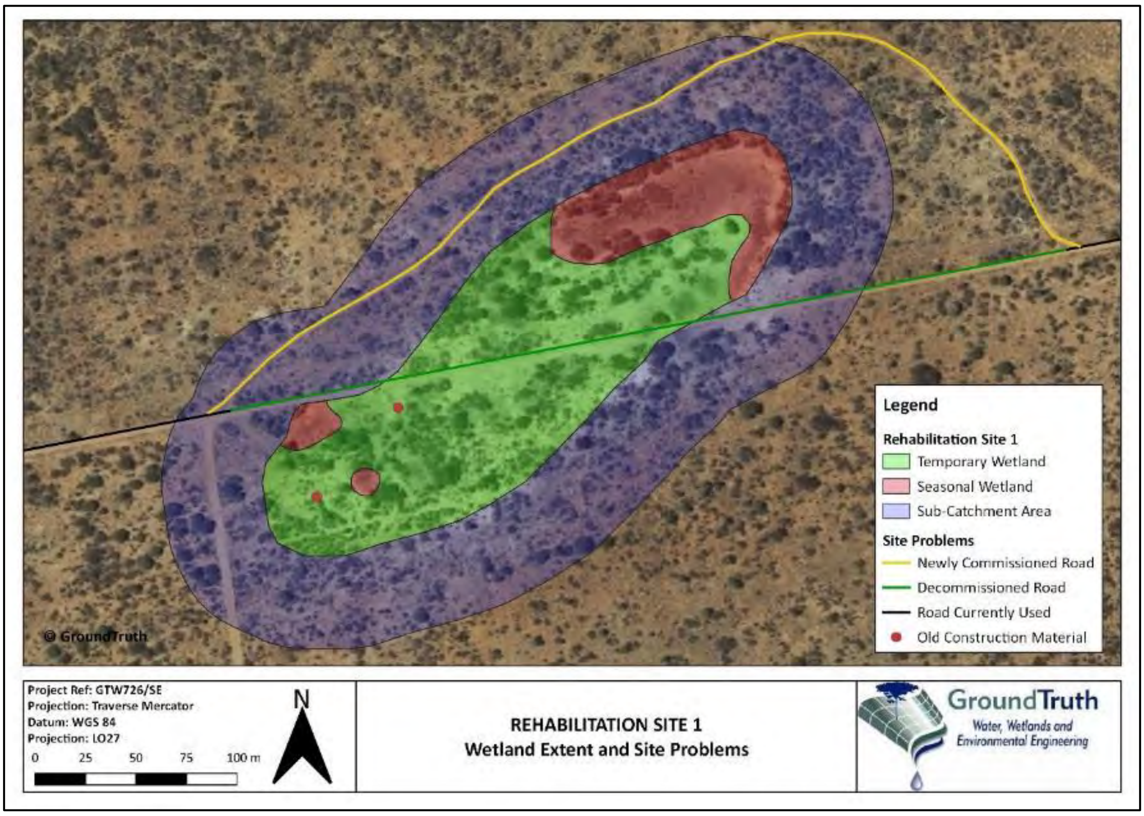


Figure 6-2 Extent of, and impacts associated with Rehabilitation Site 1.

Figure 6-3 Photo of the road bisecting Rehabilitation Site 1 (photo taken facing east)

Rehabilitation Site 2 (Wetland 2)

Rehabilitation Site 2 is the western-most rehabilitation site and contains is a small drainage system which gets temporarily wet during high rainfall seasons with a single portion of the system characterised by a more seasonal wetland that holds water for longer periods of time. The entire wetland system is 1.25ha in size and is characterised by a dense stand of trees around the wetland to the west. The temporary and seasonal portions of the wetland are bisected by a dirt track that is thought to interrupt the hydrological connectivity between the western and eastern sides of the wetland (**Figure 6-4**). There is evidence that there is natural hydrological connectivity between the two portions of the system as a section of the road has clearly historically been wet and is at the point where the seasonal wetland decants into the eastern portion of the wetland during heavy rainfall events. However, the road is thought to be responsible for preventing some of the hydrological connectivity between the two portions of the wetland.

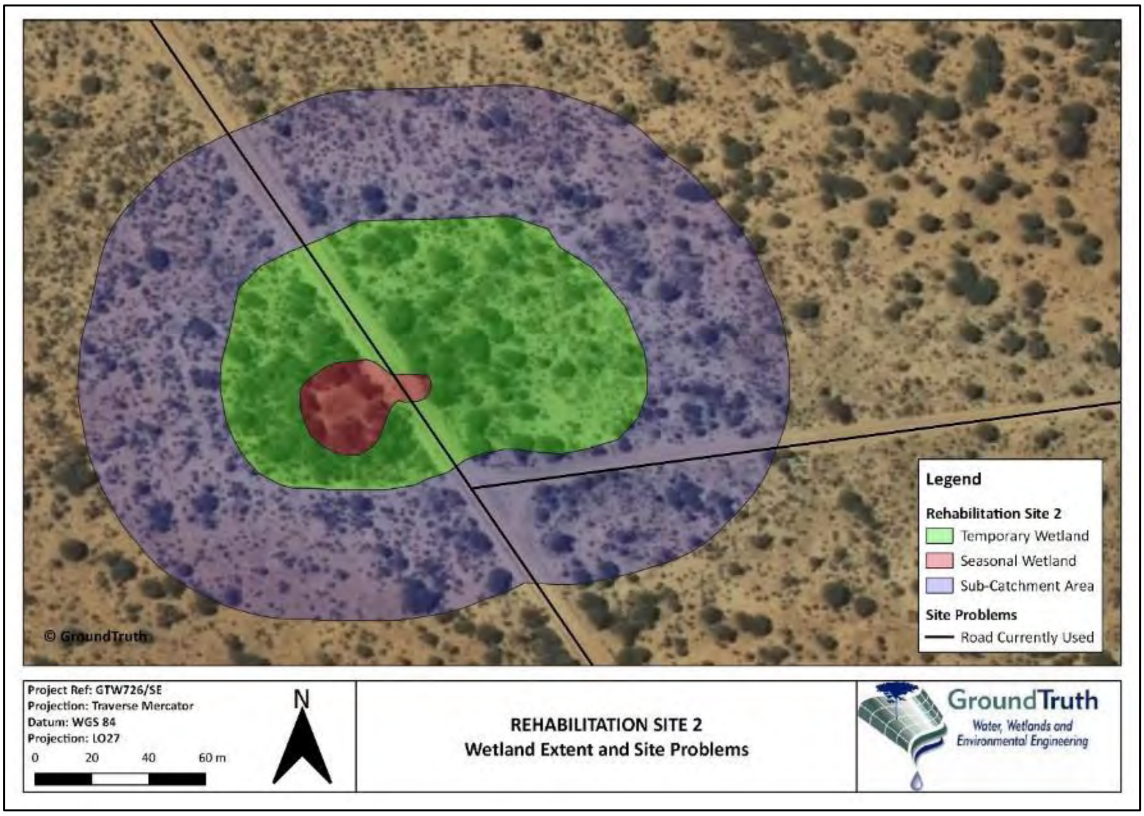


Figure 6-4 Extent of, and impacts associated with Rehabilitation Site 2.

Rehabilitation Site 3 (Wetland 3)

Rehabilitation Site 3 contains two true wetland areas wherein water is retained within the landscape for extended periods in comparison to the surrounding areas (**Figure 6-5**). The wetland area within the wider system is 3.55ha in size and is characterised by markedly denser woody plant species cover and lower grass cover than the surrounding areas. There is a dirt track that runs through the wetland and runs directly through one of the seasonal wetland areas. During the wet season, this dirt track interrupts hydrological flows between the northern and southern sections of the larger wetland as water often gets trapped in the deep tyre tracks created along the road in the wet season.

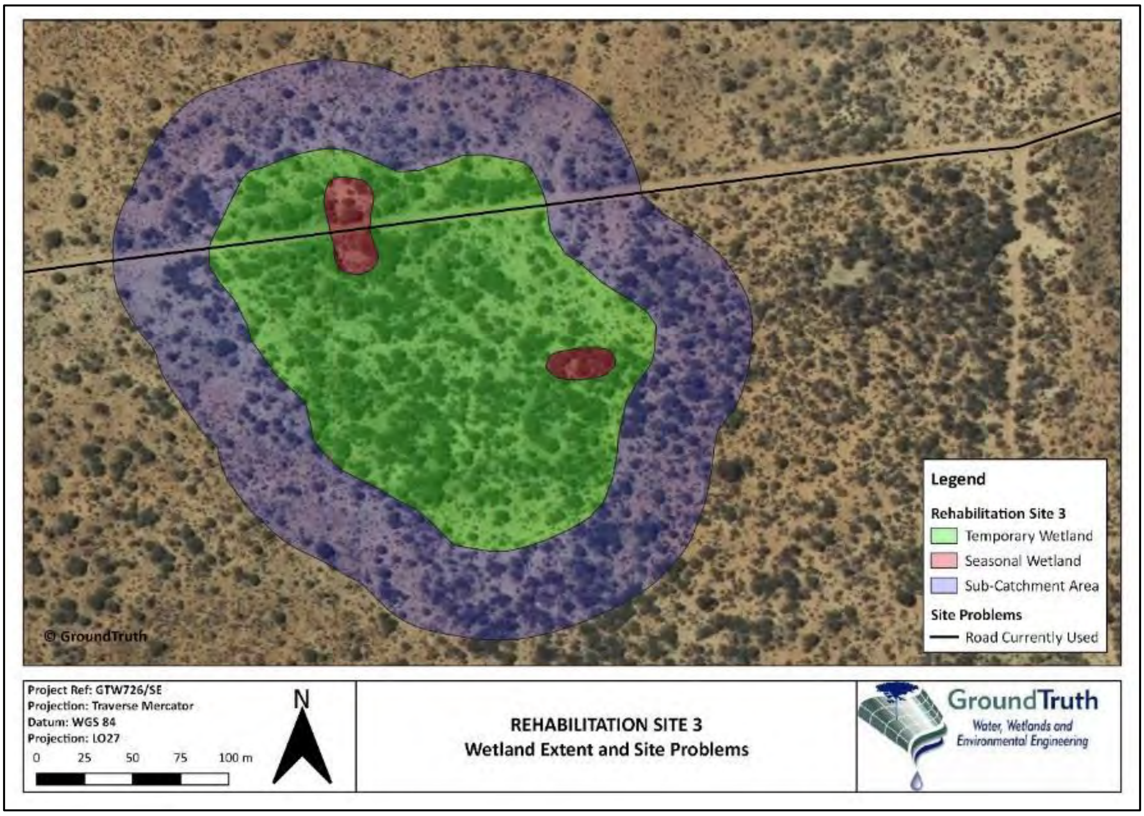


Figure 6-5 Extent of, and impacts associated with Rehabilitation Site 3.

Rehabilitation Site 4 (Wetland 4)

Rehabilitation Site 4 is a string-of-pearls configuration and contains three seasonal wetland areas that are hydrologically linked by a dendritic drainage network. The system drains in a north-westerly direction to a low point associated with a depression wetland which is located in the north-western corner of the wetland (**Figure 6-6**). The vegetation within the wetland is characterised by dense woody shrub and tree species with reduced grass cover in comparison to the surrounding landscape. There are three dirt roads that pass through the wetland area which are thought to be interrupting complete hydrological connectivity between the three seasonal wetland areas and possibly channelling water in unnatural and undesirable directions. In addition, one of the seasonal wetland areas has been artificially excavated so that it can hold more water during the wet season. The excavated material has been spoiled around the wetland and a low-level berm has been created around the wetland which may prevent surface runoff naturally entering the low-lying area.

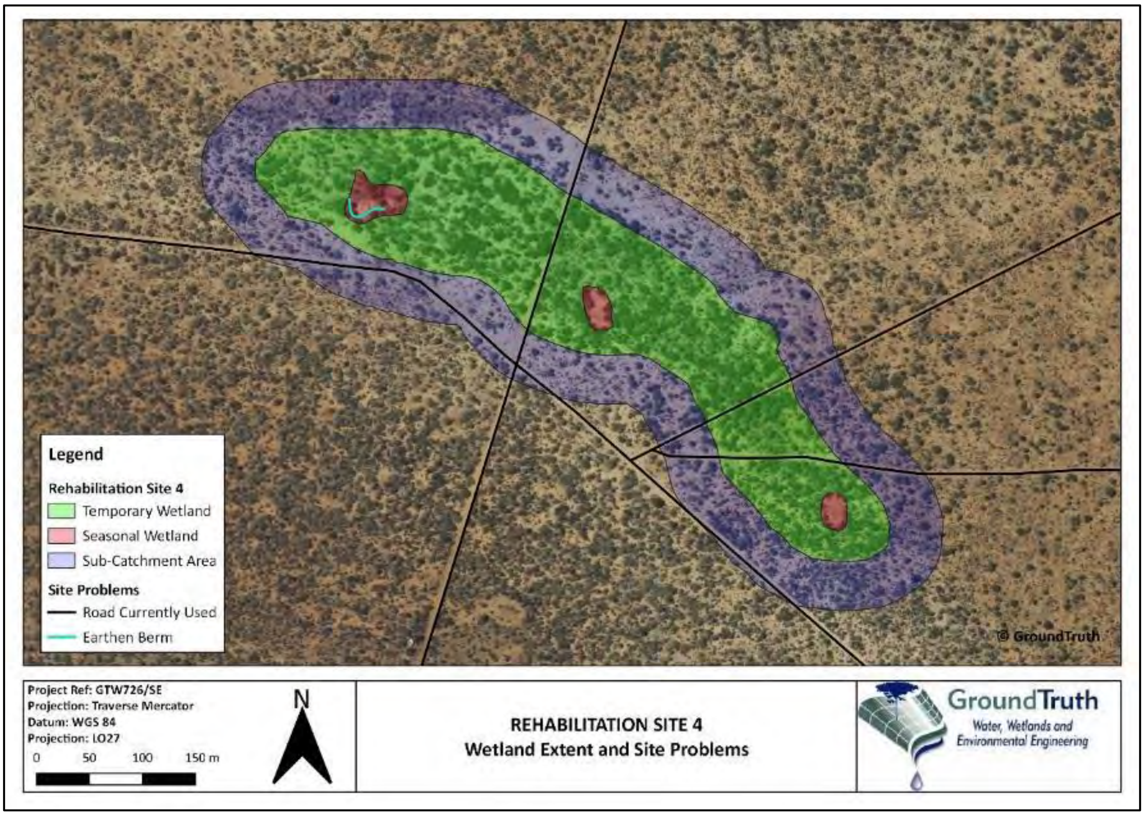


Figure 6-6 Extent of, and impacts associated with Rehabilitation Site 4.

Rehabilitation Site 5 (Wetland 5)

This wetland system lies to the south and west of a homestead located within Van Der Waltspan 310R and is surrounded by historically cultivated land. This old agricultural land is bare and the surrounding natural lands are in a degraded state. Therefore, the majority of the impacts to the wetland are associated with degradation and poor veld condition in the catchment and old roads. This is a larger string-of-pearls configuration system that drains in a southerly direction towards Rehabilitation Site 4 (indicated by the vegetation signature depicted in **Figure 6-1**). The total area of wetland in this string-of-pearls configuration amounts to 12.99ha. A number of the seasonal wetland areas contained water during both site visits in 2019, which is indicative of the importance of the wider area as a water supply area. The seasonal system directly south of the homestead is artificially maintained with water throughout the year (**Figure 6-7**). The old farm lands in the surrounding area are characterised by very sparse, disturbance tolerant vegetation that is not representative of climax natural vegetation within the area. In addition, some of these areas have formed a hard soil cap which prevents vegetation from establishing in these areas. These bare areas may increase runoff velocity which may mobilise sediment faster than vegetated areas would. In addition, there are two roads that pass directly through seasonal wetland areas and appear to interrupt natural hydrological processes in these areas.

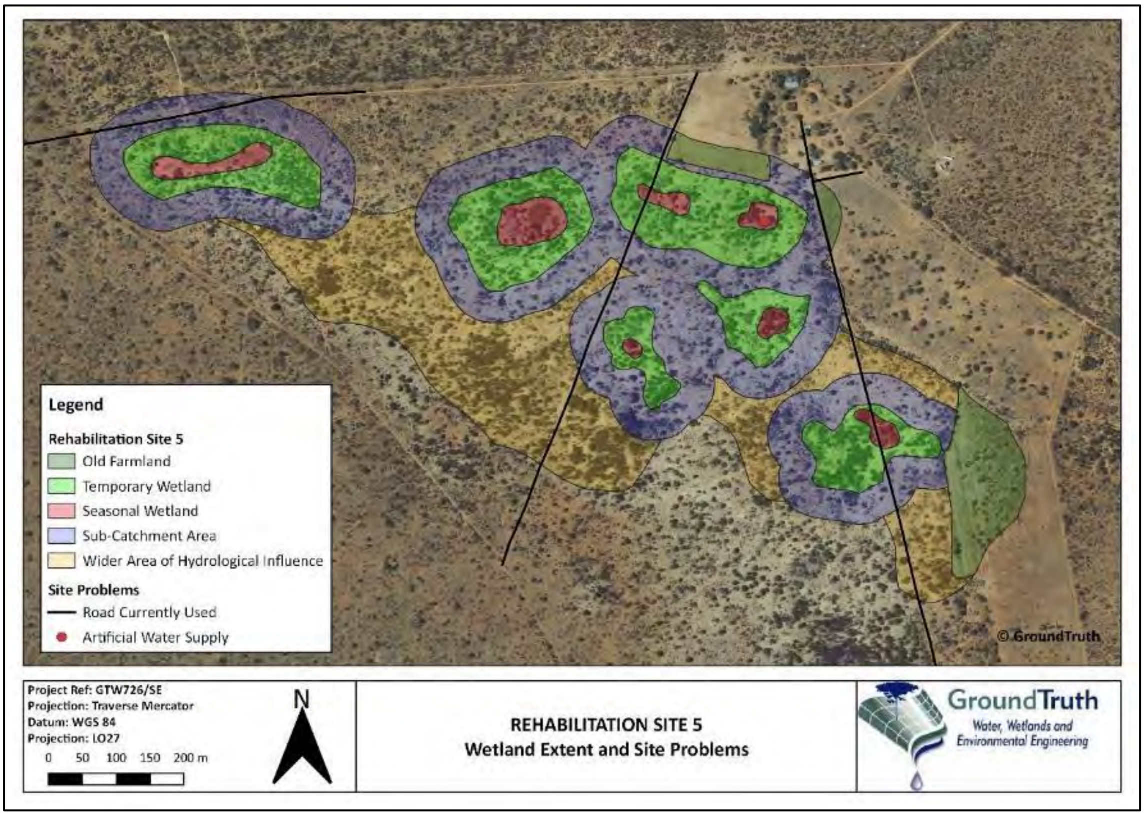


Figure 6-7 Extent of, and impacts associated with Rehabilitation Site 5.

<u>*Rehabilitation Site 6 (Wetland 6)*</u>

Rehabilitation Site 6 is approximately 0.79ha in size and consists of two distinctly different portions of the HGM unit, namely the seasonal wetland area which is located to the north-west of the HGM unit, at the lowest point in the wetland, and the more temporary wetland area located to the south (**Figure 6-8**). The seasonal zone receives the majority of the water in the wet season – as such a number of small puddles of water were observed in this section of the wetland in amongst a dense and healthy stand of *Eragrostis rotifer* and *Eragrostis acraea.* Despite the vegetation within the seasonal zone of the wetland being relatively healthy, there were erosion gullies and very bare areas of the wetland observed to the east of the seasonal zone (**Figure 6-9**). These areas appeared to have been eroded by a combination of intense animal hoof action and animal path creation and water and wind driven erosion. Through a combination of these processes, large areas of system have been cleared of vegetation and a very hard, impermeable soil cap has been created in these areas which prevents any type of vegetation from establishing –further exacerbating the erosion process. This process of erosion has also resulted in the deposition of sediment in the HGM unit, which has disturbed the natural vertical and horizontal pattern of water distribution within the wetland area.

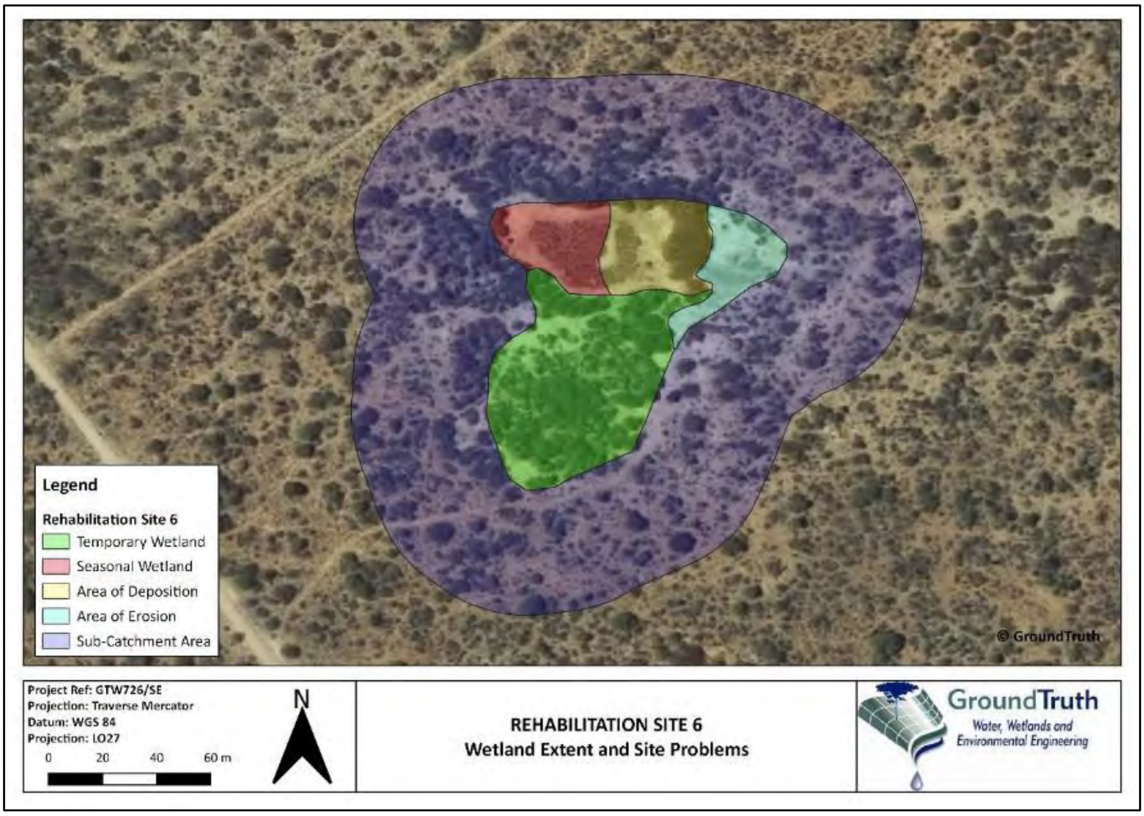


Figure 6-8 Extent of, and impacts associated with Rehabilitation Site 6.

Figure 6-9 The area of erosion to the east of the seasonal zone in Rehabilitation Site 6

<u>Rehabilitation Site 7 (Wetland 7)</u>

Rehabilitation Site 7 is one of the more extensive wetlands specified for rehabilitation, covering an area of 7.13ha. It contains a single wetland area that is artificially maintained with water throughout the year for animal watering purposes which is surrounded by a large sub-catchment (**Figure 6-10**). As can be seen, the permanent watering area is limited to a small 0.37ha area in the southern portion of the larger wetland with large areas of temporary wetland that stretch to the north. There is an old road that passes through the wetland in the southern reach of the HGM unit and interrupts natural hydrological connectivity between the northern and southern portions of the wetland. The road may also be responsible for the transportation of sediment into the low-lying areas associated with the artificial wallow during heavy rainfall events.

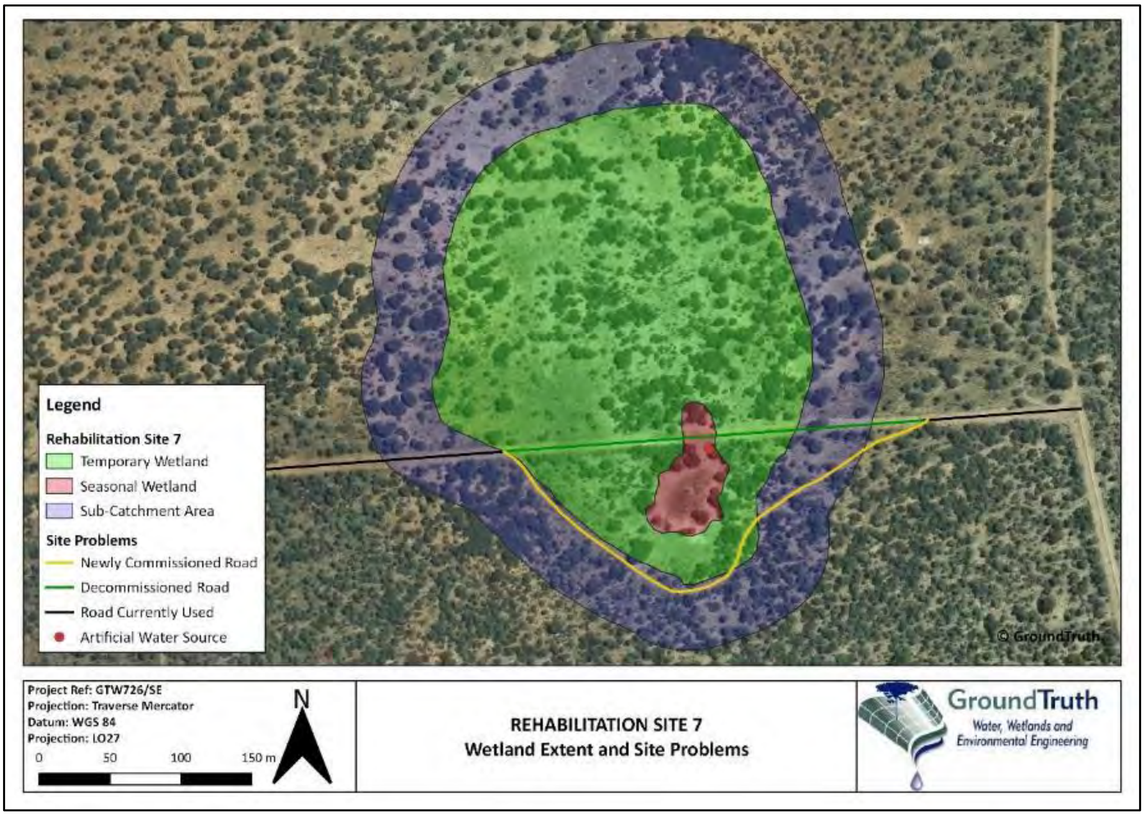


Figure 6-10 Extent of, and impacts associated with Rehabilitation Site 7.

Rehabilitation Site 8 (Wetland 8)

Rehabilitation Site 8 is a small series of hydrologically linked seasonal wetlands with a number of small seasonal low-lying wetland areas (**Figure 6-11**). One of the wetland areas is relatively large – almost 0.7ha in size – and is located on the western side of the wetland whereas the smaller wetland portions are located towards the east of the wetland. This wetland is located approximately 30m north of the main road that passes through the Manketti Game Reserve. The wetland was dry during the site visit and was characterised by a large stand of *Eragrostis rotifer* and *Eragrostis acraea* that dominated the majority of the wallow areas. A number of animal tracks were observed leading into the wetland from the surrounding veld, many of which originate from the south-western side of the HGM unit, adjacent to the road. It is thought that these animal tracks may be responsible for transporting small quantities of sediment into the wetland from the road during the wet season which could be affecting the vertical and horizontal drainage properties of the wetland itself. In addition to the animal tracks, an old dirt road was observed within the HGM unit and is thought to be having a negative effect on the natural movement of water within the wetland as the road runs perpendicular to the flow of water and would interrupt the natural flow of water from west to east. This road has recently been decommissioned and an alternative route has been created that runs around the eastern portion of the wetland. The area to the east outside of the delineated wetland has historically been farmed and as a result has become heavily invaded by *Senegalia mellifera* trees.

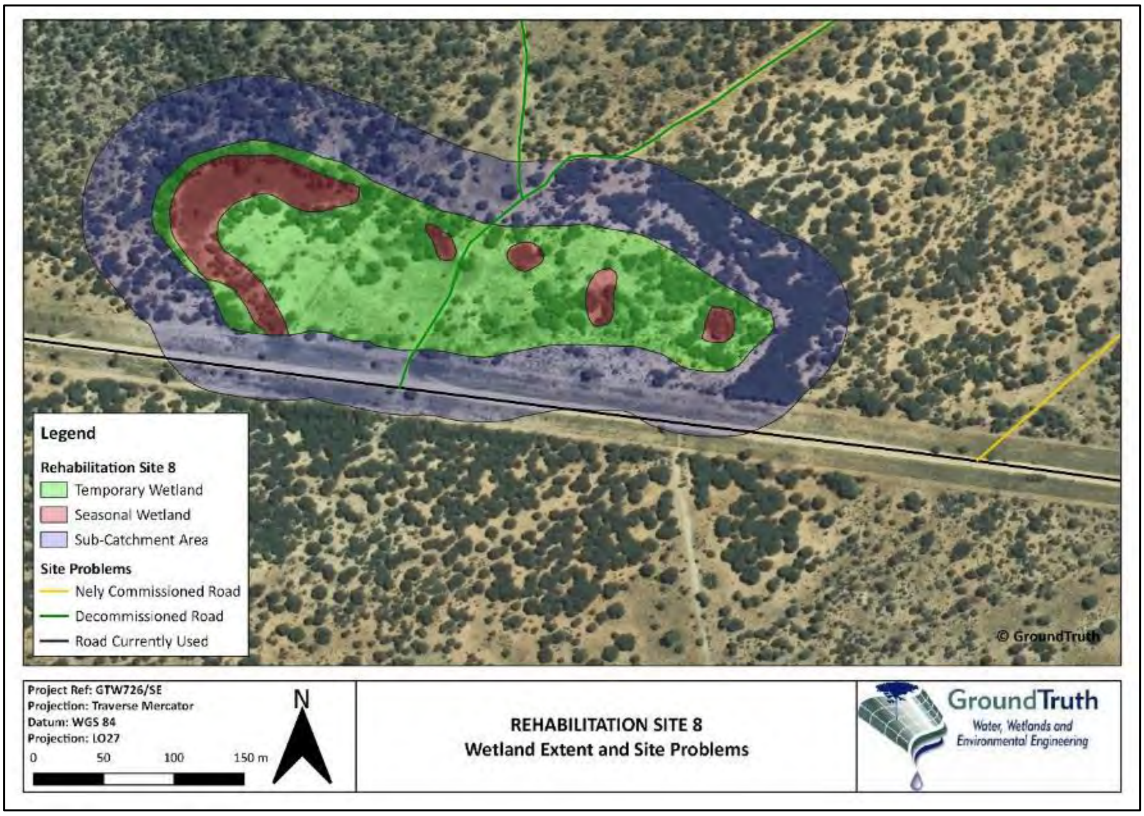


Figure 6-11 Extent of, and impacts associated with Rehabilitation Site 8.

Rehabilitation Site 9 (Wetland 9)

Rehabilitation Site 9 is a small system that contains two natural depression wetlands and a third wetland area that is artificially maintained throughout the year (**Figure 6-12**). The artificially maintained portion of the wetland is waterlogged year-round and is characterised by wetland indicator species such as *Cyperus iria*, which is indicative of seasonal to permanent flooding. The substrate within all the wallow pits consisted of very heavy clays that are semi-impermeable when wet and have formed as a result of repeated cycles of wetting, drying and chemical weathering. Similarly, to Rehabilitation Site 8, this site is also located on old cultivated lands and has been invaded by large, dense stands of *Senegalia mellifera* trees, which are unnatural in such high densities in these areas.

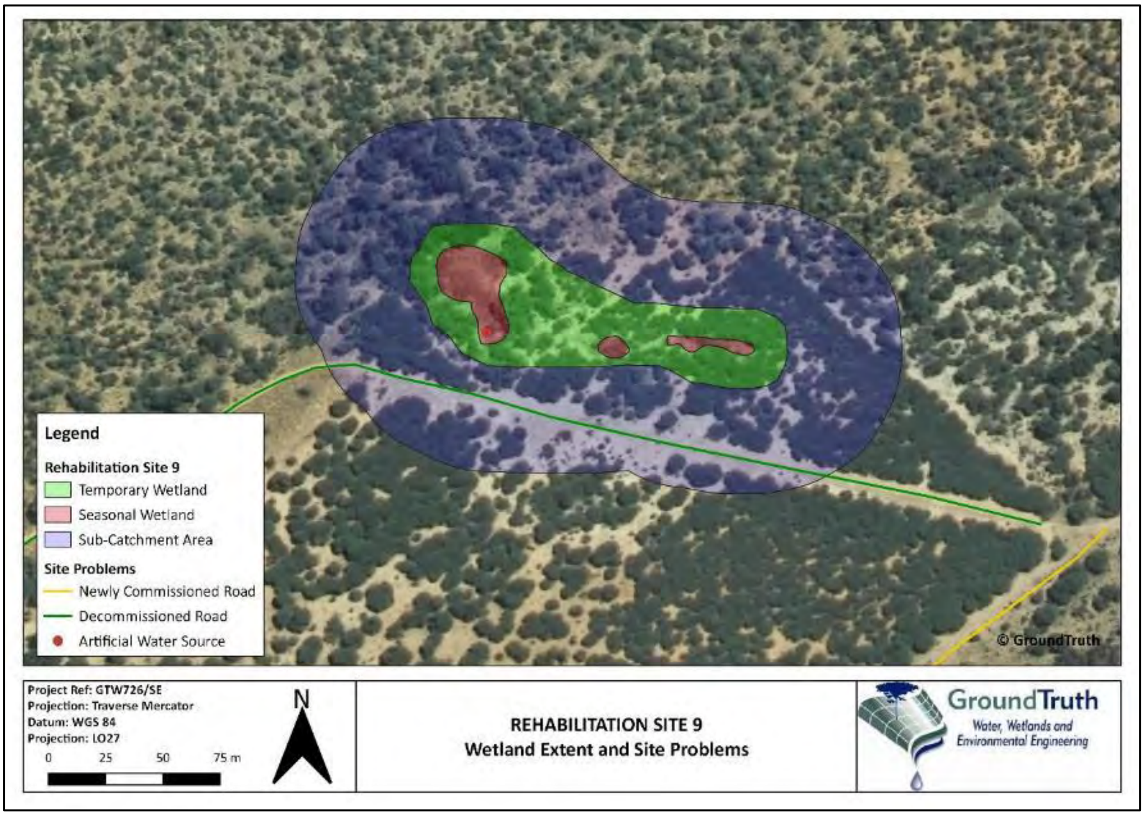


Figure 6-12 Extent of, and impacts associated with Rehabilitation Site 9.

Rehabilitation Site 10 (Wetland 10)

Rehabilitation Site 10 is the largest and most significant string-of-pearls configuration in the Manketti Game Reserve, with the wetland area spanning a total area of 5.61ha altogether. Within the wider wetland area, there are a total of eight (8) natural depression wetlands that are seasonally and temporarily wet whereas the remainder of the system is comprised of hydrologically linked areas that form the sub-catchment for the true wetland areas (**Figure 6-13**). Most of the seasonal wetland areas are characterised by trees that surround their margins while the remainder of the system is characterised by sparse vegetation and hard, capped soils that prevent vegetative growth in the area. The capped areas are very light grey/white in colour and it is thought that through repeated cycles of weathering, the majority of the colourful ions have been totally leached out of the soil profile. There are two decommissioned roads that cut through the northern portion of the string-of-pearls configuration and a new road has been created that circumnavigates the entire southern boundary of the wider system[14]. A third road runs through the northern-most seasonal wetland. A new road has been constructed to the north of the system, but the remnants of the old road still interrupt the hydrological flows to the central wetland area and hinder vertical and horizontal drainage patterns within the wetland.

[14] It should be noted that the imagery used during the mapping of these systems and associated impacts is from 2015/2016 and doesn't reflect recent changes in the landscape such as the presence of the road that circumnavigates the southern portion of the wetland. As such, this road has not been mapped.

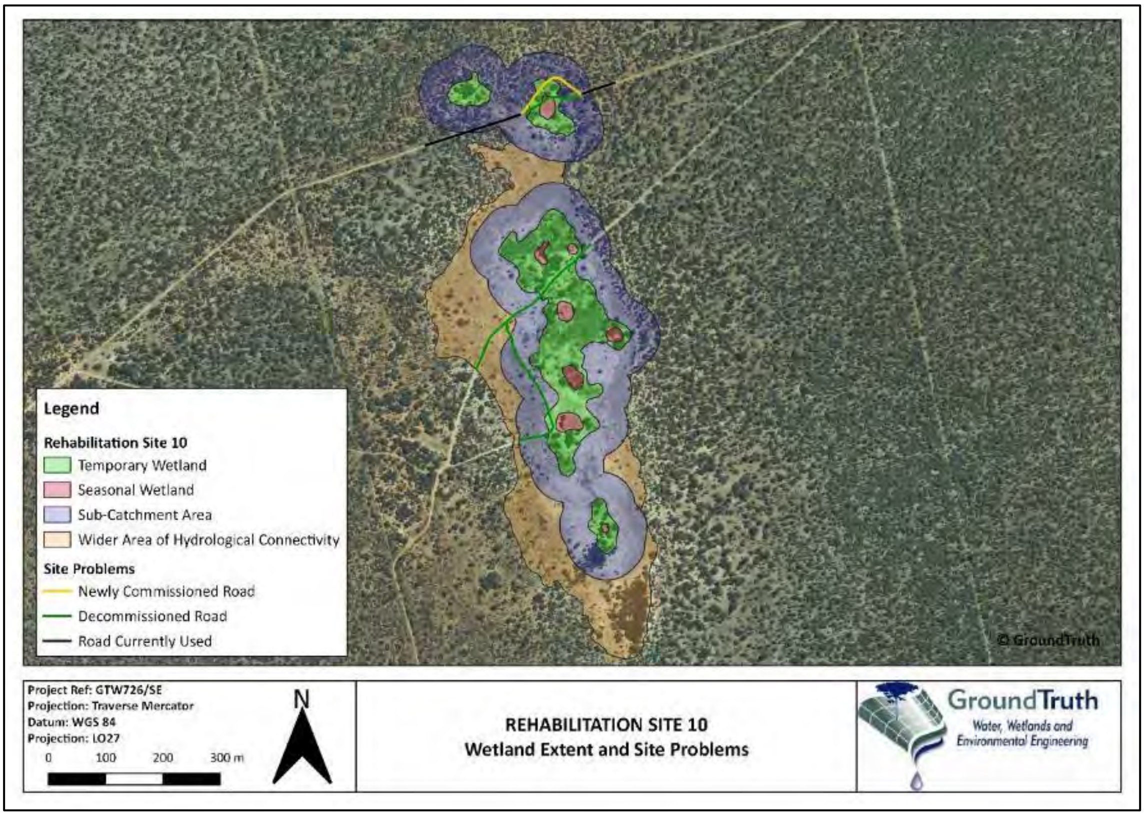


Figure 6-13 Extent of, and impacts associated with Rehabilitation Site 10.

Rehabilitation Site 11 (Wetland 11)

This wetland system is a circular feature that is located directly to the west of one of the management roads in the Manketti Game Reserve (**Figure 6-14**). The wetland is located at a low point in the road and therefore the road acts as a miniature catchment for the wetland. Water and/or animal tracks have breached the barrier between the wetland and the road and has resulted in the transport of road sand into the wetland, creating a relatively unconsolidated sediment plume within the HGM unit. This unnatural deposition of sediment has an effect on the surface roughness of the wetland and its buffer area as well as on the vertical and horizontal drainage of water entering into the wetland. Minimal vegetation was found in the wetland system itself, and all vegetation that was found in the HGM unit had been heavily grazed and was unidentifiable.

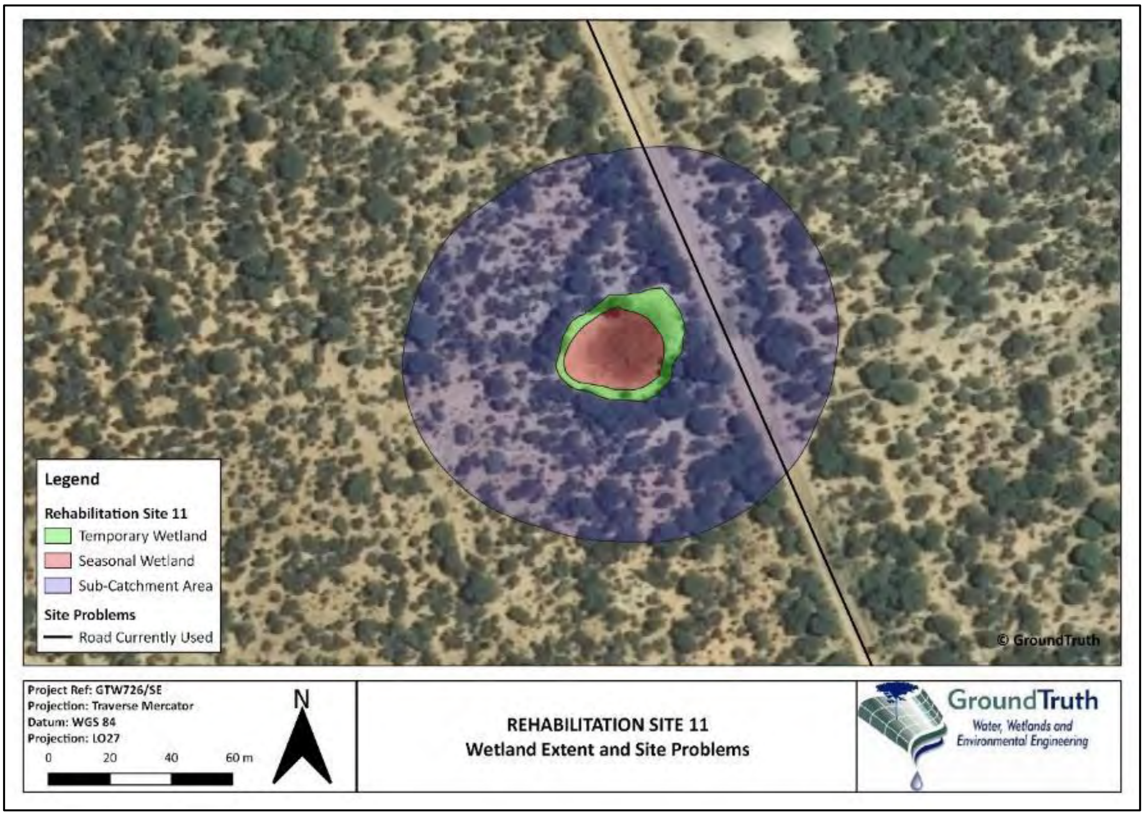


Figure 6-14 Extent of, and impacts associated with Rehabilitation Site 11.

6.3 Assessment results of the wetlands identified

The wetlands identified for rehabilitation/enhancement within the study area were assessed in terms of their functioning and condition/integrity for both the current and post-rehabilitation/enhancement[15] scenarios. The results of these assessments are described below.

6.3.1 Wetland ecosystem functioning assessment

The general features of the wetland groups (refer to **Section 6.2.1**) were assessed in terms of the ecosystem functioning at a landscape level for the current and post-rehabilitation scenarios. The score for each ecosystem service represents the likely extent to which that benefit is being supplied by the specific wetland and was interpreted based on the following rating outlined by Kotze et al. (2007):

- <0.5 Low;
- 0.5-1.2 Moderately low;
- 1.3-2.0 Intermediate;
- 2.1-2.8 Moderately high; and
- >2.8 High.

[15] The term 'enhancement' is used to describe the process of improving and enhancing the functional services provided by the wetlands through structural interventions. This differs from the term rehabilitation which refers primarily to the improvement of the integrity of a given wetland system.

<u>*Current scenario*</u>

Generally, the values recorded for the regulating and supporting services for the current scenario for the natural rehabilitation sites were ***Moderately Low*** to ***Intermediate*** (**Table 6-1** and **Table 6-2**). The regulating services provided by these wetlands are affected the fact that many of these systems exist within wider drainage features and are often the final resting place for hydrological flows through the system – thereby becoming pollutant and sediment receiving areas within the landscape. However, it is important to note that the scores for effectiveness generally outweigh the scores for opportunity in for regulating and supporting service except in the cases of sediment trapping and erosion control as sediment mobilisation and erosion are the biggest threats in the broader landscape. Biodiversity maintenance was generally recorded at an ***Intermediate*** to ***Moderately High*** standard as these systems are very unique and supply a vital source of water for both faunal and floral communities within the area. The loss of these systems within the landscape would have devastating effects on the biodiversity of the area. The systems' provision of direct benefits and services, such as harvestable natural resources and use for education, was seen as limited due to the wetlands' location within private property.

<u>*Post-rehabilitation scenario*</u>

The post-rehabilitation scenario was assessed for all rehabilitation results and will be presented as an entire group as the rehabilitation strategy for the majority of the depression wetlands is relatively similar. Therefore, the difference between the pre- and post-rehabilitation scenarios is relatively uniform across all systems (**Table 6-3** and **Table 6-4**). Generally, the majority of the systems improved in terms of their ability to provide erosion control, carbon storage and biodiversity maintenance services. This can generally be attributed to the rehabilitation of catchment related impacts and the revegetation of bare areas in specific wetlands and/or within their sub-catchments. The restoration of the surrounding veld provides additional habitat for fauna and will contribute to overall species diversity in the area and as such will increase the biodiversity maintenance rating in the post-development scenario. The rehabilitation of the veld surrounding the wetlands will inevitably increase the systems' ability to trap and store carbon and decrease erosion in the wider landscape. It should be noted that the scores for sediment trapping generally decreased in the post-rehabilitation scenario as the various sources of sediment within the immediate catchment of these systems have been deactivated and removed in many of the rehabilitation plans and as such, the opportunity and hence the overall score for sediment trapping by these systems has been reduced.

Table 6-1 Summary of current Ecosystem Services Scores[16] for Rehabilitation Sites 1-8

Ecosystem Services	Rehab 1	Rehab 2	Rehab 3	Rehab 4	Rehab 5	Rehab 6	Rehab 7	Rehab 8
Flood attenuation	2.1	2.0	2.1	1.7	1.9	1.7	2.0	1.9
Score for effectiveness:	2.4	2.2	2.4	2.2	2.2	2.2	2.2	2.6
Score for opportunity:	1.8	1.8	1.8	1.3	1.5	1.3	1.8	1.3
Stream flow regulation	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2
Sediment trapping	2.4	1.8	1.4	1.6	1.6	1.9	1.8	2.0
Score for effectiveness:	1.7	1.1	1.2	1.1	1.1	2.1	1.6	2.3
Score for opportunity:	3.0	2.5	1.7	2.0	2.0	1.7	2.0	1.7
Phosphate trapping	1.6	1.3	1.2	1.4	1.2	1.5	1.4	1.2
Score for effectiveness:	2.2	2.0	2.1	2.0	1.7	2.7	2.2	2.1
Score for opportunity:	1.0	0.5	0.3	0.7	0.7	0.3	0.7	0.3
Nitrate removal	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.6
Score for effectiveness:	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.3
Score for opportunity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toxicant removal	1.5	1.1	1.1	1.2	1.2	1.3	1.4	1.1
Score for effectiveness:	1.9	1.8	1.8	1.8	1.8	2.3	2.2	1.8
Score for opportunity:	1.0	0.5	0.3	0.7	0.7	0.3	0.7	0.3
Erosion control	2.1	2.1	2.1	1.9	1.8	1.9	2.1	1.9
Score for effectiveness:	2.3	2.3	2.3	2.0	1.8	1.8	2.3	2.0
Score for opportunity:	1.9	1.9	1.9	1.8	1.8	2.1	1.9	1.8
Carbon storage	1.7	1.7	1.7	1.3	1.7	1.3	2.0	1.7
Biodiversity maintenance	2.4	2.5	2.6	2.4	2.1	2.6	2.4	2.3
Score for noteworthiness:	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Score for integrity:	2.9	3.0	3.1	2.9	2.3	3.3	2.8	2.5
Water supply	0.2	0.2	0.2	0.2	0.5	0.2	0.5	0.2
Source of harvestable goods /resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tourism and recreation	0.3	0.3	0.3	0.4	0.6	0.3	0.6	0.3
Education and research	0.3	0.3	0.3	0.5	0.5	0.5	0.8	0.8

[16] Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

Table 6-2 Summary of current Ecosystem Services Scores[17] for Rehabilitation Sites 9-11

Ecosystem Services	Rehab 9	Rehab 10	Rehab 11
Flood attenuation	1.9	2.0	2.1
Score for effectiveness:	2.0	2.2	2.4
Score for opportunity:	1.8	1.8	1.8
Stream flow regulation	0.3	0.2	0.2
Sediment trapping	1.4	1.6	1.8
Score for effectiveness:	1.5	1.6	2.2
Score for opportunity:	1.3	1.7	1.3
Phosphate trapping	1.3	1.1	1.0
Score for effectiveness:	2.5	1.9	2.1
Score for opportunity:	0.0	0.3	0.0
Nitrate removal	1.0	0.6	0.6
Score for effectiveness:	2.0	1.3	1.3
Score for opportunity:	0.0	0.0	0.0
Toxicant removal	1.2	1.0	0.9
Score for effectiveness:	2.4	1.7	1.8
Score for opportunity:	0.0	0.3	0.0
Erosion control	2.2	2.0	2.1
Score for effectiveness:	2.5	2.0	2.3
Score for opportunity:	1.9	1.9	1.9
Carbon storage	2.0	1.7	1.7
Biodiversity maintenance	2.3	2.5	2.7
Score for noteworthiness:	2.0	2.0	2.0
Score for integrity:	2.5	3.0	3.4
Water supply	0.5	0.2	0.2
Source of harvestable goods /resources	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0
Tourism and recreation	0.6	0.3	0.3
Education and research	0.5	1.0	0.5

[17] Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

Table 6-3 Summary of post-rehabilitation Ecosystem Services Scores[18] for Rehabilitation Sites 1-8

Ecosystem Services	Rehab 1	Rehab 2	Rehab 3	Rehab 4	Rehab 5	Rehab 6	Rehab 7	Rehab 8
Flood attenuation	2.2	2.1	2.2	1.8	1.8	2.1	2.1	2.0
Score for effectiveness:	2.6	2.4	2.6	2.4	2.4	2.4	2.4	2.8
Score for opportunity:	1.8	1.8	1.8	1.3	1.3	1.8	1.8	1.3
Stream flow regulation	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2
Sediment trapping	1.9	1.6	1.3	1.3	1.4	1.4	1.6	1.8
Score for effectiveness:	1.8	1.2	1.3	1.2	1.2	1.2	1.2	1.9
Score for opportunity:	2.0	2.0	1.3	1.3	1.7	1.7	2.0	1.7
Phosphate trapping	1.1	1.2	1.2	1.2	1.4	1.4	1.5	1.3
Score for effectiveness:	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.3
Score for opportunity:	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.3
Nitrate removal	0.8	0.9	0.9	0.9	1.0	0.9	1.0	0.8
Score for effectiveness:	1.5	1.8	1.8	1.8	2.0	1.8	2.0	1.5
Score for opportunity:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toxicant removal	1.0	1.0	1.0	1.0	1.3	1.2	1.5	1.2
Score for effectiveness:	2.0	2.1	2.1	2.1	2.3	2.1	2.3	2.0
Score for opportunity:	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.3
Erosion control	2.2	2.3	2.3	2.3	2.3	2.2	2.3	2.1
Score for effectiveness:	2.5	2.8	2.8	2.8	2.8	2.5	2.8	2.5
Score for opportunity:	1.9	1.9	1.9	1.8	1.8	1.9	1.9	1.8
Carbon storage	1.7	1.7	1.7	1.7	2.0	1.7	2.0	1.7
Biodiversity maintenance	2.6	2.6	2.6	2.7	2.4	2.6	2.4	2.4
Score for noteworthiness:	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Score for integrity:	3.3	3.1	3.1	3.4	2.8	3.3	2.8	2.8
Water supply	0.2	0.2	0.2	0.2	0.5	0.2	0.5	0.2
Source of harvestable goods /resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tourism and recreation	0.3	0.3	0.3	0.7	0.6	0.3	0.6	0.3
Education and research	0.3	0.3	0.3	0.5	0.5	0.5	0.8	0.8

[18] Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

Table 6-4 Summary of post-rehabilitation Ecosystem Services Scores[19] for Rehabilitation Sites 9-11

Ecosystem Services	Rehab 9	Rehab 10	Rehab 11
Flood attenuation	2.1	2.0	2.1
Score for effectiveness:	2.4	2.2	2.4
Score for opportunity:	1.8	1.8	1.8
Stream flow regulation	0.2	0.2	0.2
Sediment trapping	1.3	1.6	1.8
Score for effectiveness:	1.2	1.6	2.2
Score for opportunity:	1.3	1.7	1.3
Phosphate trapping	1.2	1.1	1.0
Score for effectiveness:	2.4	1.9	2.1
Score for opportunity:	0.0	0.3	0.0
Nitrate removal	0.9	0.6	0.6
Score for effectiveness:	1.8	1.3	1.3
Score for opportunity:	0.0	0.0	0.0
Toxicant removal	1.0	1.0	0.9
Score for effectiveness:	2.1	1.7	1.8
Score for opportunity:	0.0	0.3	0.0
Erosion control	2.3	2.0	2.1
Score for effectiveness:	2.8	2.0	2.3
Score for opportunity:	1.9	1.9	1.9
Carbon storage	1.7	1.7	1.7
Biodiversity maintenance	2.7	2.5	2.7
Score for noteworthiness:	2.0	2.0	2.0
Score for integrity:	3.4	3.0	3.4
Water supply	0.2	0.2	0.2
Source of harvestable goods /resources	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0
Tourism and recreation	0.3	0.3	0.3
Education and research	0.5	1.0	0.5

[19] Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

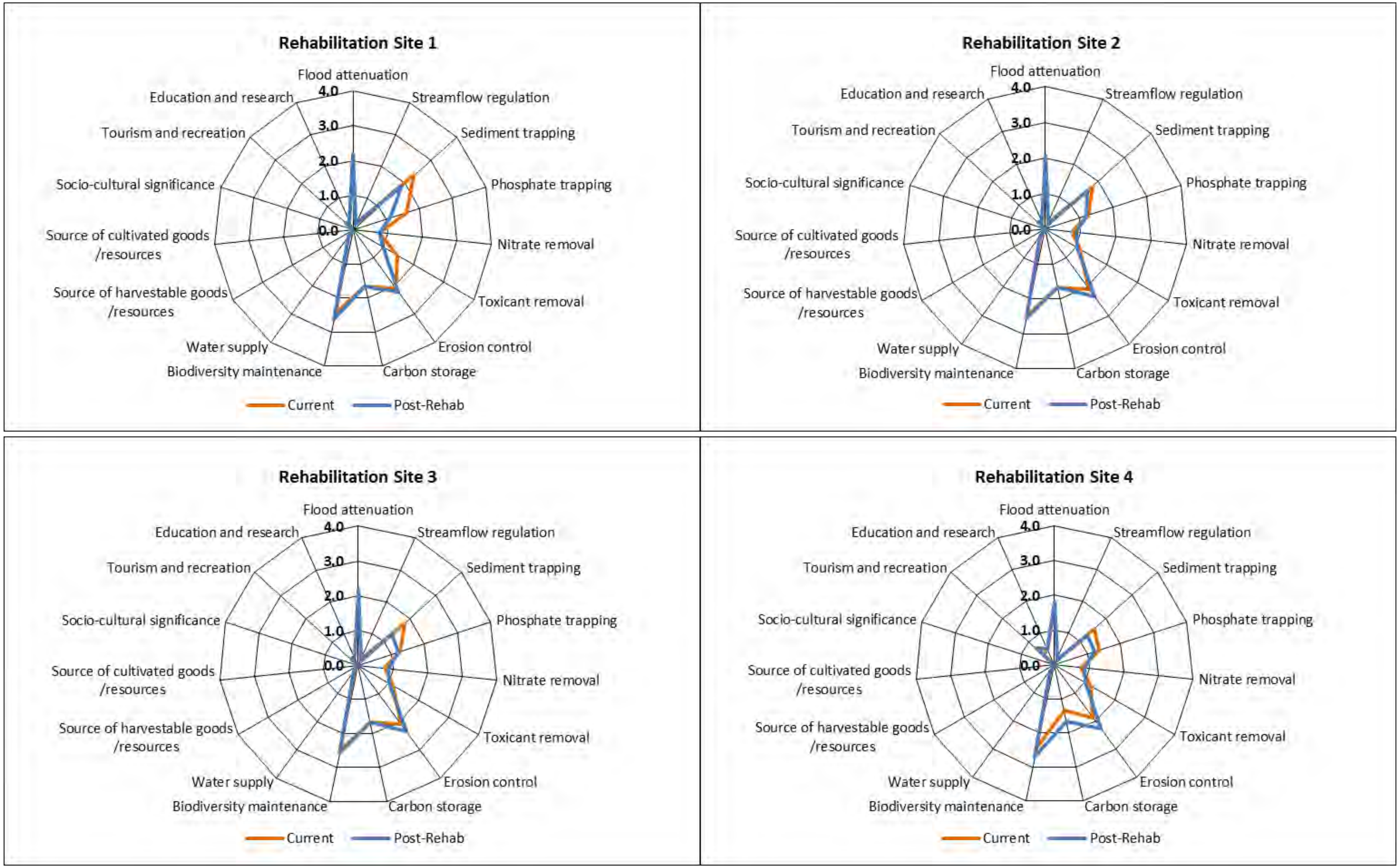


Figure 6-15 Overview of the ecosystem services provided by Rehabilitation Sites 1-4 in the current and post rehabilitation scenarios.

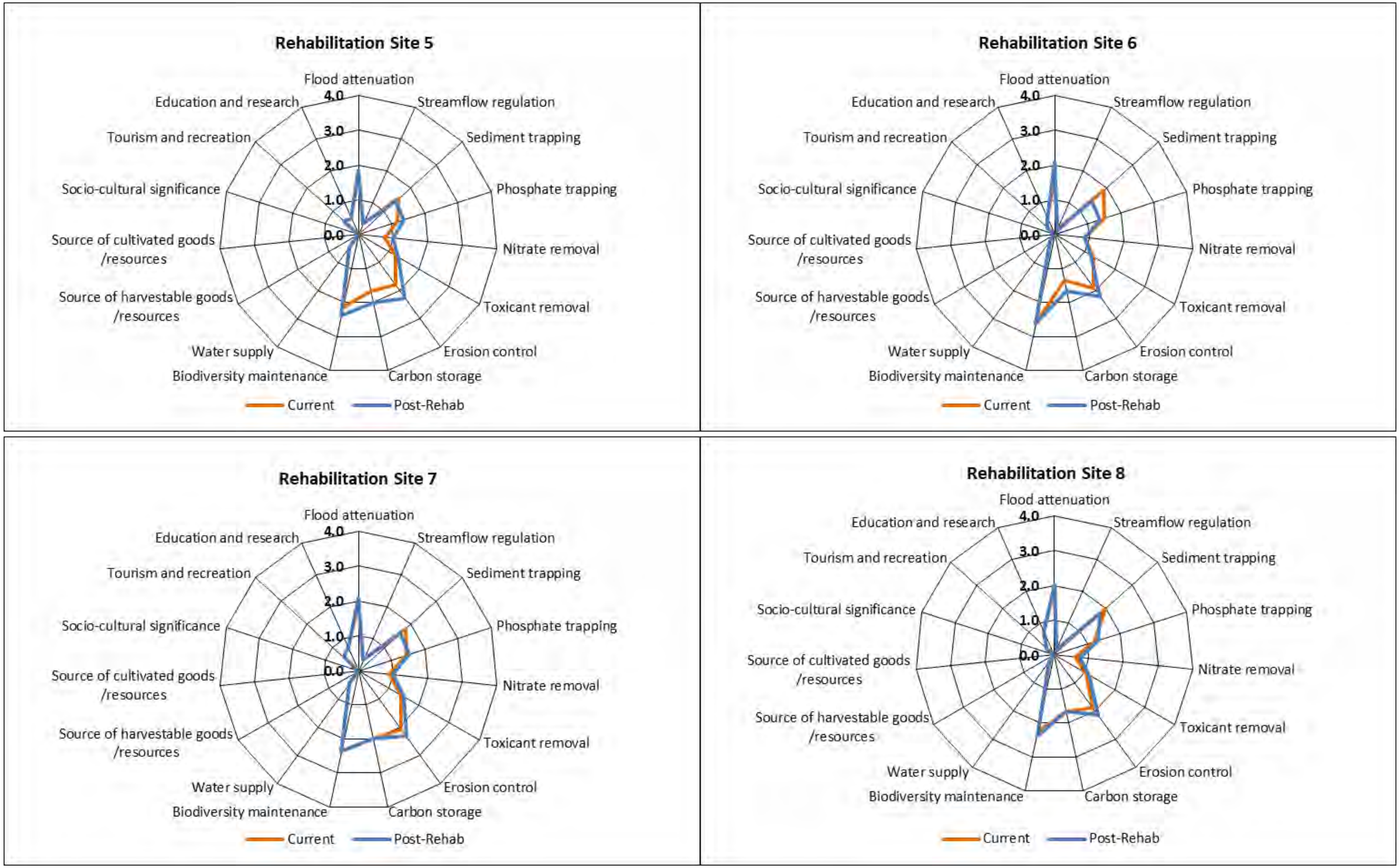


Figure 6-16 Overview of the ecosystem services provided by Rehabilitation Sites 5-8 for the current and post rehabilitation scenarios.

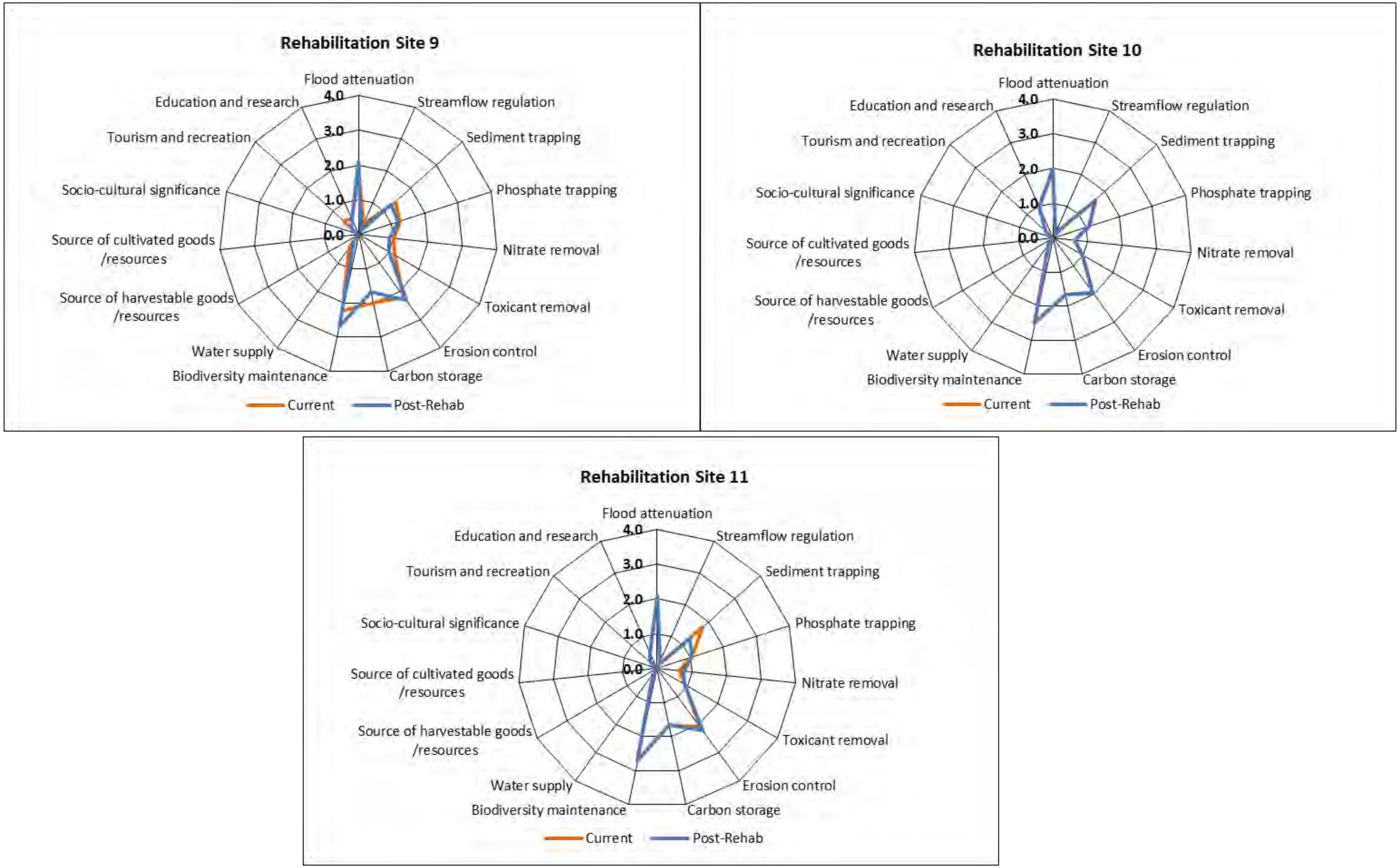


Figure 6-17 Overview of the ecosystem services provided by Rehabilitation Sites 9-11 for the current and post rehabilitation scenarios.

As WET-EcoServices does not provide a consolidated score that can be used as a target, the current and post-rehabilitation assessment scores were incorporated into the Wetland Importance and Sensitivity assessment datasheets (Rountree and Malan 2010) to provide EIS scores (refer to **Table 6-5** to **Table 6-15**).

Table 6-5 EIS scores for the Rehabilitation Site 1 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.0	Moderate
Hydro-functional importance	1.5	Low/marginal	1.4	Low/marginal
Direct human benefits	0.1	None	0.1	None
Overall Importance and Sensitivity Score/Class	2.0	**D**	2.0	**D**

Table 6-6 EIS scores for the Rehabilitation Site 2 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.4	Low/marginal
Direct human benefits	0.1	None	0.1	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

Table 6-7 EIS scores for the Rehabilitation Site 3 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.4	Low/marginal
Direct human benefits	0.1	None	0.1	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**D**

Table 6-8 EIS scores for the Rehabilitation Site 4 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Low/marginal	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.3	Low/marginal
Direct human benefits	0.2	None	0.1	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

Table 6-9 EIS scores for the Rehabilitation Site 5 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.4	Low/marginal
Direct human benefits	0.1	None	0.3	None
Overall Importance and Sensitivity Score/Class	2.0	**D**	2.2	**C**

Table 6-10 EIS scores for the Rehabilitation Site 6 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.4	Low/marginal
Direct human benefits	0.2	None	0.2	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

Table 6-11 EIS scores for the Rehabilitation Site 7 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Moderate	2.2	Moderate
Hydro-functional importance	1.5	Low/marginal	1.5	Low/marginal
Direct human benefits	0.3	None	0.3	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

Table 6-12 EIS scores for the Rehabilitation Site 8 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Low/marginal	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.4	Low/marginal
Direct human benefits	0.2	None	0.2	None
Overall Importance and Sensitivity Score/Class	2.0	**D**	2.2	**C**

Table 6-13 EIS scores for the Rehabilitation Site 9 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.2	Moderate
Hydro-functional importance	1.4	Low/marginal	1.3	Low/marginal
Direct human benefits	0.3	None	0.2	None
Overall Importance and Sensitivity Score/Class	2.0	**D**	2.2	**D**

Table 6-14 EIS scores for the Rehabilitation Site 10 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.3	Low/marginal
Direct human benefits	0.3	None	0.3	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

Table 6-15 EIS scores for the Rehabilitation Site 11 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.2	Moderate	2.2	Moderate
Hydro-functional importance	1.3	Low/marginal	1.3	Low/marginal
Direct human benefits	0.2	None	0.2	None
Overall Importance and Sensitivity Score/Class	2.2	**C**	2.2	**C**

6.3.2 Wetland ecological integrity assessment[20]

The ecological integrity or Present Ecological State (PES) of the wetlands were assessed for the hydrology, geomorphology, water quality and vegetation components, taking into account the reference/benchmark conditions. The integrity of the biophysical components of the wetlands were assessed for the current and post-rehabilitation scenarios, so as to provide an indication of the functional area gained as a result of the proposed rehabilitation activities.

It should be noted that the following assumptions were made with regards to the assessment of these systems:

- The assessment of catchment associated impacts utilised data collected both during the site visit and using aerial imagery. Historical imagery was utilised to assess the change in catchment related impacts over time so that an accurate representation of the current catchment related impacts could be incorporated into the WET-Health assessments.
- The size of most of the wetland systems assessed are generally <2% of the size of their catchments, as all catchments are >100ha in size. Therefore, it is unlikely that the portions of the catchments that are located farthest away from the wetland systems are going to have a large impact on the functioning of these wetland systems unless an exceptionally large rain event was to occur. As such, the WET-Health assessments weight catchment related impacts within a 200m buffer of the wetland more substantially than catchment related impacts located further away from the HGM unit.
- Only the areas delineated as 'true wetland' according to the DHSWS (2005) guidelines were assessed. As such, the areas delineated as 'sub-catchment areas' or 'areas of wider hydrological influence' were not included in the final hectare equivalent values and therefore were not included in the final offset calculation hectare values.

A total of eleven (11) systems were assessed in this study. Three (3) of the systems assessed have been classified as partially artificial depression wetlands as they receive artificial water inputs throughout the year, while the remaining eight (8) systems assessed have been classified as wholly natural wetland systems. Generally, the catchments of the wetlands are considered to be relatively intact due to the fact that these wetlands are located within the Manketti and Thabametsi sites and have been assessed/scored accordingly. The catchment impacts that were accounted for during the assessments include dirt roads, overgrazed vegetation (resulting in reduced surface roughness, increased risk of erosion and deposition) due to overstocking, and in instances where the dirt roads were in close proximity to the wetlands, additional sediment inputs into the systems. Generally, the in-system impacts are related to old land use practices and the presence of management roads within the wetland or the sub-catchment area. For a full description of the typical in-system impacts encountered in the eleven (11) rehabilitation sites, refer to **Section 6.1.3** (pg. 44).

Figure 6-18 depicts the identified wetlands within the study area and their respective PES categories for the current scenario. A summary of the results for each of the wetland groups are outlined below.

---

[20] Please note that the full data for the wetland ecological integrity assessment results can be made available if required

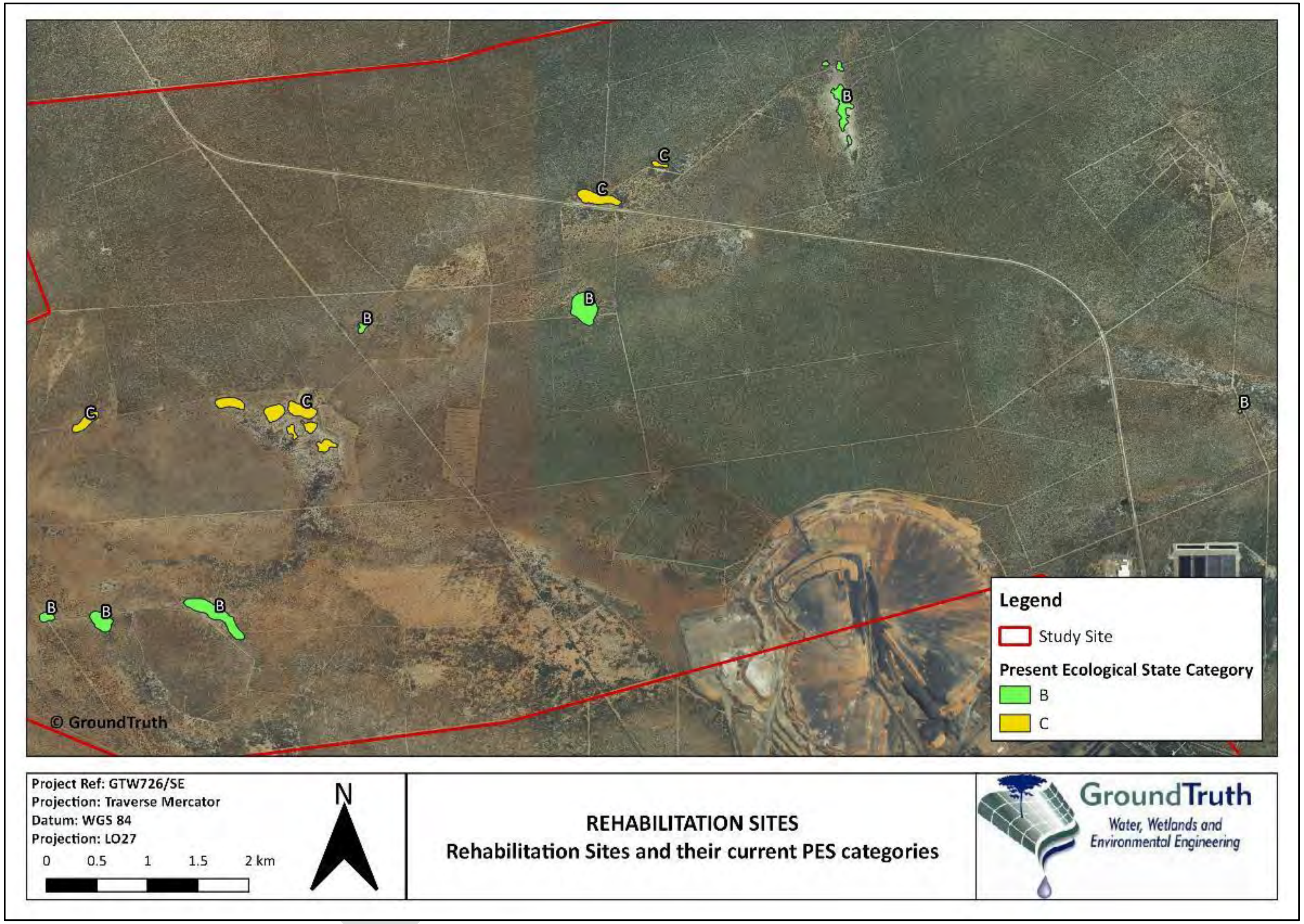


Figure 6-18 Overview of the identified wetlands within the Manketti Game Reserve and the Thabametsi areas and their associated PES category

All the wetland systems fall within the A42J and A41E quaternary catchments – most of which fall within the Manketti Game Reserve and the Thabametsi site. These systems range between 12.89ha and 0.13ha in size. The larger systems are generally characterised by a series of smaller seasonal depression wetlands that are interlinked by wider temporary zones. Generally, the catchment impacts are relatively uniform and range from the presence of dirt roads to impacts associated with degraded lands and poor veld condition as a result of old agricultural land and historical land use practices. The three rehabilitation sites (sites 5, 8 and 9) that are located in or near to old agricultural land are the most degraded of all systems – all scoring **C** categories. The only other wetland that score in the **C** category was Rehabilitation Site 1 with a range of in-system and catchment related impacts. Generally, the in-system impacts were limited to the presence of old roads within the wetland and low surface roughness associated with poor veld conditions. Poor veld conditions generally leads to a reduction in surface roughness within a wetland and can result in the mobilisation of sediment through erosion within the wetland extent. All other rehabilitation sites fell with the **B** PES category.

The post-rehabilitation scenario assumes that all the rehabilitation activities were implemented as specified in this rehabilitation plan. The majority of the rehabilitation interventions are associated with catchment related rehabilitation and the removal and rehabilitation of old roads within wetland systems.

Table 6-16 Summary of the assessment of the ecological integrity for Rehabilitation Site 1 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.90	3.48	1.80	5.41
PES category	**B**	**C**	**B**	**D**
Combined PES score	70%			
Overall PES category	**C**			
Hectares of wetland (ha)	2.56			
Hectare equivalents (ha)	1.79			
Post-rehabilitation PES score	79%			
Post-rehabilitation category	**C**			
Post-rehabilitation hectare equivalents (ha)	2.03			

Table 6-17 Summary of the assessment of the ecological integrity for Rehabilitation Site 2 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.93	0.96	0.72	3.71
PES category	A	A	A	C
Combined PES score	85%			
Overall PES category	B			
Hectares of wetland (ha)	1.25			
Hectare equivalents (ha)	1.06			
Post-rehabilitation PES score	88%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	1.1			

Table 6-18 Summary of the assessment of the ecological integrity for Rehabilitation Site 3 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.96	1.59	0.77	2.31
PES category	A	B	A	C
Combined PES score	86%			
Overall PES category	B			
Hectares of wetland (ha)	3.55			
Hectare equivalents (ha)	3.07			
Post-rehabilitation PES score	88%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	3.12			

Table 6-19 Summary of the assessment of the ecological integrity for Rehabilitation Site 4 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.59	2.42	0.66	4.29
PES category	A	C	A	D
Combined PES score	82%			
Overall PES category	B			
Hectares of wetland (ha)	7.96			
Hectare equivalents (ha)	6.50			
Post-rehabilitation PES score	87%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	6.94			

Table 6-20 Summary of the assessment of the ecological integrity for Rehabilitation Site 5 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.39	1.74	1.83	5.61
PES category	A	B	B	D
Combined PES score	78%			
Overall PES category	C			
Hectares of wetland (ha)	12.99			
Hectare equivalents (ha)	10.17			
Post-rehabilitation PES score	82%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	10.70			

Table 6-21 Summary of the assessment of the ecological integrity for Rehabilitation Site 6 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.42	2.13	1.74	3.98
PES category	A	C	B	C
Combined PES score	81%			
Overall PES category	B			
Hectares of wetland (ha)	0.79			
Hectare equivalents (ha)	0.64			
Post-rehabilitation PES score	89%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	0.71			

Table 6-22 Summary of the assessment of the ecological integrity for Rehabilitation Site 7 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.33	1.50	0.70	3.33
PES category	A	B	A	C
Combined PES score	87%			
Overall PES category	B			
Hectares of wetland (ha)	7.13			
Hectare equivalents (ha)	6.18			
Post-rehabilitation PES score	90%			
Post-rehabilitation category	A			
Post-rehabilitation hectare equivalents (ha)	6.43			

Table 6-23 Summary of the assessment of the ecological integrity for Rehabilitation Site 8 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	4.21	2.50	0.88	4.06
PES category	D	C	A	D
Combined PES score	69%			
Overall PES category	C			
Hectares of wetland (ha)	4.47			
Hectare equivalents (ha)	3.10			
Post-rehabilitation PES score	86%			
Post-rehabilitation category	B			
Post-rehabilitation hectare equivalents (ha)	3.85			

Table 6-24 Summary of the assessment of the ecological integrity for Rehabilitation Site 9 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	2.86	0.81	1.16	6.91
PES category	C	A	B	E
Combined PES score	71%			
Overall PES category	C			
Hectares of wetland (ha)	0.71			
Hectare equivalents (ha)	0.50			
Post-rehabilitation PES score	91%			
Post-rehabilitation category	A			
Post-rehabilitation hectare equivalents (ha)	0.65			

Table 6-25 Summary of the assessment of the ecological integrity for Rehabilitation Site 10 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.50	2.19	1.15	4.18
PES category	**A**	**C**	**B**	**D**
Combined PES score	82%			
Overall PES category	**B**			
Hectares of wetland (ha)	5.61			
Hectare equivalents (ha)	4.58			
Post-rehabilitation PES score	86%			
Post-rehabilitation category	**B**			
Post-rehabilitation hectare equivalents (ha)	4.82			

Table 6-26 Summary of the assessment of the ecological integrity for Rehabilitation Site 11 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	0.60	1.49	1.01	3.50
PES category	**A**	**B**	**B**	**C**
Combined PES score	85%			
Overall PES category	**B**			
Hectares of wetland (ha)	0.13			
Hectare equivalents (ha)	0.10			
Post-rehabilitation PES score	91%			
Post-rehabilitation category	**A**			
Post-rehabilitation hectare equivalents (ha)	0.11			

6.3.3 Summary of overall ecosystem integrity for the wetlands

For ease of interpretation the scores for hydrology, geomorphology, water quality and vegetation are able to be simplified into a composite impact score for the HGM unit by weighting the scores. This score was then used to derive hectare equivalents, which were used as the 'currency' for assessing the losses and gains in wetland integrity for offsetting purposes (Macfarlane et al. 2018, Cowden and Kotze 2009).

Based on the PES score for the current scenario, the 36.29ha of wetland within the Thabametsi mining rights area and the 10.90ha of wetland within the Manketti Game Reserve area (totalling 47.19ha) is considered to be the equivalent to 37.70ha of intact wetland habitat (**Table 6-27**). The graphic representation of the functional wetland area versus the total extent of the wetland habitat onsite, clearly illustrates that the wetland habitat is functioning at approximately 79.88% (**Figure 6-19**). There are hectare equivalent gains in all wetlands in the post-rehabilitation scenario.

Table 6-27 Summary of the hectare equivalents for the current and post-rehabilitation scenarios for the identified wetland groups

HGM unit	Overall size (ha)	Current ha equiv.	Post-rehabilitation ha equiv.	Gains (ha)
Thabametsi Wetlands	36.29	29.42	31.03	1.61
Manketti Wetlands	10.90	8.28	9.43	1.15
Total	**47.19**	**37.70**	**40.46**	**2.76**

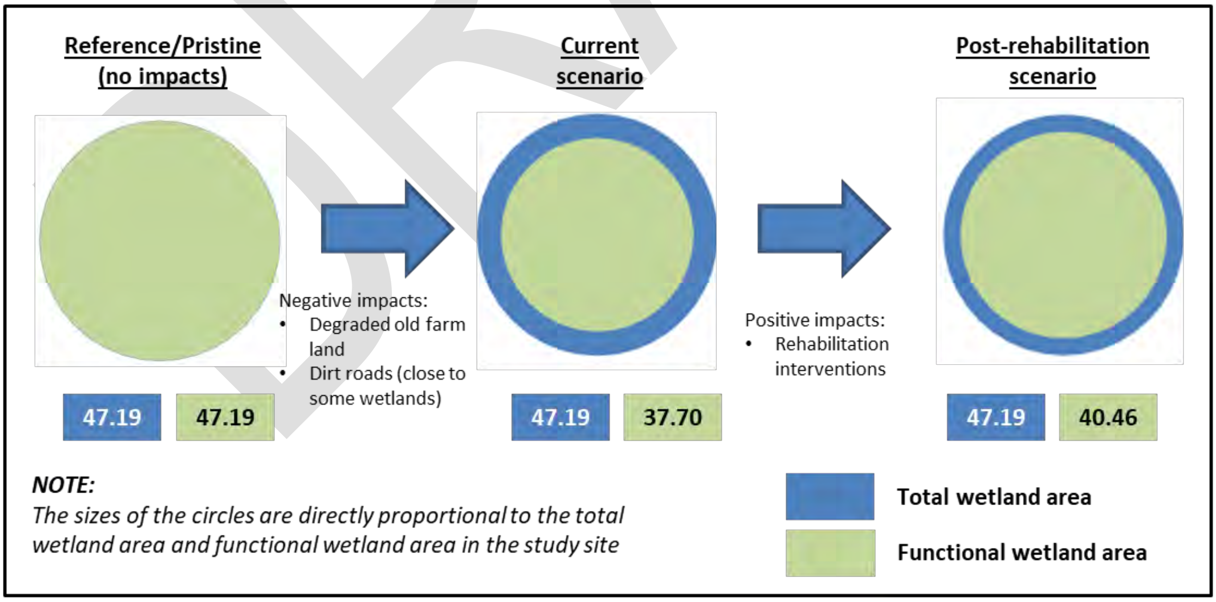


Figure 6-19 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed post-rehabilitation scenarios.

6.4 Freshwater ecosystem risk assessment

When assessing the risks associated with the proposed rehabilitation activities, it was assumed that the proposed activities will have a limited footprint on the surrounding landscape, i.e. access roads. Consideration of the principles and approach described in the DHSWS Risk Matrix (GN 1180 of 2015), highlighted that the proposed rehabilitation activities will have a **limited/low risk** of negative impacts on the functioning and integrity of the systems (**Table 6-28**). The objective of the rehabilitation activities is to improve the overall functioning and integrity of the identified systems, which can be achieved through the careful implementation of the proposed rehabilitation activities. However, the Risk Matrix cannot account for positive impacts in the environment and therefore, the potential risks depicted below are considered to be 'worst-case' scenarios.

The risk associated with the rehabilitation activities is linked to the 'construction'/ implementation phase and may include impacts such as the potential mobilisation of sediments into the pans through, for example, the removal of vegetation to create access paths. These impacts however, are considered to be low as it forms part of the rehabilitation process. It is assumed that care will be taken during the implementation phase to limit any impacts on the natural environment. Following the implementation of the proposed rehabilitation activities any disturbed areas will be suitably rehabilitated, including the immediate catchments surroundings the wetland systems.

The potential risk of the rehabilitation measures within the post-implementation landscape, is linked to the movement of wildlife into these pans prior to them being fully established/stable. However, it is unlikely to occur as the immediate areas surrounding the rehabilitated wetland systems will be suitably brush-packed and as such limiting access to the pans. In addition, it is recommended that these systems are monitoring for a period following the implementation of the rehabilitation activities, and as such guidance would be provided when the movement of wildlife into these systems would be considered to be acceptable again.

Table 6-28 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the rehabilitation activities for the natural systems

Phase	Activity	Aspect	Impact	Severity	Spatial Extent	Duration	Probability/ Likelihood	Signifi-cance	Risk Rating	Confidence level	Control Measures	Residual Risk Rating*
Construction	Creating access path to rehab sites (where applicable)	Removal of vegetation to create access path	Removal of the vegetation within the catchment of the wetlands	1.1	1	1	8	25	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Creating access path to rehab sites (where applicable)	Siltation of wetland	Siltation of pan from access roads (especially with rehab activities are undertaken during the wet periods)	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Creating access path to rehab sites (where applicable)	Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Removal of roads/sediment plumes within the pans	Compaction of section of the remaining natural pan	Removal of the vegetation within the pan and/or changing the substrate characteristics, i.e. compacted sections	1.1	1	1	8	25	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Removal of roads/sediment plumes within the pans	Removal of invertebrates from pan (i.e. through trampling of additional areas)	Reduced invertebrate diversity within the pan	1.5	1	1	8	28	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Removal of roads/sediment plumes within the pans	Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Deactivation of gullies/animal paths	Placement of ecologs/staggered logs	Siltation of pan	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Potholing within catchment	Disturbance of the sediments and/or vegetation	Siltation of the pan particularly if activity is undertaken during wet periods	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Brush-packing	Disturbance of areas within the catchment from where the brush will be sought	Removal of vegetation/ additional access paths	1.1	1	1	8	25	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Brush-packing	Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Construction	Draining artificially sustained pan	Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Operational	Access of wildlife to rehabilitated pans (worst-case scenario)	Siltation of wetland	Siltation of the pan associated with wildlife paths	1	1	2	8	32	L	90%	Management of the rehabilitation sites, ensuring that the wildlife do not gain access to the wetlands prior to them fully recovered and the vegetation in the catchment has established	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements
Operational	Access of wildlife to rehabilitated pans (worst-case scenario)	Damaging of brush-packing	Removal of vegetation/ additional access paths	1	1	2	8	32	L	90%	Management of the rehabilitation sites, ensuring that the wildlife do not gain access to the wetlands prior to them fully recovered and the vegetation in the catchment has established	Low (as these systems will receive protection for a period of 60 years), as they form part of the offset requirements

6.5 SANBI offset calculator

As the impacts associated with the proposed expansion of the Grootegeluk mine on all of the identified wetlands within the LOM footprint of the study area were unable to be mitigated through the rehabilitation of wetlands onsite, an offset requirement was 'triggered', as the residual impact associated with the proposed mining activities has not been accounted for as defined in the SANBI Offset Guidelines (Macfarlane et al. 2014). An assessment of the offset requirements was conducted for the wetlands lost (see **GTW726/301018/01**).

The loss of 5.85hectare equivalents of wetland habitat, associated with the expansion, was considered in terms of the approach specified by the SANBI Offset Guidelines (**Table 6-29**). As described previously, the SANBI Offset guidelines were used to determine the offset targets. In terms of the offset targets that would be applicable, the following would need to be considered for the impacts on the wetland systems:

- Wetland functionality target – 5.85hectare equivalents;
- Ecosystem conservation target – 1.31hectare equivalents; and
- Species of conservation concern target – not applicable as no species of special concern[21] were identified.

Table 6-29 Wetland offset targets and the contribution of the identified candidate wetlands towards the wetland functionality and ecosystem conservation targets

	Wetland functionality (ha equiv.)	Ecosystem conservation (ha equiv.)
Thabametsi Wetlands	1.06	61.54
Manketti Wetlands	0.75	21.20
Total gains	1.81	82.74
Offset targets	5.85	1.31
Surplus/shortfalls	**-4.04**	**+81.43**

It should be noted that the SANBI Offset Guidelines (Macfarlane et al. 2014) account for a level of risk associated with the rehabilitation and long-term protection of the wetlands in the receiving areas by utilising an adjustment factor that lowers the gains received from each wetland being rehabilitated offsite based on whether rehabilitation, averted loss or establishment is taking place and the level of protection the systems will receive in the post-rehabilitation/establishment scenario. In this instance, the candidate sites fall within Exxaro land holdings and therefore, are incorporated within the management and conservation protocols of Exxaro and their satellite organisations. The adjustment factor to account for risks associated with activities on other land holdings has therefore been excluded from the offset calculations to

[21] Species of special concern include Red Data Book or Red List taxa on threatened or conservation concern categories (Macfarlane et al. 2014). The nature of the study did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified

account for the fact that the wetlands fall within Exxaro land holdings and management and long-term protection of the candidate site are secured.

As is evident from **Table 6-29**, the identified candidate sites are not able to address the wetland functionality offset target, but significantly exceed the ecosystem conservation offset target. The inclusion of all candidate sites results in a nett-loss of 4.04ha in terms of wetland functionality and a gain of 81.43ha in terms of ecosystem conservation targets. It should also be noted that these wetland systems are some of the least understood and most threatened wetland types in South Africa and a like-for-like trade is necessary. It is recommended that all sites be rehabilitated to meet the agreed targets and account for impacts associated with the proposed mining activities.

It is recommended that a commitment to long-term conservation management of the identified candidate wetlands be secured through the Biodiversity Stewardship Programme[22] or having the candidate sites deemed conservation servitudes[23]. The process of meeting offset demands becomes an extremely land hungry endeavour if additional offset receiving sites are required outside of Exxaro owned and managed land as the SANBI offset calculator employs a multiplier that decreases the offset value if the land is not owned or managed by the entity responsible for the destruction of the wetlands in the first place. In a landscape that is scarce in its wetland coverage, it is advised that all additional offset work be kept on Exxaro managed land.

Even though the offset targets are unattainable within the identified areas, due to the condition of these systems being between '**A**' and '**C**' class systems[24], it should be noted that Exxaro have shown their commitment towards trying to mitigate the impacts associated with the loss of the wetland habitat within the landscape. It should be noted that the system used to calculate offsets does not penalise individuals/organisations that allow wetland systems on their properties to become degraded with the intention of using them for offsetting purposes when required, and does not reward those for maintaining healthy wetland systems. Exxaro have commenced with a study which aims to recreate wetland habitat, i.e. non-perennial pans, within the landscape (GroundTruth 2020). The objective of the trial is to recreate functional pans within the landscape, in the hope that the pans can be recreated within the rehabilitated pit area and disused borrow-pits in the future, thereby ensuring that wetland habitat is replaced within the rehabilitated pit area. Thus, even though the contribution of these created systems is currently a trial, these systems may potentially contribute to future functional gains within the modified and rehabilitated pit landscape thereby attempting to address the current deficit.

It is GroundTruth's understanding that the Zonderwater farm to the east of the Manketti Game Reserve is owned by Exxaro. There is a large feature of hydrological influence that originates in the Vooruit cadastral in Manketti that runs in an easterly direction, through the farm Ganzepan 446 and into the Zonderwater farm. This wider area of hydrological influence appears to have a

[22] This would include the development of a conservation management plan.

[23] This would be considered the responsibility of Exxaro as a part of the offset requirements

[24] '**A**' class systems are unmodified and natural systems, '**B**' class systems are slightly modified systems with slight signs of degradation, and '**C**' class systems are moderately modified systems where the alteration to the system and its ability to function have been altered although the natural system remains relatively intact.

series of wetland systems located within it and could contain a series of string-of-pearls configurations. If Exxaro were to purchase the Ganzepan 446 farm portion, there may be scope to decrease the offset deficit of 4.04ha. Upon review of the available imagery, it appears as though there may be rehabilitation potential within the Ganzepan 446 farm portion. A site visit would be required to confirm this.

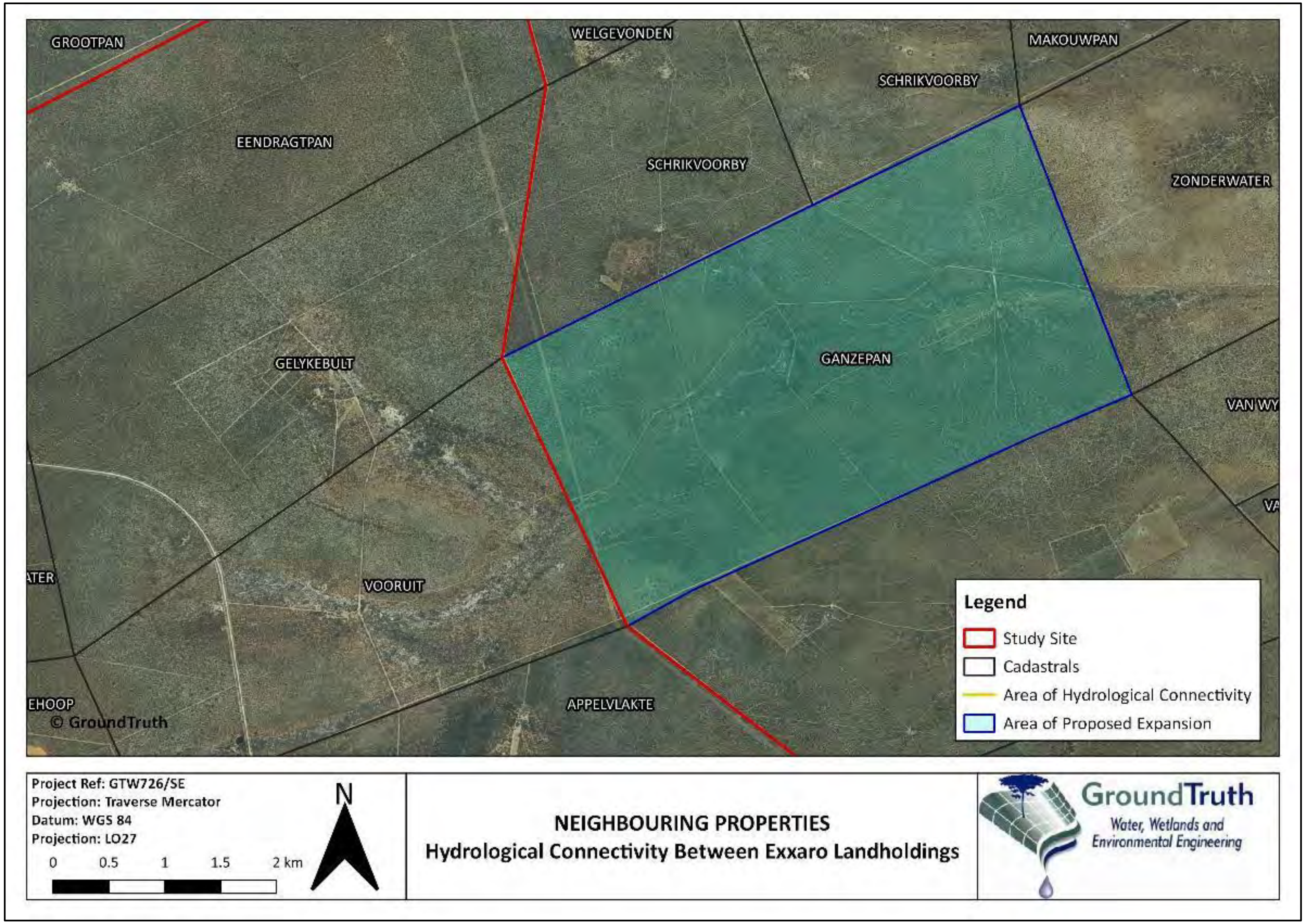


Figure 6-20 Possible areas of expansion of Exxaro property in order to achieve the wetland offset targets

7. WETLAND REHABILITATION PLAN

Wetland rehabilitation can be described as a process in which the causes and symptoms of the wetland degradation are addressed, ensuring the wetland integrity and functionality are maintained and/ or improved to a desired state. A proactive approach in terms of corrective interventions is recommended to address the impacts within the wetland systems. An example of a rehabilitated wetland is shown by **Figure 7-1**, with wetland habitat directly adjacent to a development serving to provide regulatory benefits and services such as flood attenuation and water quality enhancement.

Figure 7-1 An example of rehabilitated wetland habitat in a landscape previously devoid of functional wetland habitat

The proposed wetland rehabilitation activities aim to improve the integrity of the identified candidate depression systems thereby, ensuring the offset targets are achieved in part. The following sections serve to describe the rehabilitation of the wetland ecosystems including the problems, aims, objectives and details pertaining to the proposed structural interventions.

7.1 Wetland problems

The biophysical drivers of the depression wetlands have been significantly impacted upon by current and historical activities, including inter alia:

- Coal mining;
- Construction of mining associated housing and infrastructure;
- Road construction;
- Poor veld management and overgrazing;
- Sediment deposition and infilling; and
- Alien invasive vegetation.

7.2 Wetland rehabilitation aims and objective

With the implementation of wetland rehabilitation, it is important to set aims and objectives for the planned rehabilitation in accordance with WET-RehabPlan (Kotze et al. 2009).

Aim:
Due to the high level of cumulative loss of freshwater ecosystems in this region, the aim of the rehabilitation is to mitigate the residual impacts of the expansion of the Grootegeluk mining footprint, by enhancing the functioning and integrity of the identified wetlands within the Manketti Game Reserve and Thabametsi mining right area.

Objective:
The primary objective of the wetland rehabilitation is to secure and improve the overall integrity of the various systems, particularly focusing on improving:

- The hydrological conditions in the systems that are artificially maintained;
- The hydrological and geomorphic conditions in many of the natural systems;
- Wider hydrological connectivity between wetland systems;
- Promoting obligate wetland species to establish within the wetland habitat; and
- Promoting the establishment of an understory in the areas immediately surrounding the wetland systems.

Achieving these objectives will facilitate the provision of higher levels of ecosystem service delivery within the landscape, specifically sediment and nutrient trapping, and the maintenance of biodiversity.

Based on the nature of the stated objective, the timeframes would be subject to a lag period, but ecosystem response would be expected within five years of the implementation of the rehabilitation activities.

7.3 Wetland rehabilitation strategy

Based on the observations of ecosystem functioning and integrity during all visits made to site, the ecosystem functioning and integrity of the majority of the systems would improve with the incorporation of site specific interventions to promote diffuse flow of water into the wetland systems during the wet season by means of catchment related rehabilitation, to increase infiltration rates and surface roughness. The ecosystem functioning and integrity of the majority of the systems would further improve if access to the wetland systems and their sub-catchment areas (assuming a 50m radius) is limited during critical periods of the wet and dry seasons, allowing these areas to regenerate. In addition, small erosion control measures will also be implemented to prevent the mobilisation of sediment into the wetland systems from adjacent roads and degraded patches of veld. The design and location of the proposed interventions have been determined taking into consideration the nature of each site (refer to **Section 7.5** and **Appendix 1**).

Based on the above-mentioned approach to promote diffuse flow through the wetlands and prevent erosion, it is anticipated that the following intervention types would be required:

- Erosion control measures along the edges of the wetland systems to encourage understory recovery and to prevent sediment transport into the wetland systems. These erosion control measures include:
    - Brush-packing;
    - Timber erosion control logs; and
    - ‘Potholes’;
- Terminating artificial supplies of water to wetland areas and creating additional artificial watering points for animals in terrestrial areas – taking pressure off the wetland systems themselves;
- Removing old roads that pass-through wetland systems that have been decommissioned;
- Construction of low-key earthen berms to direct water off roads or animal tracks that run through or around wetlands; and
- Revegetation of certain areas within wetland catchments with suitable seed mixes and, where possible, suitable seed/root stock will be harvested from rehabilitation sites to be re-planted subsequent to the rehabilitation activities.

7.4 Wetland rehabilitation/enhancement interventions

There are two separate rehabilitation related terms being used to describe interventions namely: ‘rehabilitation’ and ‘enhancement’ and it is important to make a distinction between the two as they are ultimately going to have different outcomes. The types of interventions specified for both strategies are exactly the same and will therefore be described together in the sections below (refer to **Appendix 1** for details regarding each specific intervention). It should be noted that the majority of the interventions specified for each rehabilitation site are relatively generic and consist predominantly of soft interventions that do not require the use of concrete or stone work. As such, very detailed drawings for each intervention and rehabilitation site have been deemed unnecessary as generic design details can be applied across the site. Therefore, no specific designs have been included in this report, instead specific concepts and instructions have been included in the following sections that outline the method with which each intervention type should be carried out and implemented. The dimensions and the number of each intervention have been specified per rehabilitation site in **Section 7.5** in **Appendix 1**.

7.4.1 Brush-packs

These interventions have become the ubiquitous intervention for the majority of the rehabilitation sites as the majority of the wetland systems. Many catchment related impacts will be minimised through the use of brush-packs. Brush-packing is achieved by covering the ground surface with organic plant material – in this case branches and debris generated during the clearing of land for mining or the clearing of alien invasive species. Brush-packs on exposed soils simulates the protective effect of plant cover and thereby encourages plant growth (**Figure 7-2**). This is achieved through:

- The reduction of rain splash erosion;
- Increasing retention of moisture in the soil;
- Decreasing soil temperature;
- Restricting soil and humus movement in run-off and wind;
- Protecting germinating plants from grazing animals; and
- Creating habitat for soil-living animals to burrow and aerate the soil (Coetzee, 2005).

Figure 7-2 Example of the effects of brush-packing on a localised area

The brush-packs should be packed in a 200-300mm thick layer and should consist of branches and plant cuttings. Each brush-pack will should be approximately 1m in width and will vary in length depending on the extent of the area requiring rehabilitation. Generally, the rehabilitation of roads will require brush-packs that are between 5 and 7m in length whereas larger areas that are affected by erosion and/or capping may require brush-packs in excess of 15m in length. Each brush-pack should cover 70-75% of the soil surface to prevent erosion effectively, but should not be in excess of 80% cover which would limit the process of plant growth and ultimate revegetation. In particularly exposed areas, larger branches and/or small tree trunks can be used to weigh the brush-packs down to prevent them being blown away by wind. If additional organic material is required, larger branches and tree trunks can be put through a wood-chipper and laid down beneath the brush-packs to provide additional cover and organic material to aid the germination of plants beneath the brush-packs. The creation of these brush-packs will be very cost-effective and will therefore be used in the majority of the systems receiving rehabilitation, whether to stabilise eroding animal paths or to simply protect the soil and encourage vegetative regrowth of the understory.

7.4.2 Potholes/hollows

The catchments of many of the wetlands have been severely degraded as a result of overgrazing by herbivores which has reduced the vegetative cover of the immediate catchments and in some cases has resulted in capping of the ground surface. This capping is very hard and extremely impermeable, preventing infiltration during the wet season and preventing vegetation establishment in these degraded areas. Hollows or 'potholes' are small damlets that break through hard surface capping and allow for infiltration instead of runoff and can either be created by hand or machinery. In addition, the use of hollows or potholes in the catchments of a number of the wetland systems will:

- Prevent the loss of rich organic matter via run off;
- Trap wind-blown seeds and animal droppings which will germinate and fertilise simultaneously during the wet season;
- Contribute to overall soil moisture to assist with vegetation establishment;
- Create a microclimate if many potholes are dug on a degraded piece of land, creating conditions favourable for vegetation establishment; and
- Reduces the effects of erosion by water and wind (Coetzee, 2005).

Each pothole can be excavated by hand and should be 500mmx600mm by 200-300mm in depth. These potholes should be spaced 2m apart in rows that are 1.5m apart. The excavated material should be removed from the site so as to prevent excessive trapping of water in the landscape. These potholed areas can be seeded with an appropriate seed mixture that contains both herbaceous and woody species. The potholes will be packed with brush-packs so as to prevent excessive grazing by animals for as long as possible and assist in vegetative recovery of the immediate catchments.

7.4.3 Road removal and rehabilitation

Many of the rehabilitation sites are dissected by management roads that have been specified for removal. The removal of these roads will reinstate natural hydrological connectivity across the affected HGM units and will thereby increase the ability of wetlands to provide ecosystem services (**Figure 7-3**). The roads will be removed to a level that coincides with the natural ground level of the wetland such that hydrological flows are allowed to flow along natural pathways. The additional material generated by the removal of these roads will be used in the construction of the new alignments of these roads around the wetland systems. The process of breaking the road surface to encourage vegetative regeneration will either be achieved using a disking machine which pummels the road surface with two large disks to break up the surface, or scarified with the teeth of the backhoe of a tractor-loader-backhoe (TLB). Both these methods will break the hard surface of the road to allow infiltration of water and vegetation to re-establish in the area. In addition, brush-packs will be laid across the road surface to trap organic matter that may be mobilised down the old road during rain events as well as to provide a nursery environment to allow other plants to establish. An appropriate seed mix can also be spread across the old road surface to speed up the revegetation of the old road surface.

Figure 7-3 Example of a road crossing within Rehabilitation Site 4 and its effect on the hydrological connectivity within the wetland.

7.4.4 Alien/invasive vegetation removal and follow up activities

A number of invasive woody species were identified within two wetland areas and removal of these species would improve the hydrological and vegetative integrity of these two sites. Invasive trees must be felled in accordance with the general approach adopted by the Working for Water programme. Due to the risk associated with the formation of debris dams following invasive plant clearing operations, the clearing method adopted within the wetland habitat is described as 'Cut-and-Remove'. This includes the cutting down and removal of all invasive plants and material from the wetland habitat. The branches of the invasive trees can be removed and dried appropriately to be used as brush-packing material while the trunks can either be put through a wood chipper, can be used as weights for brush-pack bundles, or can be removed from the site completely. A selective herbicide for stump treatment should be used to ensure that the existing grass plants are not impacted upon.

In addition to the initial clearing of the identified invasive plant species, follow-up activities are required to eradicate emerging seedlings or coppicing stumps. The implementation of follow-up operations is essential in order to reach maintenance levels in terms of controlling invasive plants within the systems. It is recommended that the follow-up invasive plant clearing activities adopt the following approach:

- Manual activities, including hand-pulling of seedlings, to reduce the risk of the translocation of herbicide;
- Frequent follow-up operations with at least two operations being undertaken per year; and
- Where necessary foliar application of herbicide to emerging coppice.

7.4.5 Re-vegetation and planting

A number of the rehabilitation activities may result in bare areas within the wetland. These areas will need to be revegetated to restore natural ecological function and stabilise soil. It is recommended that the revegetation of the wetland areas and the surrounding sub-catchment areas is achieved through the mosaic harvesting and re-seeding of appropriate wetland and non-wetland species. The revegetation of each HGM unit and associated catchment should be done with a seed mixture that is appropriate for the ecotone that exists in that particular area. The selection of species will need to be achieved in consultation with a wetland specialist as well as the land manager responsible for the management of the Manketti Game Reserve, including the Thabametsi mining rights area.

7.4.6 Earthen diversion berms

Earthen diversion berms have been specified where flows are required to be diverted away from specific features and into or away from wetland systems. These have generally been specified for systems that have roads that either cross through or very close to the HGM unit. Earthen diversion berms will generally be constructed on a road at a specific angle to intercept flows and push the flows in a certain direction. Generally, the flows are pushed away from the wetland areas to prevent deposition of additional sediment, but in some cases, these will deflect water into the wetland in order to provide it with additional water inputs. These earthen berms have also been specified for the animal tracks that lead into Rehabilitation Site 4 which will force water out of the concentrated flow paths and encourage diffuse flows into the wetland zone.

7.5 Proposed Rehabilitation strategies for individual HGM units

Various rehabilitation and enhancement strategies have been adopted within the greater study area in order to achieve the aims of enhancing the functioning and integrity of the identified wetland systems in the broader landscape. In this section, the rationale for the selection of the interventions to achieve the adopted rehabilitation strategy is specified for the individual HGM units. An intervention layout per individual HGM unit is provided for use in conjunction with the strategy summaries (**Appendix 1**).

Proposed enhancement strategy for Rehabilitation Site 1

The problems with Rehabilitation Site 1 are primarily associated with the old road that dissects the HGM unit (**Figure 7-4**). The road prevents complete hydrological connectivity between the northern and southern portions of the wetland as there are portions of the road that are raised above natural ground level which prevent water from flowing freely across the landscape. The wetland sits at the lowest point within the wider landscape which means that it naturally becomes a collection and depositional area for water and sediment. The presence of the unvegetated road means that additional sediment is transported into the wetland during heavy rains. This road is no longer being utilised, as an alternative road has been created along an old existing track which circumnavigates the entire wetland and as such, the removal of the old road is essential to prevent further unnatural sedimentation within the wetland. In addition, old construction material like bricks, concrete, HDPE pipes and wires were observed within the wetland itself and would need to be removed and disposed of appropriately.

The enhancement strategy for this site will include the scarifying and/or disking of the old road surface to break the harder layers of ground that have been compacted over many years of use. Brush-packs will then be laid down across the road in 5-10m intervals to encourage vegetation regrowth on the old road surface as well as to prevent further sedimentation within the wetland. These brush-packs will also be reseeded to speed up the revegetation process. The construction material will also be removed from the wetland.

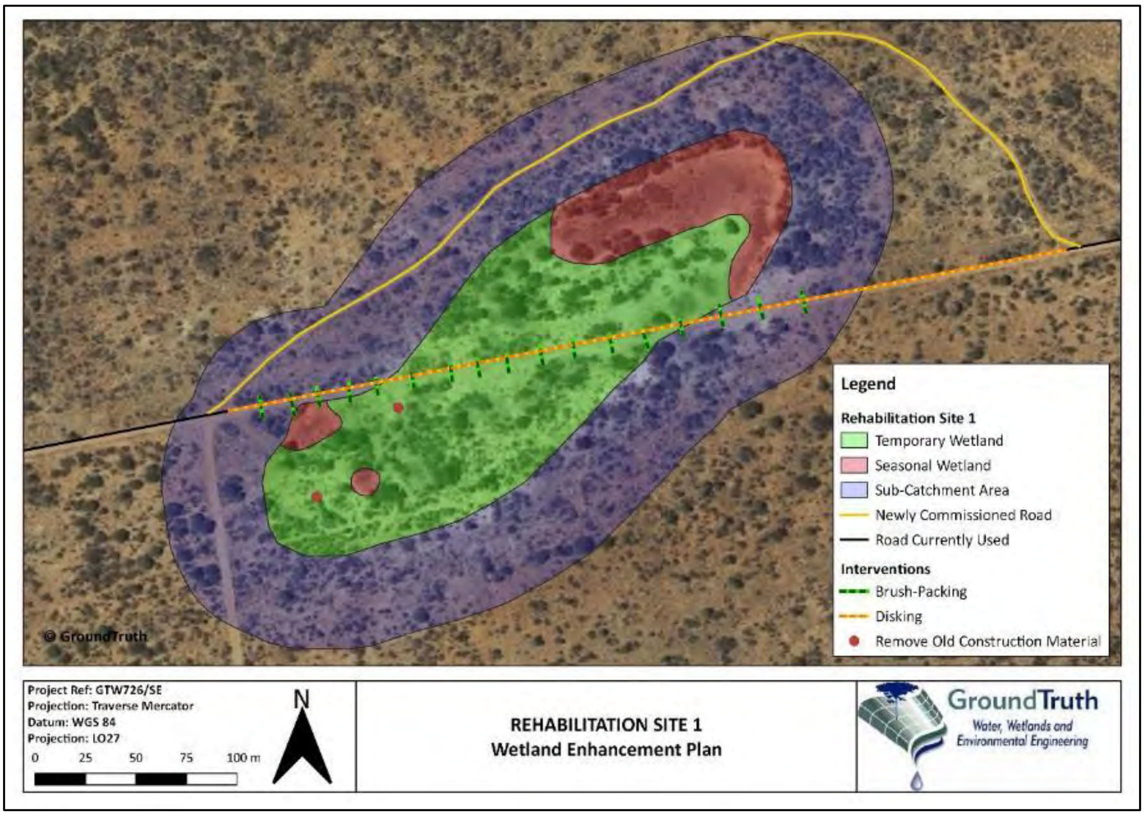


Figure 7-4 Overview of the proposed rehabilitation strategy for Rehabilitation Site 1

Proposed enhancement strategy for Rehabilitation Site 2

Rehabilitation Site 2 has been included within this rehabilitation plan because the road passing through the wetland is having a negative and an unnatural impact on the functioning of the wetland system. As such, the road has been realigned to the east of the wetland and circumnavigates the entire wetland area[25] - rendering the road through the wetland useless. (**Figure 7-5**). As such, the road passing through the HGM unit can be removed in a similar manner to that described for Rehabilitation Site 1 by scarifying/disking, brush-packing and revegetating.

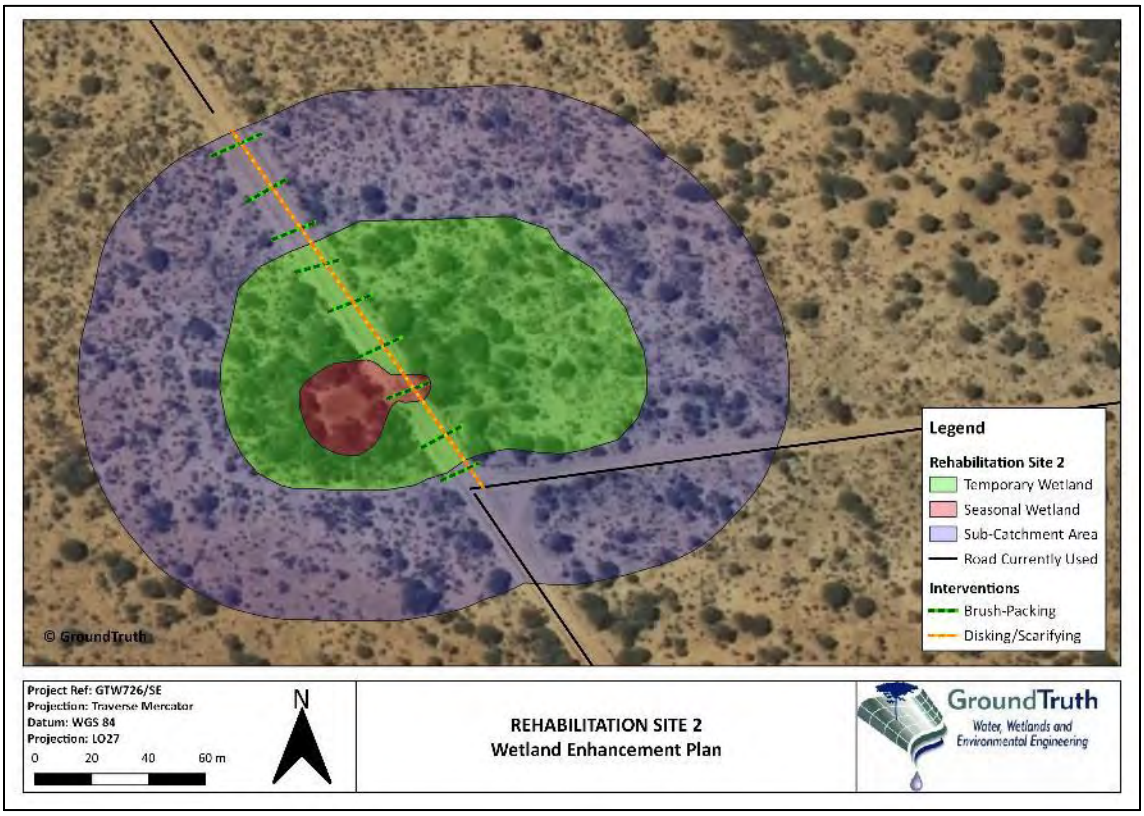


Figure 7-5 Overview of the proposed rehabilitation strategy for Rehabilitation Site 2

Proposed enhancement strategy for Rehabilitation Site 3

The enhancement strategy for Rehabilitation Site 3 is exactly the same as that of Rehabilitation Site 2 as the old management road has been rerouted to the north of the wetland system[26] and the old road that passes directly through the wetland area will be removed. As such, a combination of disking/scarifying, brush-packing and revegetating will be utilised to remove and rehabilitate this old road (**Figure 7-6**).

[25] It should be noted that the realignment of this road has been implemented subsequent to the latest site visit undertaken by GroundTruth and therefore is not displayed on the imagery.

[26] It should be noted that the realignment of this road has been implemented subsequent to the latest site visit undertaken by GroundTruth and therefore is not displayed on the imagery.

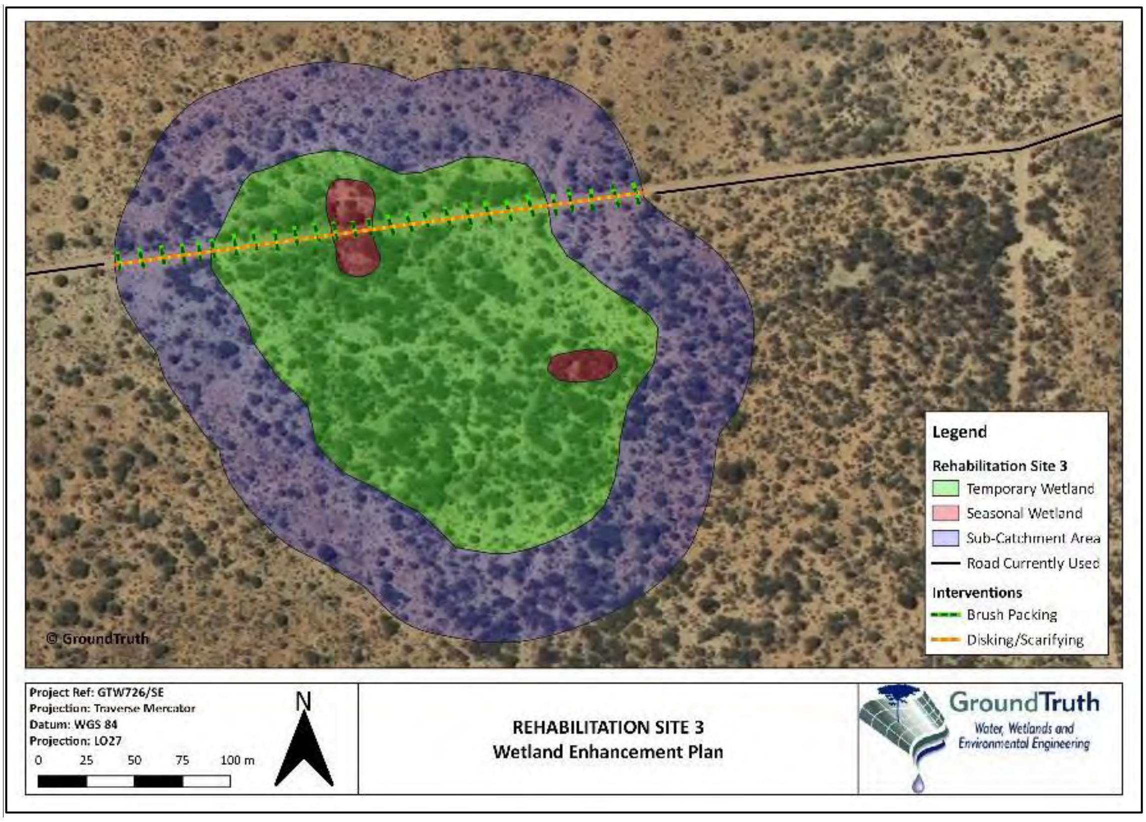


Figure 7-6 Overview of the proposed rehabilitation strategy for Rehabilitation Site 3

Proposed enhancement strategy for Rehabilitation Site 4

Similar to the enhancement strategies for Rehabilitation Sites 2 and 3, the enhancement of Rehabilitation Site 4 will also require the removal and rehabilitation of all three roads that pass through the temporary wetland area. (**Figure 7-7**). As Rehabilitation Site 4 is a string-of-pearls configuration, there is a much wider hydrological linkage that exists in the dendritic drainage network within the wetland. As such, the hydrological connectedness between the wallows is of extreme importance to the continual functioning of this particular system. As such, the three roads through the wetland itself have already been decommissioned and a new road has been constructed to the north and east of the wetland that joins the main road that runs in a north-west/south-east direction located to the south of the wetland[27].

In addition to the rehabilitation of these roads, the western-most seasonal wallow area was artificially deepened using an excavator to increase the water holding capacity of the depression. The excess material from the excavation was spoiled around the depression itself and a small low-level berm was created around portions of the wallow. As such, water cannot freely enter the depression as it naturally would have. Therefore, these small berms will be removed as a part of the enhancement plan for this rehabilitation site as well. There are multiple animal tracks (which occur naturally in the landscape) that lead to the western-most seasonal wetland area from multiple directions. Due to poor veld conditions in this particular area, these animal tracks

[27] It should be noted that the realignment of this road has been implemented subsequent to the latest site visit undertaken by GroundTruth and therefore is not displayed on the imagery.

have become semi-permanent erosion features within the landscape and generate high velocity discharges down their length during heavy rain events which mobilise sediment into the western seasonal wetland zone. A number of low-level berms will be constructed at 45 degree angles across these animal tracks to deflect water off of these paths to break the water velocity and disperse the water over a wider area before reaching the depression.

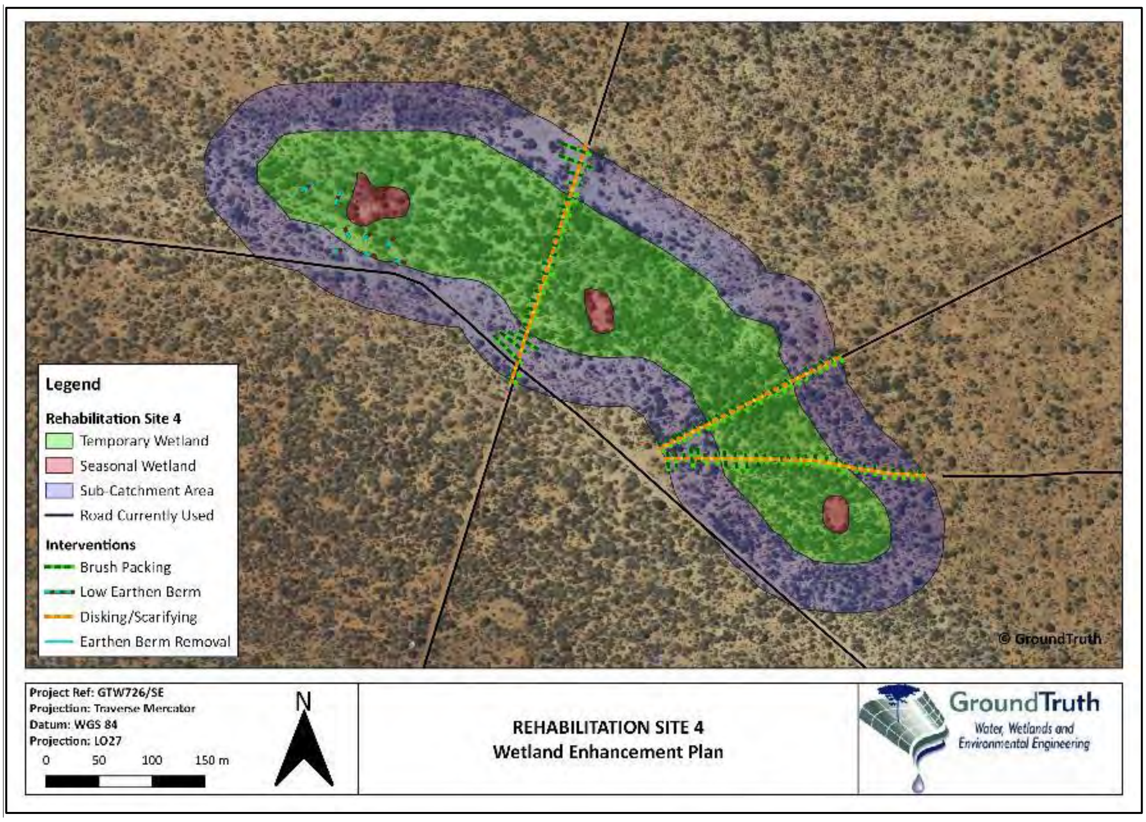


Figure 7-7 Overview of the proposed rehabilitation strategy for Rehabilitation Site 4

Proposed enhancement strategy for Rehabilitation Site 5

Rehabilitation Site 5 forms part of a larger string-of-pearls configuration that sits alongside an old farmstead and associated fields. As such, the vegetation composition within the catchment of this wetland has historically been altered and is not representative of the natural vegetation within the area. As can be seen from imagery, the old fields are still well defined within the landscape as the vegetation has simply not been able to recover in these particular areas (**Figure 7-8**).

Therefore, the enhancement strategy for Rehabilitation Site 5 is related to the rehabilitation of the catchment. Revegetation of the abandoned farm lands will need to happen with appropriate species that are representative of the natural vegetation type. Brush-packs will be used extensively in this enhancement strategy as they are effective at providing a nursery environment for undergrowth species to establish themselves with reduced pressure and stress from herbivores and climatic conditions such as heat. In addition to the brush-packing, a technique known as potholing will be utilised to encourage the growth of larger plants species. The restoration of the catchment will have positive impacts on the wetland areas that are fed by this catchment as the increased vegetation cover will decrease the volume of sediment transported into the depositional areas within the wetland. In addition to sediment trapping, increased vegetation cover will reduce evaporative losses from the wallow areas and will reduce the extent to which hard impenetrable capping of the soil occurs. In addition, the roads that currently pass through the seasonal wetland areas will be decommissioned and rehabilitated using the road removal and rehabilitation method as described for Rehabilitation Sites 2, 3 and 4.

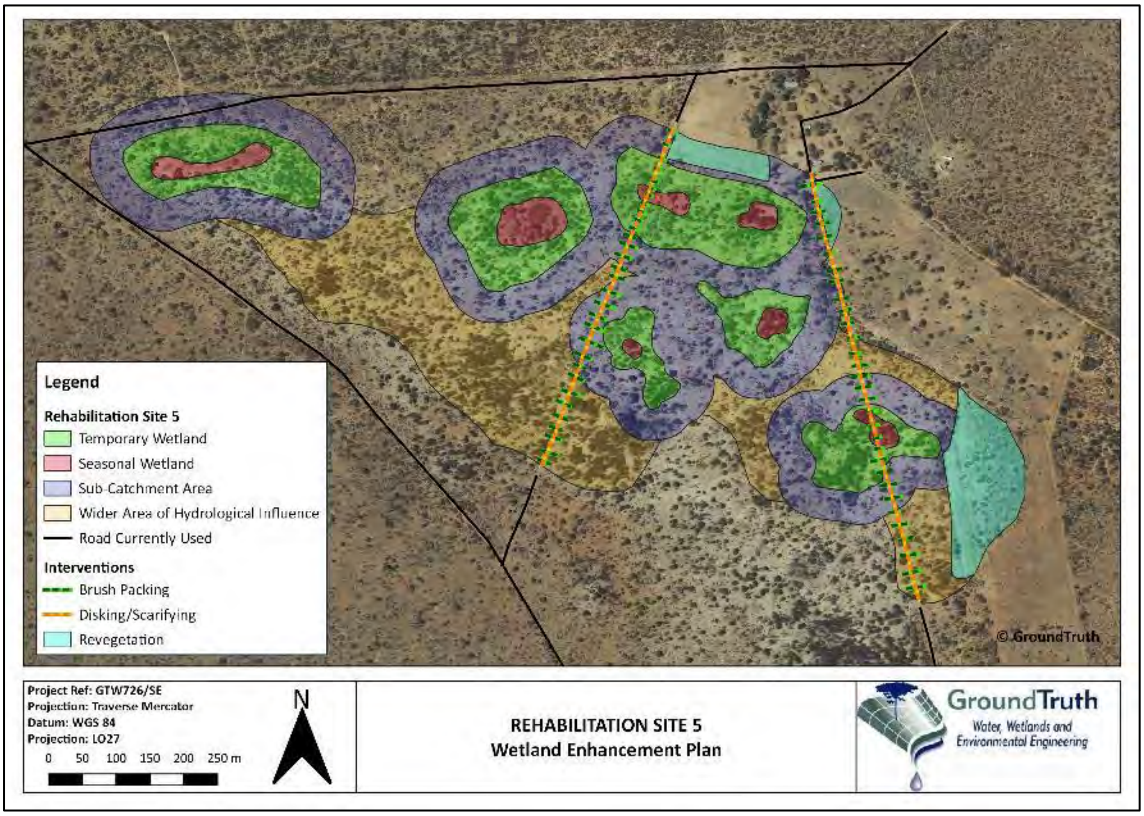


Figure 7-8 Overview of the proposed rehabilitation strategy for Rehabilitation Site 5

Proposed enhancement strategy for Rehabilitation Site 6

Rehabilitation Site 6 is a wetland system that has been severely affected by in-system erosion and deposition. A large section of the eastern side of the wetland has been eroded as a result of animal tracks and small gullies have begun to form in these areas. A large sediment mound has been created to the west of these gullies in the wetland which has resulted in the creation of a small earthen berm in the middle of the wetland (**Figure 7-9**). The additional sediment in the wetland system has altered the system's ability to hold and retain water as the infiltration rates of the imported material is much higher and water is being lost to subsurface flows. The enhancement strategy for Rehabilitation Site 6 is to remove the sediment deposit and small berm by skimming this excess material back to natural ground level. The erosion face within the wetland will be sloped back to a 1:5 slope such that many of the gullies are flattened and the run-off velocity and its ability to transport sediment will be greatly reduced. Brush-packs have also been specified for this eroded area to prevent further erosion and to encourage revegetation of this area.

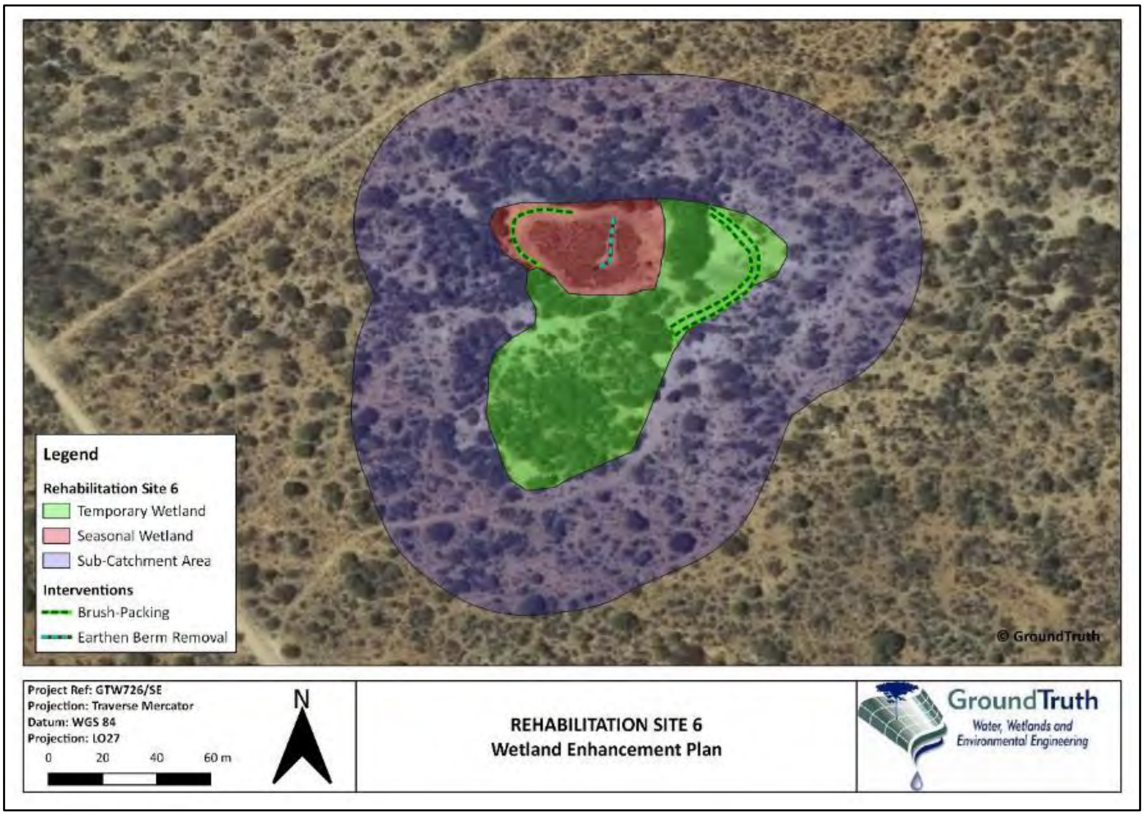


Figure 7-9 Overview of the proposed rehabilitation strategy for Rehabilitation Site 6

Proposed enhancement strategy for Rehabilitation Site 7

The problems with Rehabilitation Site 7 are primarily associated with the management road that dissects the HGM unit and the artificial supply of water to the southern side of the HGM unit (**Figure 7-10**). The road prevents hydrological connectivity between the southern and northern sections of the wetland system and a large sediment plug has been created at the lowest point of the depression which further prevents hydrological and geomorphic connectivity.

The rehabilitation strategy for this site will include the removal of the road and the portions of road that contribute to the sedimentation of the lowest point in the wetland. In addition, a series of vegetated earthen berms will be constructed along the existing road to deflect flows traveling down the road into the HGM unit, thereby decreasing the rate of sediment deposition in the bottom of the depression. Brush-packs will be placed between the berms to assist with revegetation of the road surface as well as to trap additional sediment mobilised between the berms. The road specified for removal has already been decommissioned and an alternative road has already been created to the south of the system. As such, the rehabilitation of this system is already underway with the recommended approach described above being an intensification of the rehabilitation of this system.

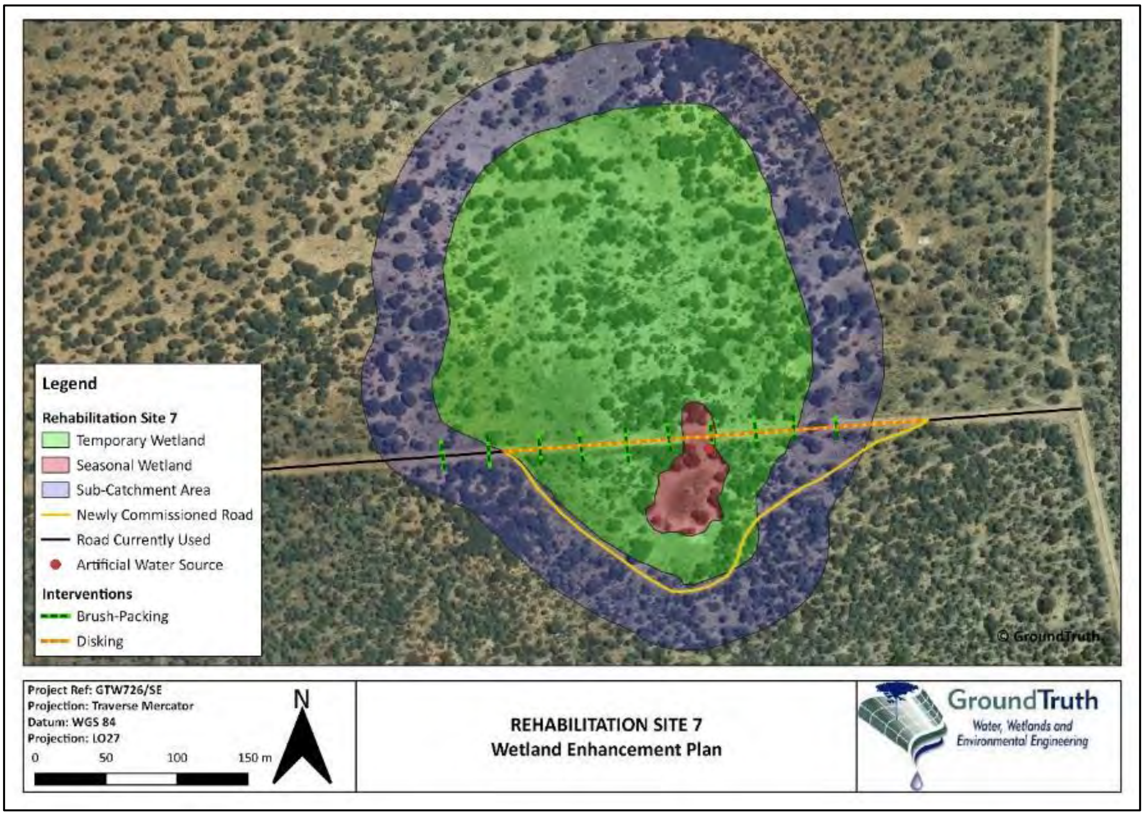


Figure 7-10 Overview of the proposed rehabilitation strategy for Rehabilitation Site 7

Proposed enhancement strategy for Rehabilitation Site 8

Rehabilitation Site 8 is located in close proximity to the main road that passes through the Manketti Game Reserve. There are multiple animal/erosion paths that lead from the road into the wetland. The animal paths are characterised by reduced surface roughness which can result in the transportation and deposition of sediment derived from the road into the wetland (**Figure 7-11**). A blocked culvert was observed beneath the main road which prevents water flows from passing freely beneath the road and as such, occasionally dams up behind the road and may decant into Rehabilitation Site 8. In addition, a slightly raised management road crosses the wetland and interrupts complete hydrological and geomorphic connectivity between the western and eastern portions of the larger string-of-pearls configuration. The wetland itself is located near to historically cultivated lands which have now been invaded by dense stands of *Senegalia mellifera* which are disturbance tolerant species and can be considered to be indigenous invasives if not kept under control. Therefore, the main wetland problems are associated with catchment management and deposition within the HGM unit.

The proposed rehabilitation strategy for Rehabilitation Site 8 includes the removal of the sediment deposits in the HGM unit itself and returning the wetland to its natural ground level. The spoil generated from this skimming will be used in the creation of a series low earthen berms to be created in between a series of potholes or ponds to the south-east of the wetland. A 10m strip of potholes will be created to encourage revegetation of this particular area as the understory is sparsely vegetated and there are signs of capping in these bare areas. These potholes will then be filled with brush-packs and an appropriate seed mix to encourage germination of plants in these areas. The road will be removed by skimming any excess material off the top of the road to return the road surface to ground level. The old surface will then be scarified and/or disked to break the compacted ground beneath the surface to encourage vegetative regrowth. The new road that circumnavigates the system to the east will also be removed in favour of a new road that is totally removed from the system. The removal of this road to the east will be undertaken with the same method described for the road running directly through the system. The area to the east of the wetland will be cleared of most *Senegalia mellifera* plants that have invaded the area. A few of the larger *S. mellifera* individuals will be left to provide a nursery environment for the new plant species that will be planted in the area. Once the clearing has been completed, the area will be scarified and/or disked and an appropriate seed mix will be applied to the newly broken soil.

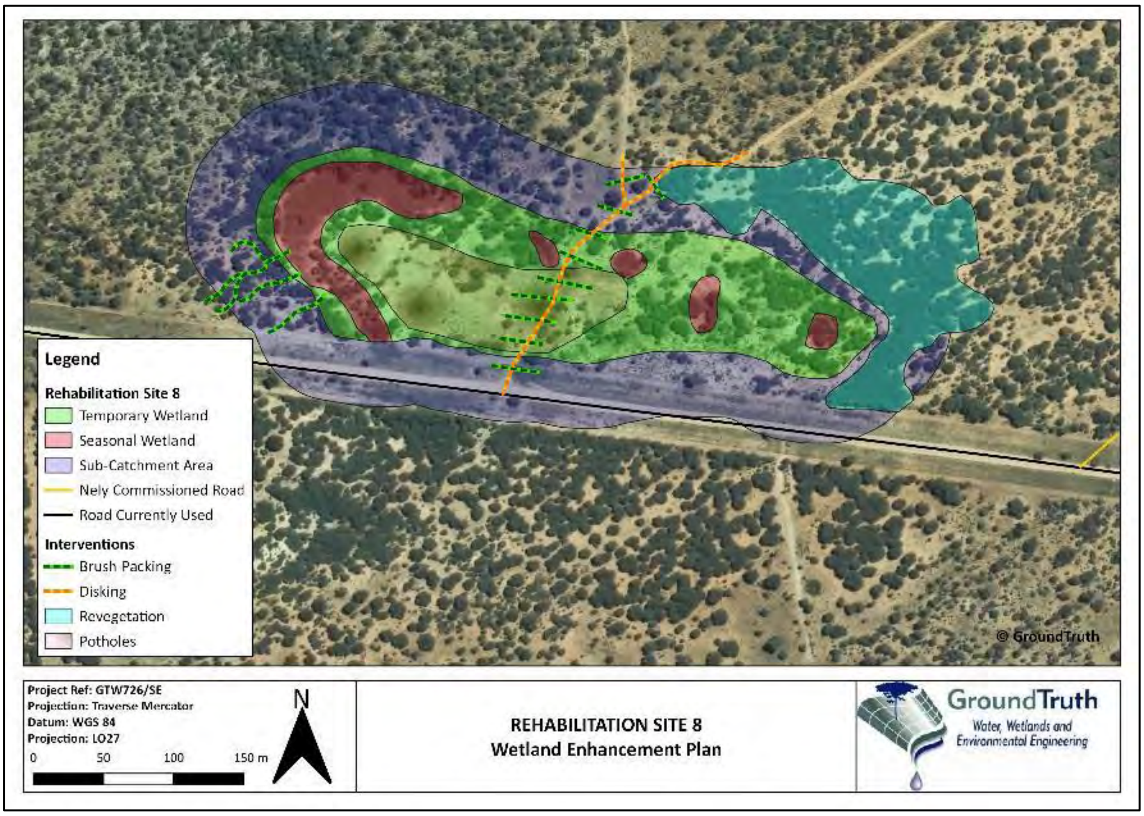


Figure 7-11 Overview of the proposed rehabilitation strategy for Rehabilitation Site 8

Proposed enhancement strategy for Rehabilitation Site 9

The problems with Rehabilitation Site 9 are associated with the old cultivated lands and the dense stands of *Senegalia mellifera* that are located to the east and the south of the wetland system. The density of the *S. mellifera* in this area would contribute to the rapid desiccation of the string-of-pearls wetland configuration in the wet months as a dense stand of trees transpires at a much more rapid rate than the naturally mixed vegetation type that surrounds the old cultivated land. The wetland in the western half of the wetland system is artificially maintained throughout the year and evidence of frequent animal activity in the vicinity of the wallow was evident. The homogenous cover of *S. mellifera* in this area may also be related to the heavy grazing pressure on other plant species due to the increased presence of animals in this particular area.

The enhancement strategy for Rehabilitation Site 9 will include the removal of the *S. mellifera* population as described in the Rehabilitation Site 8 enhancement strategy whereby the majority of the tress will be removed and an appropriate seed mix will be applied to the disturbed area. In addition, water will no longer be supplied to the western-most wallow in order to relieve some of the pressure on the vegetation and soil in this area (**Figure 7-12**). Two artificial wallow areas will be created in the nearby landscape to which water will be pumped year-round. The management road that runs along the southern border of the wetland will also be removed and rehabilitated. Brush-packs will be utilised to encourage revegetation on the bare areas as well as to prevent some of the inevitable sediment mobilisation into the wetland area. A new management road that does not affect the functioning of Rehabilitation Site 9 will be created.

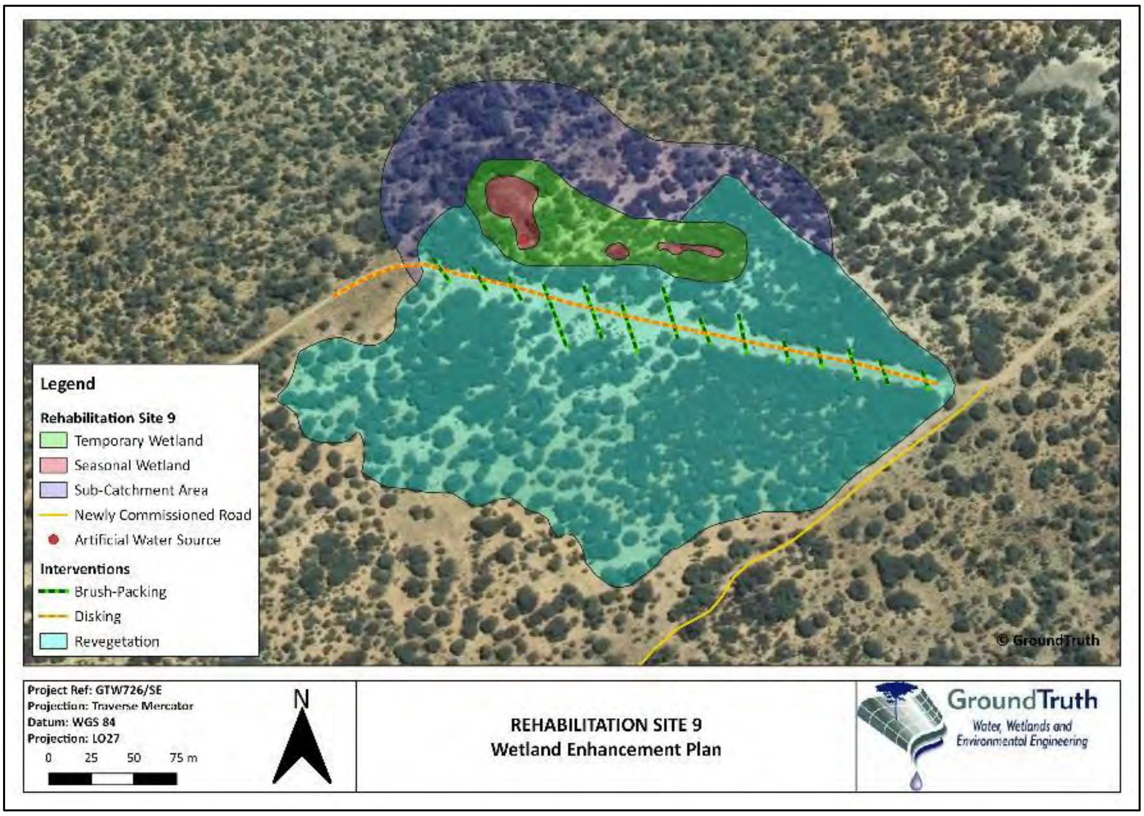


Figure 7-12 Overview of the proposed rehabilitation strategy for Rehabilitation Site 9

Proposed enhancement strategy for Rehabilitation Site 10

Rehabilitation Site 10 is negatively impacted upon by the roads that run through and around it. The roads that run through the string-of-pearls wetland inhibits the flow of water between the sections of the greater wetland (**Figure 7-13**). Evidence that water has been trapped by the road and the tyre tracks on the road was observed as a new animal wallow has recently been created on the southern-most road itself, where water has been trapped for prolonged periods of time. A second road runs along the outer western edge of the wetland for a short way will also need to be removed as it has already been decommissioned. Therefore, the enhancement strategy for Rehabilitation Site 10 will include skimming of the old road surface to return it to natural ground level. Once the surface has been skimmed, scarifying and/or disking will be undertaken to break the compacted surface of the road to allow vegetation to grow easily along the old road surface. Brush-packs will then be laid across the old road surface in 5-10m intervals and will be seeded with an appropriate seed mix to assist with the revegetation process. An alternative road circumnavigating the southern portion of the wetland has already been created. This process will be repeated for the road passing through the wetland zone located at the northern end of the wetland system.

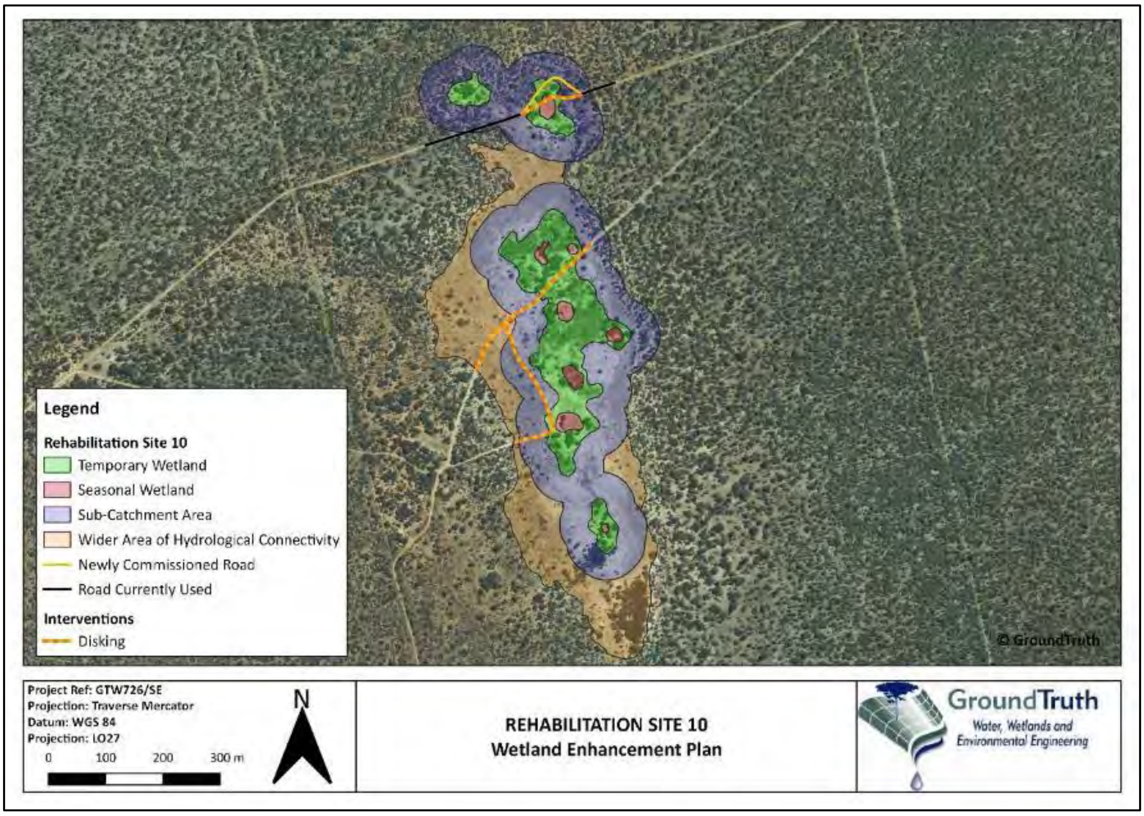


Figure 7-13 Overview of the proposed rehabilitation strategy for Rehabilitation Site 10

Proposed enhancement strategy for Rehabilitation Site 11

The problems with Rehabilitation Site 11 are primarily associated with the presence of a management road to the east of the wetland system and the fact that the berm separating the road and the wetland has been breached by herbivore hoof action. This has resulted in the deposition of sediment in the wetland (**Figure 7-14**). The excess sediment has caused the slope of the western side of the wetland to increase to an almost unnatural gradient and will alter the hydrological and geomorphic characteristics of the wetland.

These problems can be addressed through the removal of the sediment deposit in the wetland and the construction of brush-packs between the road and the wetland to prevent additional sediment from entering into the HGM unit. This removal of sediment should be done with great care so as not to disturb a large area. As such, it is suggested that a hand team equipped with spades and wheelbarrows is deployed to carry out the removal of the sediment deposit. In addition, a number of extra low earthen berms will be constructed along the road to divert water and sediment away from the wetland area. These berms will be small enough for cars to drive safely over them and will be spaced approximately 25m apart.

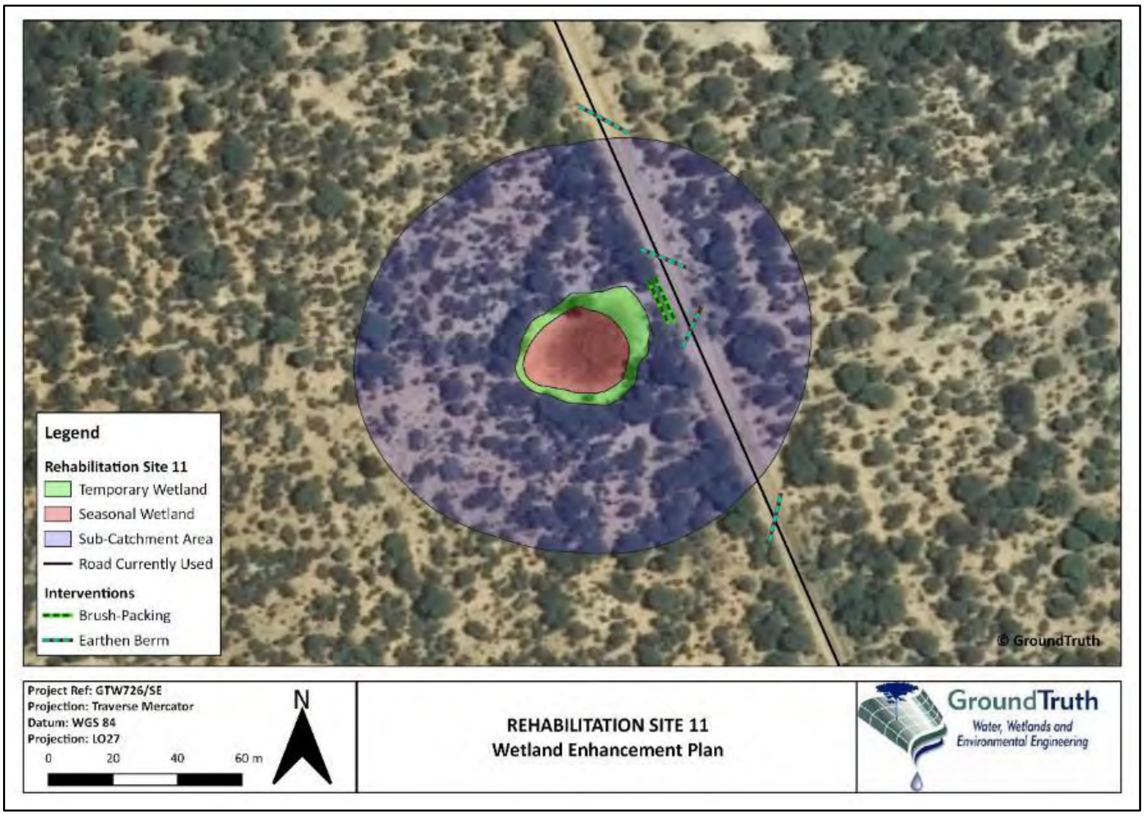


Figure 7-14 Overview of the proposed rehabilitation strategy for Rehabilitation Site 11

8. SEQUENCE OF WORK AND ESTIMATED COSTS

8.1 Sequence of work

It should be noted that the sequence of work of the proposed rehabilitation activities is critical and as such a phased approach is recommended. It is therefore recommended that the following sequence is adopted.

- Phase 1:
  - All in-system and catchment related earthworks;
  - Harvesting of all necessary material for brush-packing;
- Phase 2:
  - Revegetation of the pans (if applicable);
- Phase 3:
  - Reseeding and brush-packing of the disturbed areas.

It should be noted that the proposed phased approach should be adopted for each of the wetlands and should be continuously implemented until completed. This allows the threats posed by partial implementation to be minimised.

8.2 Estimated costs

The following tables (**Table 8-1** - **Table 8-3**) are estimated costs of the interventions based on bills of quantities included in the appendices, and rehabilitation work to be done for the eleven (11) sites. It should be noted that these costs may change, and are preliminary values that can be used as a reference.

Table 8-1 Cost summary of offset works

Rehabilitation Site	Cost Summary (R)
Rehab 01	48 352.00
Rehab 02	27 088.40
Rehab 03	29 127.60
Rehab 04	113 586.40
Rehab 05	304 855.60
Rehab 06	29 425.60
Rehab 07	40 304.00
Rehab 08	350 806.64
Rehab 09	885 864.80
Rehab 10	124 896.00
Rehab 11	5 181.00
Grand Total	**1 959 488.04**

Table 8-2 Summary of quantities for offset works (earthmoving)

Rehabilitation Site	Excavation (non-restricted and spoil) (m³)	Revegetation (m²)	Haulage (km)	Earthen material (m³)	Reshaping (ha)
Rehab 01		2 207.00	6.00		
Rehab 02		2 506.00	6.90		
Rehab 03		2 185.00	6.10		
Rehab 04	95.00	4 801.00	4.90	95.00	
Rehab 05	500.00	40 950.00	4.10		
Rehab 06	93.00	640.00	4.10		0.09
Rehab 07		2 374.00	4.50		
Rehab 08	131.00	21 118.00	8.10		
Rehab 09		75 995.00	8.70		
Rehab 10		4 341.00	10.50		
Rehab 11			10.50	23.85	
Grand Total	**819.00**	**157 117.00**	**74.40**	**118.85**	**0.09**

Table 8-3 Summary of quantities for offset works (brush-packing/erosion control)

Rehabilitation Site	Brush-packing lengths (m)	Scarifying/Disking (ha)	Alien vegetation clearing (m²)	Alien vegetation clearing (follow up treatments[28]) (m²)
Rehab 01	1 020.00	0.22		
Rehab 02	231.00	0.25		
Rehab 03	385.00	0.22		
Rehab 04	1 680.00	0.48		
Rehab 05	3 048.00	0.89		
Rehab 06	100.00			
Rehab 07	708.00	0.24		
Rehab 08	672.00	0.26	14 188.00	14 188.00
Rehab 09	900.00	0.42	35 695.00	35 695.00
Rehab 10	3 000.00	0.43		
Rehab 11	24.00			
Grand Total	**11 768.00**	**3.41**	**49 883.00**	**49 833.00**

[28] It should be noted that a total of five (5) follow up treatments have been specified for the areas that have been cleared. The first follow-up treatment should be carried out three (3) months after initial clearing with the following four (4) follow-up treatments being space six (6) months apart thereafter.

9. WETLAND REHABILITATION MONITORING AND EVALUATION

The following wetland rehabilitation monitoring framework was developed in accordance with the principles outlined in WET-RehabEvaluate (Cowden and Kotze 2009), with specific monitoring being recommended for the anticipated outputs and outcomes of the project. The monitoring includes the collection of baseline and routine monitoring information to enable the evaluation of the rehabilitation effectiveness at least five years after completion of the rehabilitation activities. It should be noted that the following recommended monitoring is considered to be the minimum level of monitoring required to show rehabilitation effectiveness, and additional monitoring may be required by the relevant authorities (e.g. water quality, vegetation composition etc.).

9.1 Monitoring of interventions

The assessment of the structural integrity would be undertaken based on the specific criteria outlined in **Table 9-1** and focus on the long-term stability of the interventions and the likelihood of achieving the stated objectives. This assessment would serve to identify weaknesses or strengths of the selected interventions within the wetlands.

Table 9-1 Criteria used for monitoring earthen structural integrity of wetland rehabilitation interventions (Modified from Cowden and Kotze 2009, p47[29]).

Earthen structures/works:
• Dimensions according to specifications • Authorised deviations from plan • Excessive settling of the soil (>10% of overall height) • Erosion on the bank • Establishment of vegetative cover • Scouring downstream • Evidence of outflanking • Adequate compaction of soil

The majority of the rehabilitation interventions are considered to be 'soft' as none of them involve major earthworks or construction of any concrete or stone structures. Brush-packing and potholing are temporary veld management measures designed to assist in veld regeneration processes. Therefore, the majority of the monitoring required will need to be observation based. Specific veld assessments can be carried out on a seasonal basis to assess the change in veld conditions in the post-rehabilitation landscape.

[29] It should be noted that **Table 9-1** is currently under review through a current Water Research Commission project (K5/2344). The project is aimed at providing a wetland rehabilitation monitoring and evaluation framework, which includes updating the structural integrity checklist.

9.2 Fixed point photography/site photographs

Pre- and post-implementation photographs must be recorded for each rehabilitation site. These should be collected in the form of Fixed-Point Photographs, as outlined in WET-RehabEvaluate, to allow repeated monitoring to be undertaken.

9.3 Wetland assessments

The ecological integrity and functioning of the wetlands should be monitored with:

- WET-Health and WET-EcoServices, collected during the planning process being used as the baseline; and
- Subsequent monitoring being undertaken approximately five years after completion of the rehabilitation strategy, to provide the final assessment of the benefits and effectiveness of the rehabilitation activities.

In addition, it should be noted that one of the systems in the Thabametsi mining rights area falls relatively close to infrastructure planned for the Thabametsi Project, which is proposed to be implemented in 30+ years. The system is Rehabilitation Site 4 which falls approximately 320m away from the planned South West Pit (IPP 145 Mt Pit as per the TIPP 1 layout provided in drawing **ECG-T01-IGN-SP-SP-00002 –** refer to **Figure 9-1**). The potential impacts on the system are likely to be negligible, as the system, for the most part, is hydrologically isolated from the IPP 145 Mt Pit and would not be negatively affected upon by hydrologically derived impacts. However, it would be important to monitor both Rehabilitation Site 4 and Rehabilitation Site 3 (which lies approximately 530m away from the mentioned pit) as there may be negative impacts derived from aeolian transport of sediment and coal dust associated with the IPP 145 Mt Pit. These systems should be assessed in terms of their integrity and functionality before the implementation of the Thabametsi Project and for a number of years thereafter, depending on the progress of the remainder of the Thabametsi Project. It should be noted that a number of the wetland systems fall within the area of influence of the opencast pit associated with the Thabametsi Project. However, Exxaro communicated that these areas will only be mined in 30+ years from now.

9.4 Wetland rehabilitation effectiveness

All of the above-mentioned monitoring should be used to inform the evaluation of the effectiveness of the rehabilitation and enhancement. This would be undertaken once the required monitoring information has been collected, five years following the completion of the wetland rehabilitation activities.

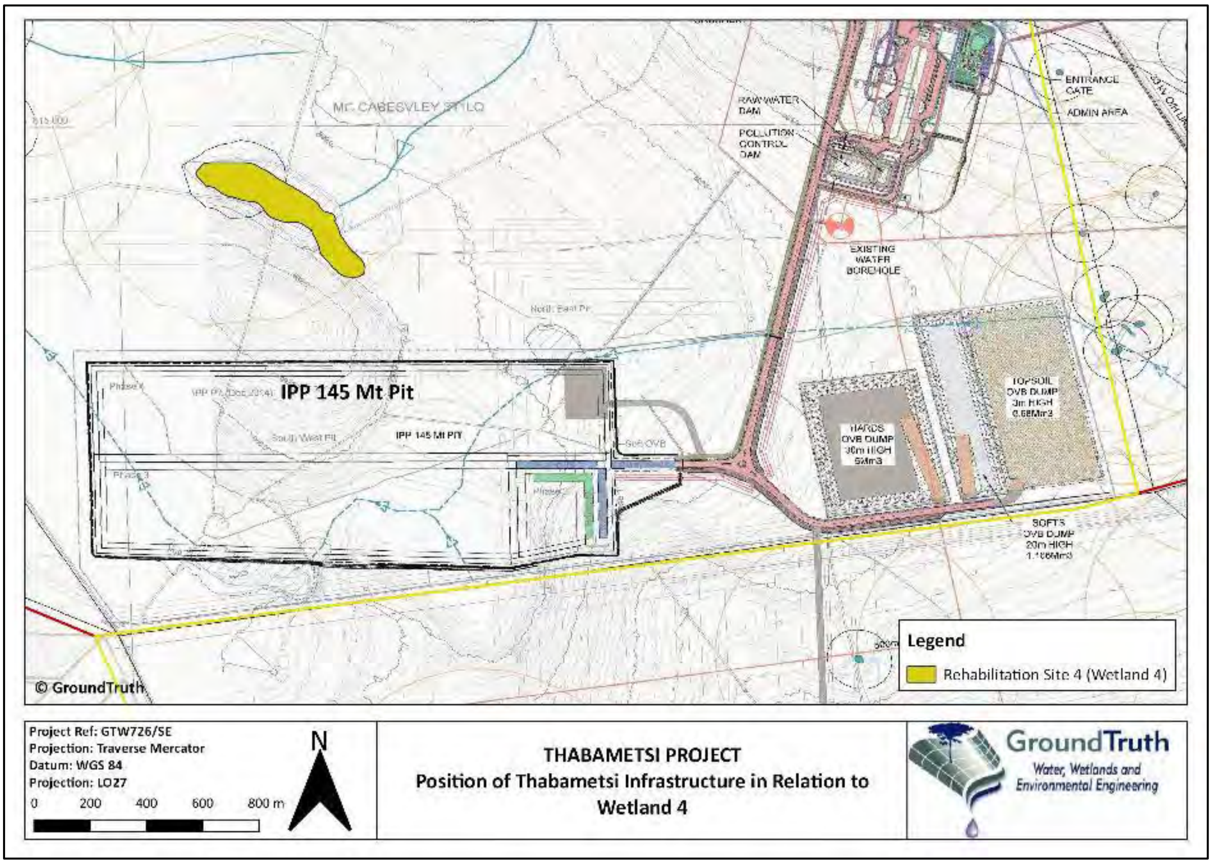


Figure 9-1 Location of Rehabilitation Site 4 (Wetland 4) in relation to the Thabametsi Project infrastructure – specifically the IPP 145 Mt Pit.

10. *RECOMMENDATIONS/CONCLUSION*

The study area is located within a more arid portion of South Africa (refer to **Section 4.2**), with limited large interconnected freshwater ecosystems within the landscape. The study area does not contain any perennial streams and fringe habitat wetlands within its boundaries but rather an expansive number of wetland systems varying in size from 0.13ha to 12.98ha. Despite there being no perennial streams, there are large areas of wider hydrological connectivity that make up a complex dendritic drainage network that operates for only a few days during the wet season. However, these dendritic drainage networks are only preferential flows paths within the landscape and not actual streams (i.e. are not characterised by the presence of alluvial material and vegetation distinctly different from adjacent terrestrial vegetation).

Due to the location of the pans/depressions within the Manketti Game Reserve (including the Thabametsi mining area), the eleven (11) identified wetlands are considered to be predominantly in good condition, i.e. '**B**' and '**C**' category systems and cover an area of 47.19ha. Based on the integrity assessment (Macfarlane et al 2018), the wetlands were considered to be equivalent to 37.7ha of functional wetland habitat. The offset requirements calculated in the GroundTruth (2018) reports stipulated that the wetland functionality target is 5.85hectare equivalents and the ecosystem conservation target amounted to 1.31hectare equivalents. The wetland functionality target will not be met with the current rehabilitation work proposed in this report as only 1.81hectare equivalents from this rehabilitation work will contribute to the wetland functionality target. However, the ecosystem conservation targets were well exceeded with 81.43hectare equivalents that are suitable to contribute to these targets.

Due to the nature of the distribution and extent of wetlands within the broader landscape, the wetland functionality targets are unable to be met within Exxaro's landholdings, despite the proposed rehabilitation presented in this study. While opportunities may exist to look further afield for additional offset candidate systems, in this instance achieving the SANBI guideline's wetland functionality targets may be practically unachievable, requiring expansive areas. It should be noted that Exxaro are in the process of implementing the created wetland study (see report **GTW726/120918/01**) which may yield results that will allow for Exxaro to create wetland habitat in old quarries and borrow pits in the offset areas or create additional wetland habitat on the rehabilitated pit in the post-mining scenario. This concern largely stems from attempting to achieve gains from predominantly intact wetland areas that cover small areas within the landscape and would contribute less to the offset targets the farther away these candidates are from the area of loss. However, if Exxaro were to consider purchasing the Ganzepan 446 farm portion to the east of the Manketti Game Reserve – there could be significant opportunity to obtain additional offset-worthy areas that may assist in closing the gap on the functional hectare equivalent requirements.

However, Exxaro have shown their commitment to protecting and rehabilitating these systems through their commitment to this rehabilitation process and the wetland creation project (see **GTW726/22012020/CW01**). The created wetland project is considered as advancing the wetland field of practice by means of a documented experimental approach to address impacts on wetlands in the landscape. This experimental design would not yet contribute to offset requirements as it is still in the experimental phase, but Exxaro would invest in the protection of these systems by financing the wetland creation and committing time and energy into this experimental approach. As such, the authorities may favourably consider Exxaro's multi-faceted approach towards addressing the offset targets by partially meeting wetland functionality targets, significantly exceeding in the ecosystem conservation targets and by meaningfully contributing to the wetland field of practice by means of experimental wetland creation, which may ultimately lead to the creation of additional wetland habitat in the post-mining landscape. This would need to be determined in consultation with the relevant authorities as recommended by the SANBI guidelines for any wetland offset plan. In addition, with the proof-of-concept that may come though the wetland creation process, it may be possible to look into rehabilitating old borrow pits such as the systems specified for rehabilitation in **Appendix 2**.

11. REFERENCES

Cowden C, Kotze DC. 2009. *WET-RehabEvaluate: Guidelines for the monitoring and evaluation of wetland rehabilitation projects.* WRC Report No TT 342/08. Pretoria: Water Research Commission.

Davies, B. and Day. J.1998. *Vanishing waters*. University of Cape Town Press, Cape Town, South Africa.

De Meester L., Declerck S., Stocks R., Louette G., Van de Meutter F., De Bie T., Michels E. and Brendonck L. 2005. Ponds and pools as model systems in conservation biology, ecology and evolutionary biology. *Aquatic Conservation* 15: 715–725.

De Roeck ERM., Vanschoenwinkel B., Day JA., Xu Y., Raitt L. and Brendonck L. 2007. *Conservation status of large branchiopods in the Western Cape*, South Africa. Wetlands 27: 162-173.

DWAF (Department Of Water Affairs and Forestry). 2005. *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas.* Edition 1, September 2005. Pretoria: DWAF.

Digby Wells Environmental 2018. Wetland assessment associated with the proposed Exxaro Thabametsi Coal Mine, Limpopo Province. Project code: EXX0564. Gauteng: South Africa.

DHSWS 2017. Proposed classes of water resource and resource quality objectives for Mokolo, Matlabas, Crocodile (west) and Marico catchments. Draft version. *Government Gazette South Africa* 630 (41310).

GroundTruth. 2018a. *Wetland study within the Exxaro Grootegeluk complex.* Project Code: GTW726/301018/01. KwaZulu-Natal: South Africa.

GroundTruth. 2018b. *Wetland study within the Exxaro Grootegeluk Complex – Turfvlakte.* Project Code: GTW726/110918/01. KwaZulu-Natal: South Africa.

GroundTruth. 2020. *Exxaro Grootegeluk Complex: Non-perennial pan creation.* Project Code: GTW726/22012020/CW01. KwaZulu-Natal: South Africa.

Kotze DC, Riddell E, Grundling PL, and Grundling A. 2018. *Appendix A: Developing a conceptual description of how the water enters, passes through and leaves a wetland*. As part of the WRC K5/2549 research project. Pretoria: Water Research Commission.

Kotze DC, Marneweck GC, Batchelor AL, Lindley DS, Collins NB. 2007. *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No TT 339/08. Pretoria: Water Research Commission.

Macfarlane DM, Holness SS, Von Hase A, Brownlie S, Dini J. 2014. *Wetland offsets: a best practice guideline for South Africa.* Pretoria: South African National Biodiversity Institute and the Department of Water Affairs.
Macfarlane DM, Kotze D, Walters D, Koopman V, Goodman P, Ellery W, Goge C. 2007. *WET-Health. A technique for assessing wetland health*. WRC Report No. TT340/08. Pretoria: Water Research Commission.

Macfarlane DM, Ollis D, and Kotze DC. 2018. *Draft suite of tools for assessing the present ecological ststae of wetland ecosystems.* Unpublished. WRC Project K5/2549. Pretoria: Water Research Commission.

Macfarlane DM, Walters D, Cowden C. 2012. *A wetland health assessment of KZNs priority wetlands*. Draft Unpublished Report prepared for Ezemvelo KZN Wildlife. Pietermaritzburg: EKZNW.

Midgley DC, Pitman WV, Middleton BJ. 1994. *Surface water resources of South Africa 1990, Vol I–VI*. WRC Reports No. 298/1.1/94 to 298/6.1/94. Pretoria: Water Research Commission.

Mucina L, Rutherford MC (eds). 2006. *The vegetation of South Africa, Lesotho and Swaziland.* South African National Biodiversity Institute. Pretoria: Strelitzia 19.

Natural Scientific Services. 2011. Grootegeluk coal mine: terrestrial ecological scan. Project Nr: 1295. Gauteng: South Africa.

Nel JL, Driver A. 2011. *National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component*. CSIR Report Number CSIR/ECO/IR/2012/0022/A. Stellenbosch: Council for Scientific and Industrial Research.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L, Nienaber S. 2011. *Technical report for the national freshwater ecosystem priority areas project*. WRC Report No. 1801/2/11. Pretoria: Water Research Commission.

Novak, V., Simunek, J., & van Genuchten, M. (2000, January). Infiltration of Water into Soil with Cracks. Journal of Irrigation and Drainage Engineering, 41-47.

Ollis D, Snaddon K, Job N and Mbona N. 2013. *Classification System for Wetlands and other Aquatic Ecosystems in South Africa: User manual: Inland Systems.* SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria.

Rountree MW, Malan H. (eds). 2010. *Rapid Ecological Reserve Determination Methods for Wetlands* (Version 2.0). Joint Department of Water Affairs and Water Research Commission Study. In preparation. Pretoria: Water Research Commission.

SANBI. 2009. *Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report*. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI). Pretoria: SANBI.

Schulze RE. (ed). 2007. *South African Atlas of climatology and agrohydrology*. WRC Report 1489/1/06. Pretoria: Water Research Commission.

Sheng, T. C. (1990). Watershed Management Field Manual. Rome: Food and Agriculture Organization of the United Nations.

Waterkeyn A. 2009. *Community Structuring Processes in Mediterranean Temporary Wetlands*. PhD Thesis. Katholieke Universiteit Leuven.

Zacharias I., E. Dimitriou, A. Dekker & E. Dorsman (2007) Overview of temporary ponds in the Mediterranean region: threats, management and conservation issues. Journal of Environmental Biology 28: 1-9.

Zedler JB and Kercher S. 2005. Wetlands resources: status, trends, ecosystem services and restorability. *Annual Review of Environmental Resources* 30: 39-74.

12. APPENDICES

12.1 Appendix 1: Proposed Intervention Details for Manketti Sites

This appendix provides a summary of details regarding the rehabilitation interventions proposed for the wetland rehabilitation plan. The summary includes and overall layout of the rehabilitation area (provided in **Figure A12-1**). The details of each proposed intervention provided includes a table with the following relevant information:

- Intervention type;
- Intervention objectives;
- Co-ordinate locations;
- Dates of when the structure was planned; and
- Intervention drawing numbers.

In addition to the tabulated relevant information, a photograph, Bill of Quantities and intervention specific notes for each proposed intervention have been provided.

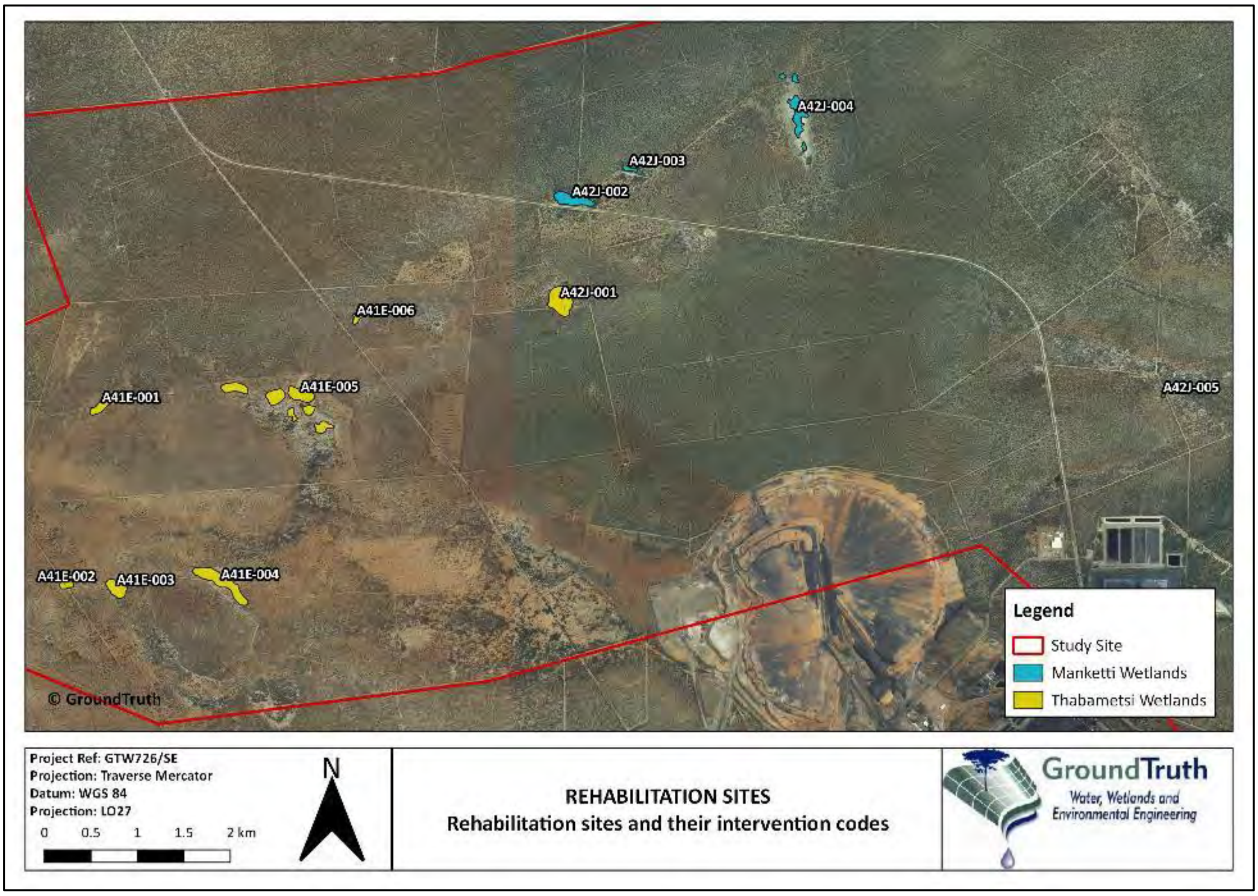


Figure A12-1 Layout of A41E and A42J interventions

12.1.1 *Intervention A41E-001*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit
Latitude	-23.61973 S
Longitude	27.45912 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-2 Location Photograph (A41E-001)

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	2 207
Revegetation	m^2	2 207
Brush-packs Brush-pack length[30]	no. m	85 1020
Overhaul[31] distance from future mining if needed	km	6.3

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.2 *Intervention A41E-002*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit
Latitude	-23.63860 S
Longitude	27.45536 E
Designed By	Trevor Pike
Date	February 2020

[30] It should be noted that the length associated with the brush-packs is highly dependent on site specific conditions. In areas where there are vast areas of open and disturbed space surrounding the road, brush-packing may need to extend farther off the road footprint than in areas where there is good vegetative cover surrounding the roads. The final area per brush-pack will need to be decided at the time of implementation. An average length of 7m per brush-pack was assigned to well vegetated areas and an average value of 12m was assigned to less well vegetated areas for the purpose of pricing in this report.

[31] A free haulage distance of 5km is assumed.

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	2 506
Revegetation	m^2	2 506
Brush-packs Brush-pack length	no. m	33 231
Haulage distance from future mining if needed	km	6.9

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.3 *Intervention A41E-003*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit
Latitude	-23.63899 S
Longitude	27.46068 E
Designed By	Trevor Pike
Date	February 2020

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	2 185
Revegetation	m^2	2 185
Brush-packs Brush-pack length	no. m	55 385
Haulage distance from future mining if needed	km	6.1

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.4 *Intervention A41E-004*

Intervention Type	Scarify, brush-pack, revegetate and minor earthworks
Rehabilitation Objective	Removing old roads through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit. Low earthen berms to divert water off animal tracks to encourage diffuse flow into wetland
Latitude	-23.63841 S
Longitude	27.47169 E
Designed By	Trevor Pike
Date	February 2020

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	4 801
Revegetation	m^2	4 801
Brush-packs Brush-pack length	no. m	140 1 680
Earthen berm removal	m^3	95
Earthen berm construction	m^3	95

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- The removal of the berm around the wetland area should be carried out during the dry season and should be carried out by a hand team to minimise disturbance;
- The removal of the berms should be done to natural ground level and the material from the removal can be utilised for the construction of the earthen berms along the animal tracks;
- The construction of the berms along the animal tracks should be done at 45 degrees to the flow of water in order to deflect the water off the animal track most effectively;
- At least two berms should be constructed per animal track and each should deflect water in the opposite direction to the berms below and above it (if applicable);
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.5 *Intervention A41E-005*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit. Potholing approach will also be used to assist germination and growth of larger species
Latitude	-23.61925 S
Longitude	27.47833 E
Designed By	Trevor Pike
Date	February 2020

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	8 900
Revegetation	m^2	40 950
Potholes (excavation)	m^3	500
Brush-packs Brush-pack length	no. m	254 3 048
Haulage distance from future mining if needed	km	4.1

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Potholing should be carried out using a tractor-loader-backhoe and the excavations should not exceed 1m in length, 0.5m in width and 0.5m in depth;
- One pothole should be placed every $10m^2$;
- Potholes should be seeded immediately after excavation and covered with additional brush-packs to provide a nursery environment for the germinating plants;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.6 *Intervention A41E-006*

Intervention Type	Earthworks and sediment traps
Rehabilitation Objective	Sloping with brush-pack bundles Removal of sediment and earthen berm
Latitude	-23.61058 S
Longitude	27.48599 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-3 Location Photograph (A41E-006)

Bill of Quantities

Item	Unit	Quantity
Excavation	m^3	93
Brush-packs Brush-pack length	no. m	8 100
Earthworks for reshaping	m^3	850
Revegetation	m^2	640
Haulage distance from future mining if needed	km	4.1

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Sediment plug to be removed and surplus material to be disposed appropriately off site;
- Backfill material to be compacted in 150mm layers;
- Backfill material to be moistened to optimum moisture content to ensure optimum compaction;
- Before brush-packing, loosen soil and scarify paths, then seed area and brush-pack over seed; and
- Reshaping of the eroded area to be done to 1:5 (V:H) in order to achieve an appropriate grade to prevent erosion during heavy rains.

12.1.7 *Intervention A42J-001*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit
Latitude	-23.60867 S
Longitude	27.50750 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-4 Location Photograph (A42J-001)

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	2 374
Revegetation	m^2	2 374
Brush-packs Brush-pack length	no. m	59 708
Haulage distance from future mining if needed	km	4.5

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);

- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.8 *Intervention A42J-002*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit. Potholing approach will also be used to assist germination and growth of larger plant species. Removal of invasive vegetation will be undertaken too.
Latitude	-23.59806 S
Longitude	27.50870 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-5 Location Photograph (A42J-002)

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	2556
Revegetation	m^2	21 118
Potholes (excavation)	m^3	131
Brush-packs Brush-pack length	no. m	56 672
Alien veg. removal	m^2	14 188
Alien veg. follow up treatments	m^2	14 188 (x5)
Haulage distance from future mining if needed	km	3.1

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Removal of invasive tree species should be done using the cut-stump method whereby the trees are cut off at their stumps;
- These stumps should be treated with an appropriate herbicide to reduce coppicing;
- Follow up invasive plant removal protocols should be implemented to ensure the suppression and ultimate elimination of invasive species from the site;
- The invasive tree removal should happen before or after seeding season i.e. it should happen in winter. This will allow for the cut invasive trees to be utilised as brush-pack material without fear of reseeding in the brush-packed areas;
- Potholing should be carried out using a tractor-loader-backhoe and the excavations should not exceed 1m in length, 0.5m in width and 0.5m in depth;
- One pothole should be placed every $10m^2$;
- Potholes should be seeded immediately after excavation and covered with additional brush-packs to provide a nursery environment for the germinating plants;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.9 *Intervention A42J-003*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit. Removal of invasive vegetation will be undertaken too.
Latitude	-23.59481 S
Longitude	27.51472 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-6 Location Photograph (A42J-003)

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	4 214
Revegetation	m^2	75 995
Brush-packs Brush-pack length	no. m	75 900
Alien veg. removal	m^2	35 695
Alien veg. follow up treatments	m^2	35 695 (x5)
Haulage distance from future mining if needed	km	8.7

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Removal of invasive tree species should be done using the cut-stump method whereby the trees are cut off at their stumps;
- These stumps should be treated with an appropriate herbicide to reduce coppicing;
- Follow up invasive plant removal protocols should be implemented to ensure the suppression and ultimate elimination of invasive species from the site;
- The invasive tree removal should happen before or after seeding season i.e. it should happen in winter. This will allow for the cut invasive trees to be utilised as brush-pack material without fear of reseeding in the brush-packed areas;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.10 *Intervention A42J-004*

Intervention Type	Scarify, brush-pack and revegetate
Rehabilitation Objective	Removing old road through wetland by scarifying, brush-packing and revegetating. Will serve to prevent additional sediment entering into the HGM unit.
Latitude	-23.58869 S
Longitude	27.53240 E
Designed By	Trevor Pike
Date	February 2020

Bill of Quantities

Item	Unit	Quantity
Scarification/disking	m^2	4 341
Revegetation	m^2	4 341
Brush-packs Brush-pack length	no. m	250 3 000
Haulage distance from future mining if needed	km	10.5

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Scarification/disking should not be allowed disturb the soil profile below a depth of 200mm to prevent long term damage to the soil profile, especially within the wetland itself;
- Revegetation should take place using an appropriate grass-seed mix based on the ecotone present at this particular site (can be assigned at the park managers discretion);
- The revegetated areas should be watered directly after seeding to encourage immediate germination and growth; and
- Brush-packing and revegetation should happen immediately after scarification to minimise mobilisation of sediment via wind and/or rain.

12.1.11 *Intervention A42J-005*

Intervention Type	Earthworks and brush-packing
Rehabilitation Objective	Construct diversion berms along existing road. Brush-pack along edge of road before pan for sediment control and vegetation establishment.
Latitude	-23.57100 S
Longitude	27.61870 E
Designed By	Trevor Pike
Date	February 2020

Figure A12-7 Location Photograph (A42J-005)

Bill of Quantities

Item	Unit	Quantity
Earthworks for earthen berms	m³	23.85
Brush-packs Brush-pack length	no. m	2 24
Haulage distance from future mining if needed	km	10.5

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Backfill material to be compacted in 150mm layers;
- Backfill material to be moistened to optimum moisture content to ensure optimum compaction;
- Earthen berms are to be smoothed to allow vehicle to easily drive over;
- Berms are to be angled towards the natural slope of the topography; and
- Before brush-packing, loosen soil and scarify paths, then seed area and brush-pack over seed.

12.2 Appendix 2: Borrow-pit assessments

Please note: *The following rehabilitation plans will only contribute towards the Grootegeluk offset requirements, should the created wetland concept be deemed successful and the creation of artificial wetland areas within this landscape be deemed a plausible possibility (refer to Section 2.1). In addition, it should be noted that the assessments and rehabilitation planning methods used to inform these plans were identical to those documented in* ***Section 5****.*

12.2.1 *Characteristics of the freshwater ecosystems*

A total of three (3) disused quarries/borrow pits were assessed during the site visit, two of which held minimal water at the time of the site visit and the third showed recent signs of water retention. All three quarries/borrow pits were characterised by very heavy clay material at the lowest point in the pit, which can be explained by weathering of the substrate as a result of continuous wetting and drying cycles. All three quarries also displayed recent signs of animal activity in and around the waterlogged zone of the pit.

Borrow pit 1

Borrow Pit 1 is a large and relatively deep disused borrow pit that spans 0.36ha (**Figure 12-8**). It is located adjacent to the main road running through the Greater Manketti Game Reserve and was historically used as a borrow pit to provide material for road construction and maintenance. The centre of the pit is almost completely devoid of any vegetation and it is assumed that this is a result of the very hard cap that has formed on the surface of the majority of the pit. This cap is comprised of clay material that dries to become a very hard, impermeable layer that overlies a subsurface clay layer which is significantly softer and less impermeable. This pit was considered as a potential rehabilitation site because it appeared to have a small catchment that it derived additional water from during the wet season. Evidence of water entering the pit from a surrounding catchment was observed as there were a number of small headcut erosional features running down the side walls of the pit, and many flow paths that originated outside of the pit walls were observed.

Figure 12-8 View of Borrow Pit 1. The dark area in the centre being the lowest point of the pit and the lighter areas to the right being the impermeable capped material.

Borrow pit 2

Borrow Pit 2 is a smaller disused borrow pit that was also historically utilised to generate material for road construction and maintenance (**Figure 12-9**). This site was selected for rehabilitation as it appears to have a small catchment that supplies it with additional water in the wet season and evidence existed of wetland characteristics forming in the lower portion of the pit. This pit had similar erosional features to those that were observed in the Borrow Pit 1 indicating water flowing into the system from localised areas. One of these erosion pathways is connected to the access road located to the east of the pit and is responsible for the movement of sediment from the road into the pit. A resultant sediment mound has formed on the eastern side of the pit. Very little water remained in the pit during the site visit, however a heavy clay was observed in the remaining wet areas of the pit and capping of the areas surrounding the lowest point in the pit was also observed – similar to Site 1.

Figure 12-9 View of Borrow Pit 2. Black lines represent approximate sediment mound generated by sand washed in from the adjacent road.

Borrow pit 3

Borrow Pit 3 was the final disused borrow pit that was specified for rehabilitation. The total size of the borrow pit was much larger than the other two borrow pits, but the opportunity for wetland creation is fairly limited by the topography of the borrow pit and as such, two smaller wetland areas of 0.12ha and 0.018ha will be created within this particular pit. The sides of Site 3 slope much more gently than the other two borrow pits and as such, there are much smaller bowls in the middle of the pit. The pit consists of two bowls – one main bowl in the centre and another smaller bowl in a raised section of the pit located to the east of the main bowl (**Figure 12-10**). Site 3 is characterised by a different substrate to the other borrow pits as this borrow pit appears to be much more recently excavated and remnant sandstone parent material outcrops still extrude from the ground in multiple locations within the pit. Therefore, the nature of the clay within the bowls of the pit is slightly coarser than, and not as heavy as, the clay found in the other two borrow pits.

Figure 12-10 View of Borrow Pit 3. The large bowl is encircled in the black and the secondary smaller bowl for wetland creation is encircled in the white.

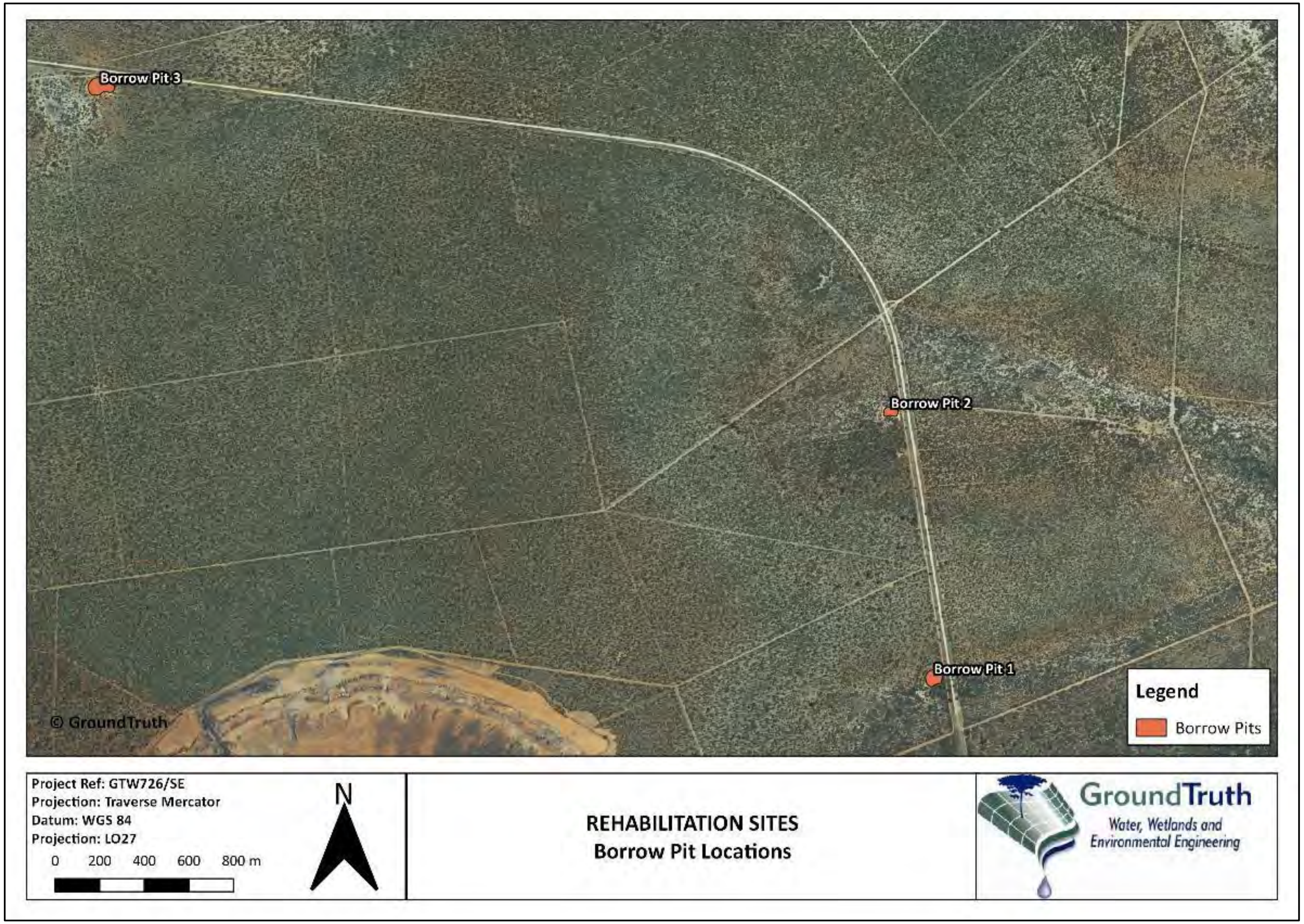


Figure 12-11 Overview of the borrow pits identified within the study site

12.2.2 *Assessment results of the wetlands identified*

The borrow pits identified for rehabilitation/enhancement within the study area were assessed in terms of their functioning and condition/integrity for both the current and post-rehabilitation/enhancement scenarios. The results of these assessments are described below.

12.2.2.1 Wetland ecosystem functioning assessment

The general features of the wetland groups were assessed in terms of the ecosystem functioning at a landscape level for the current and post-rehabilitation scenarios. The score for each ecosystem service represents the likely extent to which that benefit is being supplied by the specific wetland and was interpreted based on the following rating outlined by Kotze et al. (2007):

- <0.5 Low;
- 0.5-1.2 Moderately low;
- 1.3-2.0 Intermediate;
- 2.1-2.8 Moderately high; and
- >2.8 High.

<u>*Current scenario: Borrow pit rehabilitation sites*</u>

Generally, the values recorded for the regulating and supporting services for the current scenario for the borrow pit sites were ***Moderately Low*** to ***Intermediate*** (**Table 12-1** and **Figure 12-12**). In some instances, the wetlands' effectiveness at providing a particular ecosystem service differs markedly from the opportunity that exists to supply that ecosystem service. For example, the opportunity of the wetlands to trap sediments was considered to be ***Intermediate***, due to erosive potential of the soils within the catchment. However, the gentle gradient of the catchment and the fact that the delivery of any sediments into the wetlands would not be likely even with changes to land use practices e.g. agricultural activities; but is rather a natural process in such a landscape. Furthermore, the isolated nature of these systems from a stream network also reduces the 'value' these systems have within the landscape as they are not connected to systems that would be 'receiving' their benefits. Biodiversity maintenance values were considered to be ***Moderately High***. This can be attributed to the fact that the borrow pits are located within a game reserve. The systems' provision of direct benefits and services, such as harvestable natural resources and use for education, was seen as limited due to the systems' location within private property.

<u>*Post-rehabilitation scenario*</u>

The post-rehabilitation scenario was assessed for all rehabilitation results and will be presented as an entire group as the rehabilitation strategy for the majority of the depression wetlands is relatively similar. Therefore, the difference between the pre- and post-rehabilitation scenarios is relatively uniform across all systems (**Table 6-3** and **Table 6-4**). Generally, the majority of the systems improved in terms of their ability to provide erosion control, carbon storage and biodiversity maintenance services. This can generally be attributed to the rehabilitation of catchment related impacts and the revegetation of bare areas in specific wetlands and/or within their sub-catchments. The restoration of the surrounding veld provides additional habitat for fauna and will contribute to overall species diversity in the area and as such will increase the biodiversity maintenance rating in the post-development scenario. The rehabilitation of the veld surrounding the wetlands will inevitably increase the systems' ability to trap and store carbon and decrease erosion in the wider landscape. It should be noted that the scores for sediment trapping generally decreased in the post-rehabilitation scenario as the various sources of sediment within the immediate catchment of these systems have been deactivated and removed in many of the rehabilitation plans and as such, the opportunity and hence the overall score for sediment trapping by these systems has been reduced.

Table 12-1 Summary of current Ecosystem Services Scores[32] for the borrow-pit rehabilitation sites

Ecosystem Services	Borrow Pit 1	Borrow Pit 2	Borrow Pit 3
Flood attenuation	2.1	2.1	2.4
Score for effectiveness:	2.4	2.4	2.8
Score for opportunity:	1.8	1.8	2.0
Stream flow regulation	0.0	0.0	0.0
Sediment trapping	1.6	1.6	1.4
Score for effectiveness:	1.2	1.2	1.4
Score for opportunity:	2.0	2.0	1.3
Phosphate trapping	0.9	0.9	0.9
Score for effectiveness:	1.7	1.7	1.8
Score for opportunity:	0.0	0.0	0.0
Nitrate removal	0.5	0.5	0.5
Score for effectiveness:	1.0	1.0	1.0
Score for opportunity:	0.0	0.0	0.0
Toxicant removal	0.7	0.7	0.7
Score for effectiveness:	1.3	1.3	1.4
Score for opportunity:	0.0	0.0	0.0
Erosion control	1.8	1.8	2.0
Score for effectiveness:	1.8	1.8	2.0
Score for opportunity:	1.9	1.9	2.0
Carbon storage	1.3	1.3	1.3
Biodiversity maintenance	1.9	1.9	2.0
Score for noteworthiness:	1.0	1.0	1.0
Score for integrity:	2.8	2.8	3.0
Water supply	0.0	0.0	0.0
Source of harvestable goods /resources	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0
Tourism and recreation	0.3	0.3	0.3
Education and research	0.0	0.0	0.0

32 Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

Table 12-2 Summary of post-rehabilitation Ecosystem Services Scores[33] for the borrow-pit rehabilitation sites

Ecosystem Services	Borrow Pit 1	Borrow Pit 2	Borrow Pit 3
Flood attenuation	2.1	2.1	2.4
Score for effectiveness:	2.4	2.4	2.8
Score for opportunity:	1.8	1.8	2.0
Stream flow regulation	0.2	0.2	0.2
Sediment trapping	1.6	1.6	1.4
Score for effectiveness:	1.2	1.2	1.4
Score for opportunity:	2.0	2.0	1.3
Phosphate trapping	1.0	1.0	1.1
Score for effectiveness:	2.1	2.1	2.1
Score for opportunity:	0.0	0.0	0.0
Nitrate removal	0.8	0.8	0.8
Score for effectiveness:	1.5	1.5	1.5
Score for opportunity:	0.0	0.0	0.0
Toxicant removal	0.9	0.9	0.9
Score for effectiveness:	1.8	1.8	1.9
Score for opportunity:	0.0	0.0	0.0
Erosion control	2.2	2.2	2.3
Score for effectiveness:	2.5	2.5	2.5
Score for opportunity:	1.9	1.9	2.0
Carbon storage	1.7	1.7	1.7
Biodiversity maintenance	2.6	2.6	2.6
Score for noteworthiness:	2.0	2.0	2.0
Score for integrity:	3.1	3.1	3.1
Water supply	0.2	0.2	0.2
Source of harvestable goods /resources	0.0	0.0	0.0
Source of cultivated goods /resources	0.0	0.0	0.0
Socio-cultural significance	0.0	0.0	0.0
Tourism and recreation	0.3	0.3	0.3
Education and research	0.0	0.0	0.0

[33] Where applicable the scores for opportunity and effectiveness have been presented to ensure understanding of effectiveness of the systems.

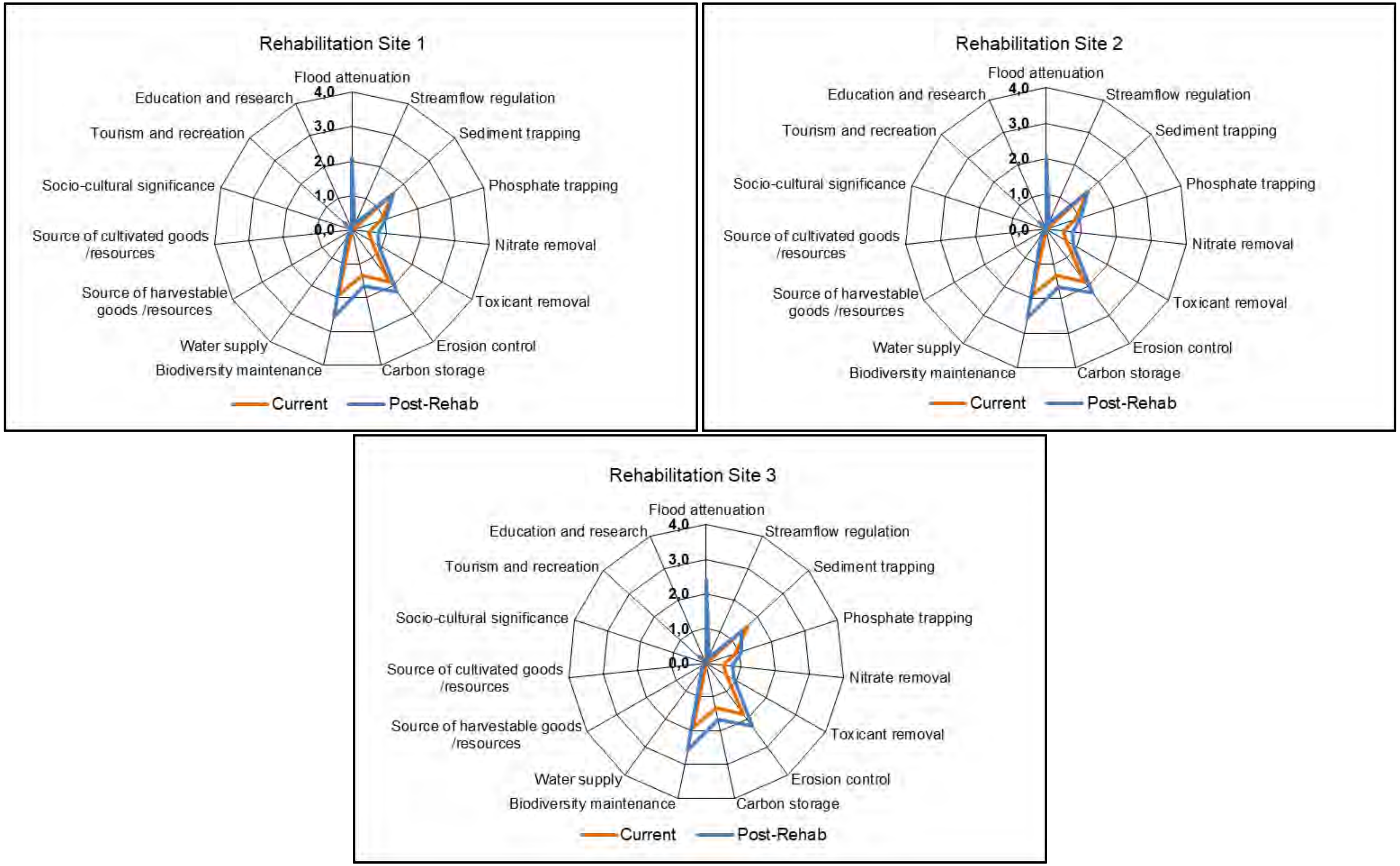


Figure 12-12 Overview of the ecosystem services provided by the borrow pits for the current and post rehabilitation scenarios.

As WET-EcoServices does not provide a consolidated score that can be used as a target, the current and post-rehabilitation assessment scores were incorporated into the Wetland Importance and Sensitivity assessment datasheets (Rountree and Malan 2010) to provide EIS scores (refer to **Table 12-3** to **Table 12-5**).

Table 12-3 EIS scores for the Borrow pit 1 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.0	Moderate
Hydro-functional importance	1.1	Low/marginal	1.3	Low/marginal
Direct human benefits	0.1	None	0.1	None

Table 12-4 EIS scores for the Borrow pit 2 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.2	Moderate
Hydro-functional importance	1.1	Low/marginal	1.3	Low/marginal
Direct human benefits	0.1	None	0.1	None

Table 12-5 EIS scores for the Borrow pit 3 in the current and post-rehabilitation scenario

	Current		Post-rehabilitation	
Categories	**Importance Score**	**Importance Rating**	**Importance Score**	**Importance Rating**
Ecological importance & sensitivity	2.0	Moderate	2.0	Moderate
Hydro-functional importance	1.2	Low/marginal	1.3	Low/marginal
Direct human benefits	0.1	None	0.1	None

12.2.2.2 Wetland ecological integrity assessment[34]

The ecological integrity or Present Ecological State (PES) of the borrow pits, were assessed for the hydrology, geomorphology, water quality and vegetation components, taking into account the reference/benchmark conditions. The integrity of the biophysical components of the borrow-pits were assessed for the current and post-rehabilitation scenarios, so as to provide an indication of the functional area gained as a result of the proposed rehabilitation activities.

It should be noted that the following assumptions were made with regards to the post-rehabilitation scenario:

[34] Please note that the full data for the wetland ecological integrity assessment results can be made available if required

- The assessment of catchment associated impacts utilised data collected both during the site visit and using aerial imagery. Historical imagery was utilised to assess the change in catchment related impacts over time so that an accurate representation of the current catchment related impacts could be incorporated into the WET-Health assessments.
- The size of most of the wetland systems assessed are generally <2% of the size of their catchments, as all catchments are >100ha in size. Therefore, it is unlikely that the portions of the catchments that are located farthest away from the wetland systems are going to have a large impact on the functioning of these wetland systems unless an exceptionally large rain event was to occur. As such, the WET-Health assessments weight catchment related impacts within a 200m buffer of the wetland more substantially than catchment related impacts located further away from the HGM unit.
- Only the areas delineated as 'true wetland' according to the DHSWS (2005) guidelines were assessed. As such, the areas delineated as 'sub-catchment areas' or 'areas of wider hydrological influence' were not included in the final hectare equivalent values and therefore were not included in the final offset calculation hectare values.
- All borrow pit offset receiving systems specified for rehabilitation were delineated and assessed by DWE (2018). The extents mapped by DWE were utilised for the purposes of this study, however, GroundTruth reassessed all of the rehabilitation sites in terms of their integrity and functioning. It is understood that the borrow pit sites are not natural wetland systems and were therefore assessed as 'desired-state' systems.

Borrow Pits

This group comprises of Borrow Pits 1, 2 and 3 within the A42J quaternary catchment and are all less than 0.5ha in extent. Generally, the catchment impacts for these systems are uniform and are associated with poor veld condition and the presence of roads. The catchment of Borrow Pit 1 does have mining associated impacts which has affected the integrity of the system. These impacts have been accounted for accordingly.

These smaller, artificial systems tend to be very temporary in nature and only retain water for short periods during the wet season. The assumption was made that these systems retain water, i.e. surface water[35], for approximately four (4) weeks per annum[36]. **Table 12-6** - **Table 12-8** provide summaries of the systems' biophysical drivers for the current and post-rehabilitation scenarios. The post-rehabilitation scenario incorporates positive impacts associated with brush-packing and erosion control in the immediate catchments to prevent sediment deposition in these systems. Brush-packing will also encourage vegetation recovery and an increase in surface roughness.

[35] It should be noted that this does not include the period during which the soil profile is inundated.

[36] It should be noted that this assumption can only be confirmed with long-term seasonal monitoring of the systems but is based on infield observations.

Table 12-6 Summary of the assessment of the ecological integrity for Borrow Pit 1 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	2.05	3.02	1.76	5.48
PES category	**C**	**C**	**B**	**D**
Combined PES score	70%			
Overall PES category	**C**			
Hectares of wetland (ha)	0.362			
Hectare equivalents (ha)	0.255			
Post-rehabilitation PES score	75%			
Post-rehabilitation category	**C**			
Post-rehabilitation hectare equivalents (ha)	0.271			

Table 12-7 Summary of the assessment of the ecological integrity for Borrow Pit 2 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.28	2.42	1.37	4.56
PES category	**B**	**C**	**B**	**D**
Combi-ned PES score	77%			
Overall PES category	**C**			
Hectares of wetland (ha)	0.205			
Hectare equivalents (ha)	0.158			
Post-rehabilitation PES score	86%			
Post-rehabilitation category	**B**			
Post-rehabilitation hectare equivalents (ha)	0.178			

Table 12-8 Summary of the assessment of the ecological integrity for Borrow Pit 3 for the current and post-rehabilitation scenarios

	Hydrology	Geomorphology	Water Quality	Vegetation
Impact scores	1.52	3.12	2.86	7.47
PES category	**B**	**C**	**C**	**E**
Combined PES score	65%			
Overall PES category	**C**			
Hectares of wetland (ha)	0.132			
Hectare equivalents (ha)	0.086			
Post-rehabilitation PES score	71%			
Post-rehabilitation category	**C**			
Post-rehabilitation hectare equivalents (ha)	0.094			

12.2.3 Summary of overall ecosystem integrity for the wetlands

For ease of interpretation the scores for hydrology, geomorphology, water quality and vegetation are able to be simplified into a composite impact score for the HGM unit by weighting the scores. This score was then used to derive hectare equivalents, which were used as the 'currency' for assessing the losses and gains in wetland integrity for offsetting purposes (Macfarlane et al. 2018, Cowden and Kotze 2009).

Based on the PES score for the current scenario, the 0.70ha of borrow-pit habitat is considered to be the equivalent to 0.5ha of intact borrow-pit wetland habitat (**Table 12-9**). The graphic representation of the functional wetland area versus the total extent of the wetland habitat onsite, clearly illustrates that the wetland habitat is functioning at approximately 71.4% (**Figure 12-13**). There are hectare equivalent gains in all three wetland groups in the post-rehabilitation scenario.

Table 12-9 Summary of the hectare equivalents for the current and post-rehabilitation scenarios for the identified wetland groups

HGM unit	Overall size (ha)	Current ha equiv.	Post-rehabilitation ha equiv.	Gains (ha)
Borrow pits	0.70	0.50	0.54	0.04

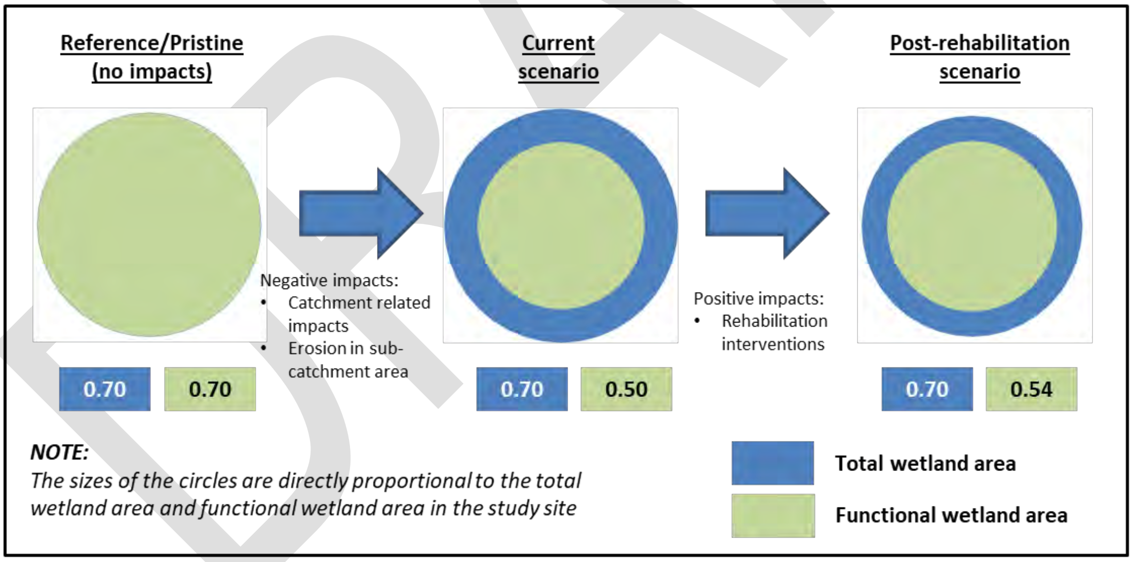


Figure 12-13 A graphic representation of the wetland systems identified within the study area, in terms of both spatial extent and functional area, from reference conditions through to the proposed post-rehabilitation scenarios.

12.2.4 *Freshwater ecosystem risk assessment*

When assessing the risks associated with the proposed rehabilitation activities, it was assumed that the proposed activities will have a limited footprint on the surrounding landscape, i.e. access roads. The assessment of the potential risks posed by the rehabilitation activities have been grouped according to the nature of the systems, i.e. natural versus artificial/quarry.

Consideration of the principles and approach described in the DHSWS Risk Matrix (GN 1180 of 2015), highlighted that the proposed rehabilitation activities will have a **limited/low risk** of negative impacts on the functioning and integrity of the systems (**Table 12-10**). The objective of the rehabilitation activities is to improve the overall functioning and integrity of the identified systems, which can be achieved through the careful implementation of the proposed rehabilitation activities. However, the Risk Matrix cannot account for positive impacts in the environment and therefore, the potential risks depicted below are considered to be 'worst-case' scenarios.

The risk associated with the rehabilitation activities is linked to the 'construction'/ implementation phase and may include impacts such as the potential mobilisation of sediments into the borrow pits through, for example, the removal of vegetation to create access paths. These impacts however, are considered to be low as it forms part of the rehabilitation process. It is assumed that care will be taken during the implementation phase to limit any impacts on the natural environment. Following the implementation of the proposed rehabilitation activities any disturbed areas will be suitably rehabilitated, including the immediate catchments surroundings the wetlands/quarries.

The potential risk of the rehabilitation measures within the post-implementation landscape, is linked to the movement of wildlife into these pans prior to them being fully established/stable. However, it is unlikely to occur as the immediate areas surrounding the rehabilitated pans/quarries will be suitably brush-packed and as such limiting access to the pans. In addition, it is recommended that these systems are monitoring for a period following the implementation of the rehabilitation activities, and as such guidance would be provided when the movement of wildlife into these systems would be considered to be acceptable again.

Table 12-10 Freshwater ecosystem risk assessment activities, impacts and risk ratings for the rehabilitation activities for the borrow-pits

Phase	Activity	Aspect	Impact	Severity	Spatial Extent	Duration	Probability /Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Residual Risk Rating*
Construction	Creating access path to rehab sites (where applicable)	Removal of vegetation to create access path	Removal of the vegetation within the catchment of the borrow-pit	1.1	1	1	8	25	L	90%	Adoption of the environmentally sensitive measures during the implementation phase to be supplied during the detailed design phase	Low (as these systems will receive protection for a period of XX years), as they form part of the offset requirements
		Siltation of borrow-pit	Siltation of borrow-pit from access roads (especially with rehab activities are undertaken during the wet periods)	1	1	1	8	24	L			
		Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L			
	Removal of sediment plumes within the borrow-pits	Compaction of section of the remaining borrow-pit	Removal of the vegetation within the borrow-pit and/or changing the substrate characteristics, i.e. compacted sections	1.1	1	1	8	25	L			
		Removal of invertebrates from borrow-pit (i.e. through trampling of additional areas)	Reduced invertebrate diversity within the borrow-pit	1.5	1	1	8	28	L			
		Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L			
	Deactivation of gullies/animal paths	Placement of ecologs/staggered logs	Siltation of borrow-pit from access roads (especially with rehab activities are undertaken during the wet periods)	1	1	1	8	24	L			
	Brush-packing	Disturbance of areas within the catchment from where the brush will be sought	Removal of vegetation/ additional access paths	1.1	1	1	8	25	L			
		Movement of machinery	Water contamination/ pollution	1	1	1	8	24	L			
Operational	Access of wildlife to enhanced borrow-pits (worst-case scenario)	Siltation of borrow-pit	Siltation of the borrow-pit associated with wildlife paths	1	1	2	8	32	L	90%	Management of the rehabilitation sites, ensuring that the wildlife do not gain access to the wetlands prior to them fully recovered and the vegetation in the catchment has established	
		Damaging of brush-packing	Removal of vegetation/ additional access paths	1	1	2	8	32	L			

12.2.5 *SANBI offset calculator*

As the impacts associated with the proposed expansion of the Grootegeluk mine on all of the identified wetlands within the LOM footprint of the study area were unable to be mitigated through the rehabilitation of wetlands onsite, an offset requirement was 'triggered', as the residual impact associated with the proposed mining activities has not been accounted for as defined in the SANBI Offset Guidelines (Macfarlane et al. 2014). An assessment of the offset requirements was conducted for the wetlands lost (see **GTW726/301018/01**).

The loss of 5.85 hectare equivalents of wetland habitat, associated with the expansion, was considered in terms of the approach specified by the SANBI Offset Guidelines. As described previously, the SANBI Offset guidelines were used to determine the offset targets. In terms of the offset targets that would be applicable, the following would need to be considered for the impacts on the wetland systems:

- Wetland functionality target –5.85 hectare equivalents;
- Ecosystem conservation target – 1.31 hectare equivalents; and
- Species of conservation concern target – not applicable as no species of special concern[37] were identified.

Table 12-11 Wetland offset targets and the contribution of the identified candidate wetlands towards the wetland functionality and ecosystem conservation targets

	Wetland functionality (ha equiv.)	Ecosystem conservation (ha equiv.)
Thabametsi Wetlands	1.06	61.54
Manketti Wetlands	0.75	21.20
Borrow pits	0.03	1.20
Total gains	1.84	83.94
Offset targets	5.85	1.31
Surplus/shortfalls	**-3.72**	**+82.74**

It should be noted that the SANBI Offset Guidelines (Macfarlane et al. 2014) account for a level of risk associated with the rehabilitation and long-term protection of the wetlands in the receiving areas by utilising an adjustment factor that lowers the gains received from each wetland being rehabilitated offsite based on whether rehabilitation, averted loss or establishment is taking place and the level of protection the systems will receive in the post-rehabilitation/establishment scenario. In this instance, the candidate sites fall within Exxaro land holdings and therefore, are incorporated within the management and conservation

[37] Species of special concern include Red Data Book or Red List taxa on threatened or conservation concern categories (Macfarlane et al. 2014). The nature of the study did not allow for the identification of any species of potential concern, and therefore, this component of the wetland offset calculations was excluded. Should biodiversity studies identify faunal or floral species of conservation significance that are dependent on the identified

protocols of Exxaro and their satellite organisations. The adjustment factor to account for risks associated with activities on other land holdings has therefore been excluded from the offset calculations to account for the fact that the wetlands fall within Exxaro land holdings and management and long-term protection of the candidate site are secured.

As is evident from **Table 12-11**, the identified candidate sites are not able to address the wetland functionality offset target, but significantly exceed the ecosystem conservation offset target. The inclusion of all candidate sites results in a nett-loss of 3.72ha in terms of wetland functionality and a gain of 82.74ha in terms of ecosystem conservation targets. It should also be noted that these wetland systems are some of the least understood and most threatened wetland types in South Africa and a like-for-like trade is necessary. It is recommended that all sites be rehabilitated to meet the agreed targets and account for impacts associated with the proposed mining activities.

It is recommended that a commitment to long-term conservation management of the identified candidate wetlands be secured through the Biodiversity Stewardship Programme[38] or having the candidate sites deemed conservation servitudes[39]. The process of meeting offset demands becomes an extremely land hungry endeavour if additional offset receiving sites are required outside of Exxaro owned and managed land as the SANBI offset calculator employs a multiplier that decreases the offset value if the land is not owned or managed by the entity responsible for the destruction of the wetlands in the first place. In a landscape that is scarce in its wetland coverage, it is advised that all additional offset work be kept on Exxaro managed land.

It is GroundTruth's understanding that the Zonderwater farm to the east of the Manketti Game Reserve is owned by Exxaro. There is a large feature of hydrological influence that originates in the Vooruit cadastral in Manketti that runs in an easterly direction, through the farm Ganzepan 446 and into the Zonderwater farm. This wider area of hydrological influence appears to have a series of wetland systems located within it and could contain a series of string-of-pearls configurations. If Exxaro were to purchase the Ganzepan 446 farm portion, there may be scope to drastically decrease the offset deficit of 4.04ha. Upon review of the available imagery, it appears as though there may be rehabilitation potential within the Ganzepan 446 farm portion. A site visit would be required to confirm this.

[38] This would include the development of a conservation management plan.

[39] This would be considered the responsibility of Exxaro as a part of the offset requirements

12.3 Appendix 3: Proposed rehabilitation strategies for individual borrow pits

Various rehabilitation and enhancement strategies have been adopted within the greater study area in order to achieve the aims of enhancing the functioning and integrity of the identified borrow-pits and wetland systems in the broader landscape. In this section, the rationale for the selection of the interventions to achieve the adopted rehabilitation strategy is specified for the individual HGM units. An intervention layout per individual HGM unit is provided for use in conjunction with the strategy summaries (**Appendix 5**).

12.3.1 Proposed enhancement strategy for Borrow Pit 1

The proposed interventions for the enhancement of the borrow-pit are specified in this section (**Figure 12-14**). Currently, the steepness of the sides of the borrow-pit encourages erosion on the pit sides and deposition of sediment in the central reaches of the borrow-pit, which disturbs the natural process of wetland soil pedogenesis in the bottom of the borrow-pit. The actual depression within the borrow-pit is too deep and covers a small surface area, and as such, water concentrates over a small surface area in the wetland and creates an unnaturally deep pool during the wet season.

The approach to the enhancement of this borrow-pit will be to reshape the extent of the pit so that it is morphologically similar to natural wetland systems. This approach will include the sloping out the sides of the wetland to a much gentler grade (between 3 and 10%) such that sediment isn’t as readily mobilised from the pit sides. Revegetation of the sloped sides with an appropriate grass and shrub seed mix will be carried out as soon as the reshaping has been completed. The central area of the borrow-pit will be filled with an appropriate substrate to create a much flatter bottomed system that will be more representative of a natural wetland system.

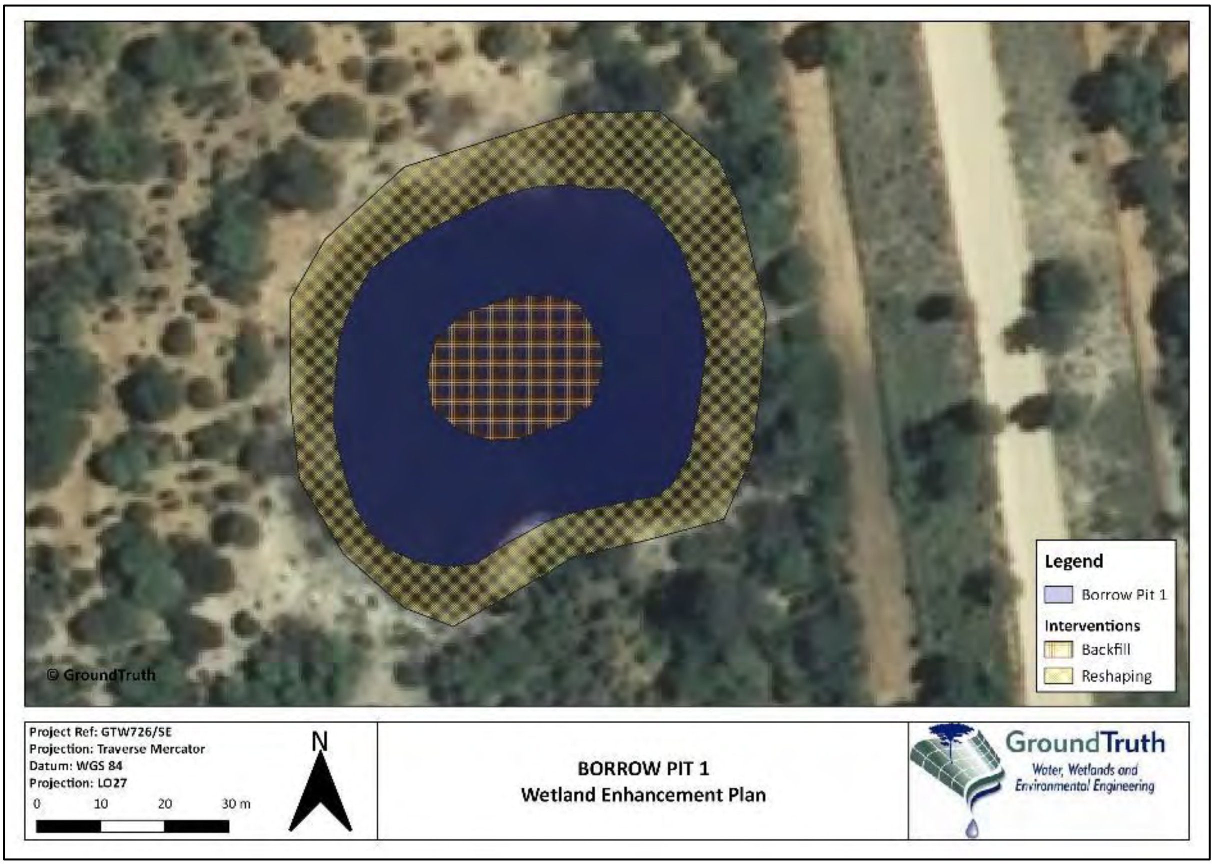


Figure 12-14 Overview of the proposed rehabilitation strategy for Borrow Pit 1

12.3.2 Proposed enhancement strategy forBorrow Pit 2

The system problems associated with this borrow-pit site are identical to those in Borrow Pit 1 and will be treated in the same way. However, the access road located to the east of this borrow pit is acting as a source of sediment to the borrow-pit and erosion of the road embankment has resulted in the formation a gully from the road into the wetland (**Figure 12-15**).

The approach to the enhancement of this borrow-pit will be the same as the approach in Borrow Pit 1. The reshaping of the sides of the borrow-pit will result in gradients ranging between 1% and 12% around the central depression which will also be filled to create a flatter bottomed depression. Further propagation of the gully will be prevented by reshaping the eastern slope of the borrow-pit down to a 1% grade and shaving the ground level on either side of the erosion gully down to the level of the bottom of the gully. This way diffuse flows from the road will be encouraged. The section of road that contributes to the hydrological and geomorphic functioning of this borrow-pit will also be sloped to have a 2% mono-camber facing the borrow-pit.

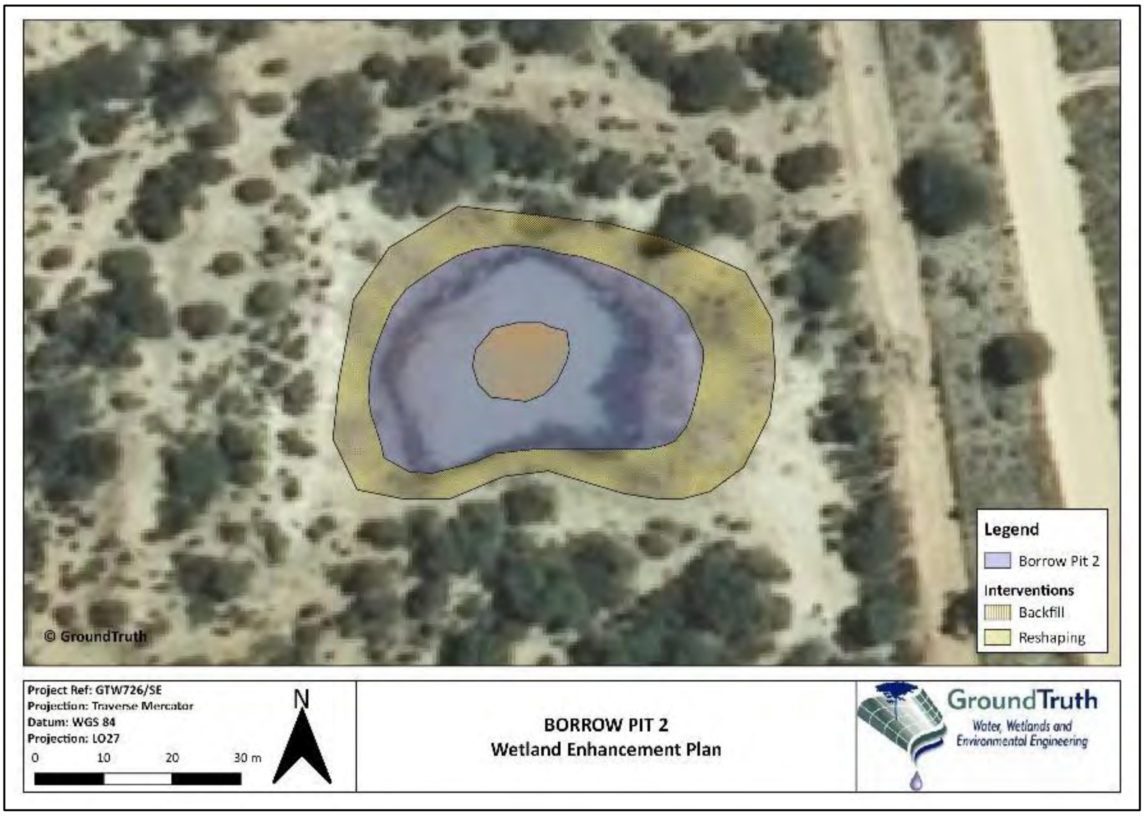


Figure 12-15 Overview of the proposed rehabilitation strategy for Borrow Pit 2

12.3.3 Proposed enhancement strategy for Borrow Pit 3

Like Borrow Pit 1 and 2, Borrow Pit 3 has similar problems associated with a deep depression and steep depression sides. However, Borrow Pit 3 is significantly deeper and is limited in its capacity to be reshaped as much of the depression lies on exposed sandstone bedrock. A management road is located directly to the north of the borrow-pit and is a source of sediment to the depression. There are two distinctive depressions that will be enhanced in this rehabilitation site, and will eventually become two separate HGM units.

Due to the limited reshaping potential in Borrow Pit 3, alternative sediment control and bank stabilisation methods are required to enhance this system. A 20m wide terrace will be sloped to a 1% grade on the northern side of the borrow-pit and will be laterally lined with brush-packs in 3m intervals to trap sediment mobilised from the road (**Figure 12-16**). There is a large berm located to the south of the rehabilitation site which will be used as backfilling material if necessary.

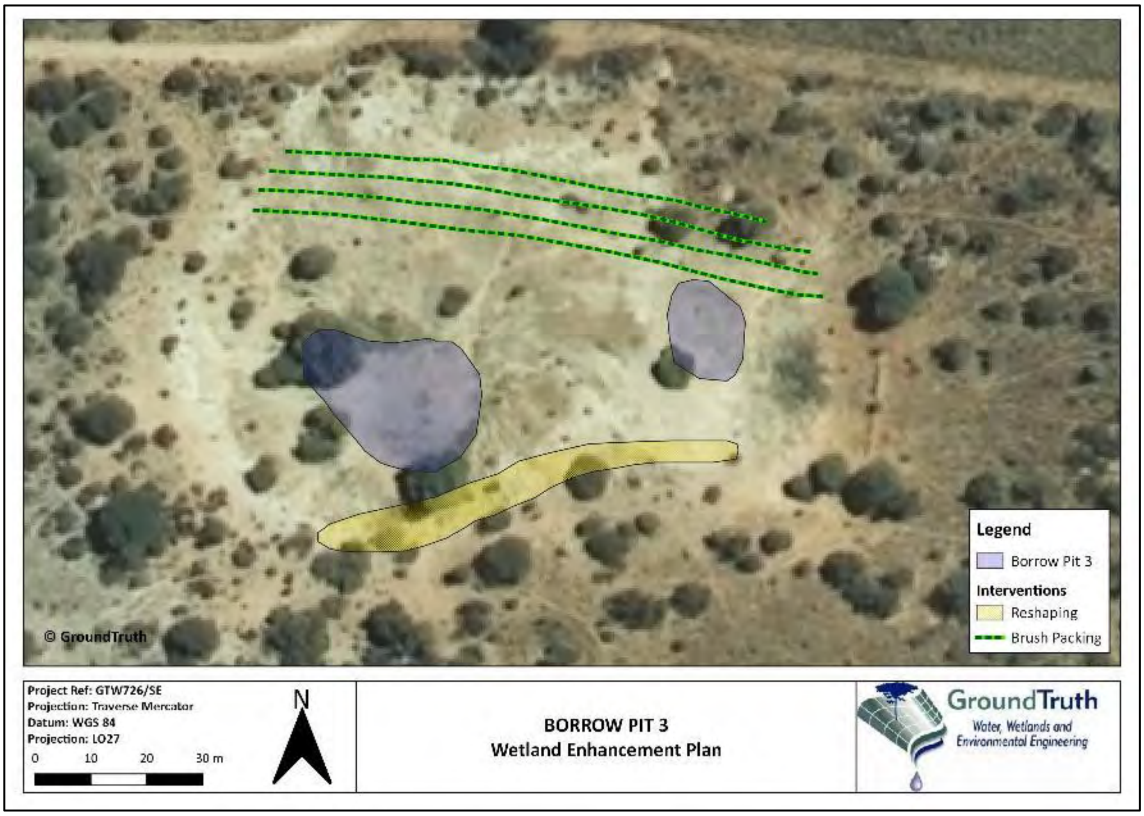


Figure 12-16 Overview of the proposed rehabilitation strategy for Borrow Pit 3

12.3.4 *Sequence of work*

It should be noted that the sequence of work of the proposed rehabilitation activities is critical and as such a phased approach is recommended. It is therefore recommended that the following sequence is adopted.

- Phase 1:
  - All in-system and catchment related earthworks;
  - Harvesting of all necessary material for brush-packing;
- Phase 2:
  - Revegetation of the pans (if applicable);
- Phase 3:
  - Reseeding and brush-packing of the disturbed areas.

It should be noted that the proposed phased approach should be adopted for each of the wetlands and should be continuously implemented until completed. This allows the threats posed by partial implementation to be minimised.

12.3.5 *Estimated costs*

The following tables (**Table 12-12** - **Table 12-14**) are estimated costs of the interventions based on bills of quantities included in the appendices, and rehabilitation work to be done for the eleven (11) sites. It should be noted that these costs may change, and are preliminary values that can be used as a reference.

Table 12-12 Cost summary of offset works

Rehabilitation Site	Cost Summary (R)
Borrow Pit 1	169 113.46
Borrow Pit 2	1 307 287.46
Borrow Pit 3	355 093.97
Grand Total	**1 831 494.89**

Table 12-13 Summary of quantities for offset works (earthmoving)

Rehabilitation Site	Excavation (m^3)	Spoil Material (m^3)	Haulage (km)	Earthen material (m^3)	Clay Liner Material (m^3)
Rehab 01	2 481.90		3.08		900.00
Rehab 02	13 101.15	7 166.16	3.08	1934.99	360.00
Rehab 03	3 259.73		11.88	3238.26	400.00
Grand Total	**18 842.78**	**7 166.16**	**18.04**	**5 173.25**	**1 660.00**

Table 12-14 Summary of quantities for offset works (brush-packing/erosion control)

Rehabilitation Site	Brush-packing lengths (m)
Rehab 01	
Rehab 02	
Rehab 03	149.00
Grand Total	**149.00**

12.3.6 *Wetland rehabilitation monitoring*

The following wetland rehabilitation monitoring framework was developed in accordance with the principles outlined in WET-RehabEvaluate (Cowden and Kotze 2009), with specific monitoring being recommended for the anticipated outputs and outcomes of the project. The monitoring includes the collection of baseline and routine monitoring information to enable the evaluation of the rehabilitation effectiveness at least five years after completion of the rehabilitation activities. It should be noted that the following recommended monitoring is considered to be the minimum level of monitoring required to show rehabilitation effectiveness, and additional monitoring may be required by the relevant authorities (e.g. water quality, vegetation composition etc.).

12.3.6.1 Monitoring of interventions

The assessment of the structural integrity would be undertaken based on the specific criteria outlined in **Table 12-15** and focus on the long-term stability of the interventions and the likelihood of achieving the stated objectives. This assessment would serve to identify weaknesses or strengths of the selected interventions within the wetlands.

Table 12-15 Criteria used for monitoring earthen structural integrity of wetland rehabilitation interventions (Modified from Cowden and Kotze 2009, p47[40]).

Earthen structures/works:
• Dimensions according to specifications • Authorised deviations from plan • Excessive settling of the soil (>10% of overall height) • Erosion on the bank • Establishment of vegetative cover • Scouring downstream • Evidence of outflanking • Adequate compaction of soil

The majority of the rehabilitation interventions are considered to be ‘soft’ as none of them involve major earthworks or construction of any concrete or stone structures. Brush-packing and potholing are temporary veld management measures designed to assist in veld

[40] It should be noted that **Table 12.20** is currently under review through a current Water Research Commission project (K5/2344). The project is aimed at providing a wetland rehabilitation monitoring and evaluation framework, which includes updating the structural integrity checklist.

regeneration processes. Therefore, the majority of the monitoring required will need to be observation based. Specific veld assessments can be carried out on a seasonal basis to assess the change in veld conditions in the post-rehabilitation landscape.

12.3.6.2 Fixed point photography/site photographs

Pre- and post-implementation photographs must be recorded for each rehabilitation site. These should be collected in the form of Fixed Point Photographs, as outlined in WET-RehabEvaluate, to allow repeated monitoring to be undertaken.

12.3.6.3 Wetland assessments

The ecological integrity and functioning of the wetlands should be monitored with:

- WET-Health and WET-EcoServices, collected during the planning process being used as the baseline; and
- Subsequent monitoring being undertaken approximately five years after completion of the rehabilitation strategy, to provide the final assessment of the benefits and effectiveness of the rehabilitation activities.

12.3.6.4 Wetland rehabilitation effectiveness

All of the above-mentioned monitoring should be used to inform the evaluation of the effectiveness of the rehabilitation and enhancement. This would be undertaken once the required monitoring information has been collected, five years following the completion of the wetland rehabilitation activities.

12.4 Appendix 4: Proposed Intervention Details for borrow pit sites

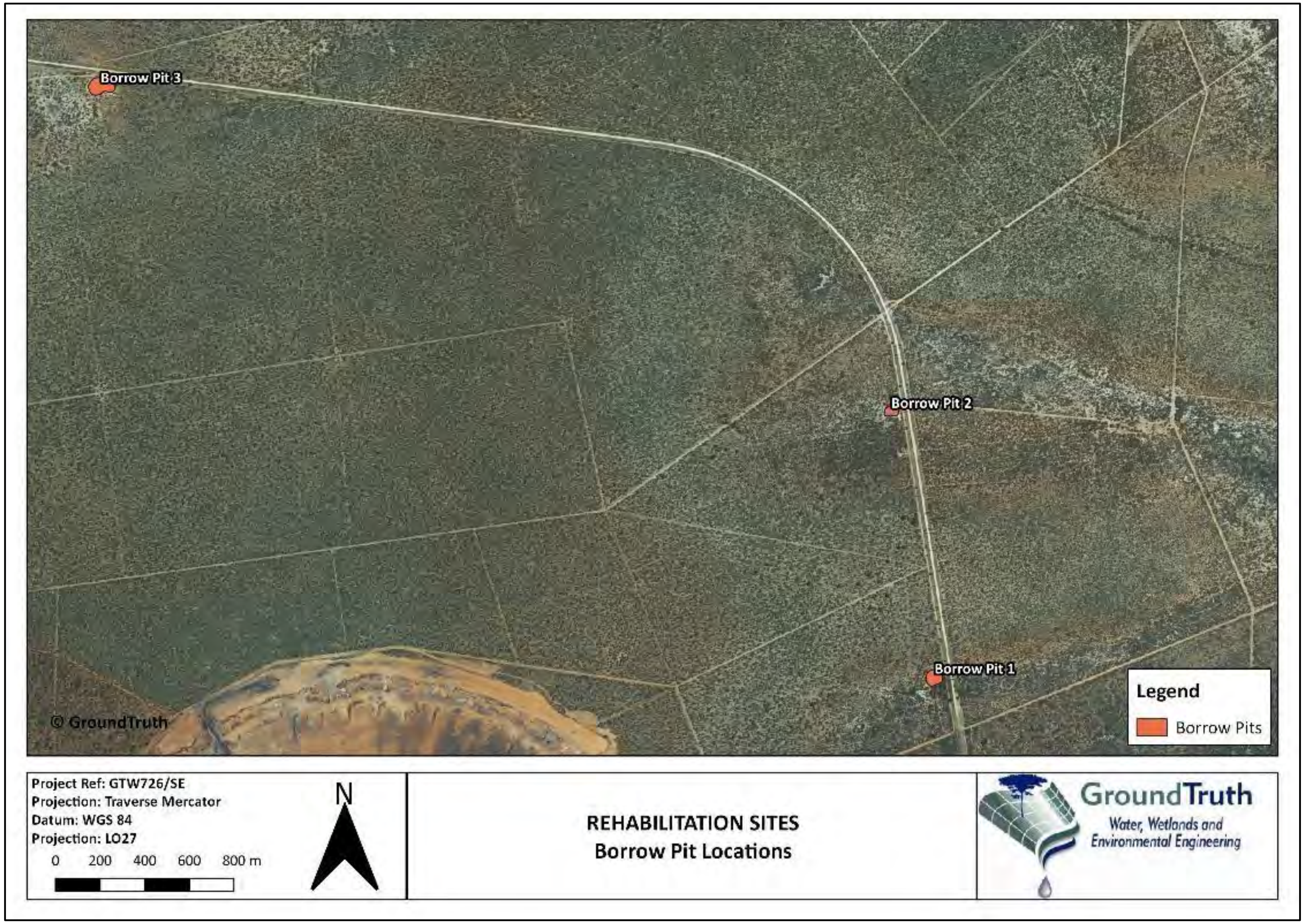


Figure 12-17 Layout of borrow pit interventions

12.4.1 *Intervention A42J-006*

Intervention Type	Earthworks
Rehabilitation Objective	Reshaping of existing quarry and revegetation to re-establish and optimize pan functioning.
Latitude	-23.62781371 S
Longitude	27.55981462 E
Designed By	Trevor Pike, Keaton Parker
Date	February 2020
Design Drawings	A42J-006-01

Figure A12-18 Location Photograph (A42J-006)

Bill of Quantities

Item	Unit	Quantity
Excavation	m^3	2482
Earthworks	m^3	6372
Clay liner	m^3	900
Revegetation	m^2	6000
Fill material to be received from A42J-001	m^3	4000
Haulage distance from A42J-001	km	1.3

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Backfill material to be compacted in 150mm layers;
- Backfill material to be moistened to optimum moisture content to ensure optimum compaction;
- Vegetation and topsoil is to be removed from the footprint of the quarry prior to its rehabilitation. The topsoil is to be spread and vegetation replanted on the side slopes of the quarry (vegetation is to be watered after removal and re-planting). Grass seeding of the slopes will be required if replanting the sods is unsuccessful;
- The slope of the created pan is to be at 3% until it reaches an area of 2000m^2;
- A 450mm thick clay layer is to be placed over the footprint of the created pan to reach design level;
- All slopes to be max 1:10 (V:H), unless otherwise specified;
- Excess material required for sloping the sides of the quarry is to be taken from the excavation of intervention A42J-006; and
- Material is to be transported using the road running alongside the intervention.

12.4.2 *Intervention A42J-007*

Intervention Type	Earthworks
Rehabilitation Objective	Reshaping of quarry and revegetation to re-establish and optimize pan functioning.
Latitude	-23.61596521 S
Longitude	27.55784247 E
Designed By	Trevor Pike, Keaton Parker
Date	February 2020
Design Drawings	A42J-007-01

Figure A12-19 Location Photograph (A42J-007)

Bill of Quantities

Item	Unit	Quantity
Excavation	m^3	13101
Earthworks	m^3	1935
Clay liner	m^3	360
Revegetation	m^2	5500
Material to be moved to A42J-001	m^3	4000
Haulage distance to A42J-001	km	1.3
Spoil material	m^3	7166

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem.
- Backfill material to be compacted in 150mm layers
- Backfill material to be moistened to optimum moisture content to ensure optimum compaction
- Vegetation and topsoil is to be removed from the footprint of the quarry prior to its rehabilitation. The topsoil is to be spread and vegetation replanted on the side slopes

of the quarry (vegetation is to be watered after removal and re-planting). Grass seeding of the slopes will be required if replanting the sods is unsuccessful;

- The slope of the created pan is to be at 3% until it reaches an area of 800m²;
- A 450mm thick clay layer is to be placed over the footprint of the created pan to reach design level;
- All slopes to be max 1:10 (V:H), unless otherwise specified;
- Excess cut material to be used for intervention A42J-006;
- Material is to be transported using the road running alongside the intervention; and
- All excess cut material to be used for other interventions where needed or spoiled appropriately.

12.4.3 *Intervention A42J-008*

Intervention Type	Earthworks and Brush-packing
Rehabilitation Objective	Reshaping of quarry and revegetation to re-establish and optimize pan functioning. Brush-packs along created terrace for sediment control
Latitude	-23.60174243 S
Longitude	27.52350469 E
Designed By	Trevor Pike, Keaton Parker
Date	February 2020
Design Drawings	A42J-008-01

Figure A12-20 Location Photograph (A42J-008)

Bill of Quantities

Item	Unit	Quantity
Excavation	m^3	3260
Earthworks	m^3	3238
Clay Liner	m^3	400
Number of 2m long brush-pack bundles	No.	150
Area of loose brush-packing	m^2	1940
750mm Wooden Pegs	no.	100
3mm steel wire	m	281
Revegetation	m^2	2740
Haulage distance from future mining if needed	km	17.88

Construction Notes

The following construction notes apply to the proposed intervention:

- The contractor is to inform the engineer if site conditions have changed and that the intervention no longer adequately addresses the problem;
- Backfill material to be compacted in 150mm layers;
- Backfill material to be moistened to optimum moisture content to ensure optimum compaction;
- Vegetation and topsoil is to be removed from the footprint of the quarry prior to its rehabilitation. The topsoil is to be spread and vegetation replanted in the footprint area (vegetation is to be watered after removal and re-planting). Grass seeding of the berm will be required if replanting the sods is unsuccessful;
- All slopes to be no steeper than a 1:5 (V:H) slope, unless otherwise specified;
- The slope of the created pan is to be at 5% until it reaches an area of 800m^2;
- A 450mm thick clay layer is to be placed over the footprint of the created pan to reach design level; and
- Before brush-packing, loosen soil and scarify paths, then seed area and brush-pack over seed.