APPENDIX J:
WETLAND REPORT

Underground Coal Gasification Project and Associated Infrastructure in support of co-firing of gas at the Majuba Power Station, Amersfoort, Mpumalanga - Wetland Assessment Study – EIAR Phase

Eskom Holdings SOC Ltd

Revision 3

July 2014

DOCUMENT DESCRIPTION

Client:

Eskom Holdings SOC Ltd

Project Name:

Underground Coal Gasification Project and Associated Infrastructure in support of co-firing of gas at the Majuba Power Station, Amersfoort, Mpumalanga - Wetland Assessment Study – EIA Phase – **Revision 3**

Royal HaskoningDHV Reference Number:

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Compiled by:

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Date:

July 2014

Location:

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Approval: Prashika Reddy

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Signature

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Glossary of Terms

Anaerobic	The absence of molecular oxygen
Aquiclude	A rock or soil low of very low permeability that would effectively prevent the downward movement of water through the soil profile
Baseflow	The component of river flow that is sustained from groundwater sources rather than from surface water runoff
Catena	A repeated sequence of soil profiles that is related to relief features, indicating the same sequence when traced from the crest (interfluve) to the valley floor. Profiles change in character as one moves downslope (change in slope angle and drainage conditions), so that different degrees of leaching / translocation are encountered
Facultative	Occurring optionally in response to circumstances rather than by nature; applied to wetland plants in this context – a facultative species is a species usually found in wetlands (67-99% of occurrences), but occasionally found in non-wetland areas
Flood Wrack	The (primarily vegetative) material washed down river courses during flood / spate flow events, and which is trapped behind branches and other obstacles, remaining in situ after the flood has passed
Gleying	The process by which a material (soil) has been or is becoming subject to intense reduction as a result of prolonged saturation by water. Gleyed soils are characterised by grey (due to an absence of iron compounds), blue and green colours (due to an absence of ferrous compounds)
Hydric / Hydromorphic Soils	Soils formed under conditions of saturation, flooding or ponding for sufficient periods of time for the development of anaerobic conditions and thus favouring the growth of hydrophytic vegetation
Hydrology	The scientific study of the distribution and properties of water on the earth's surface
Hydrological Activation	The degree and period of time of inundation of an area / channel by water, potentially resulting in the development of hydromorphic conditions
Hydromorphy	A process of gleying and mottling resulting from intermittent or permanent presence of free water in soil. Results in hydromorphic soils
Hydroperiod	The term hydroperiod describes the different variations in water input and output that form a wetland, characterising its ecology – i.e. the water balance of the wetland
Hydrophyte	A plant that grows in water or in conditions that are at least periodically deficient in

	oxygen as a result of saturation by water – these are typically wetland plants
Interfluve	A watershed.
Macro Channel (Bank)	The (overall) compound channel of a watercourse that is situated between the two outermost and highest-lying banks
Melanic Soils	A type of topsoil horizon that is dark-coloured and usually well-structured.
Micro-topography (Micro-relief)	Slight undulations of the surface created by changes in the form of material overlying bedrock, rather then by irregularities in the bedrock itself. These are typically landforms less than 1m in height which can be caused by such factors as fluvial activity, erosion, animal trampling, etc.
Obligate	A species that almost always occurs in wetlands. Obligate wetland species occur in wetlands >99% of the time.
Reach	A portion / stretch of a river
Redoximorphic	Features within soil that are a result of the reduction, translocation and oxidation (precipitation) of Fe (iron) and Mn (manganese) oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic
Stream Order	A morphometric classification of a drainage system according to a hierarchy or orders of the channel segments. Within a drainage network the unbranched channel segments which terminate at the stream head are termed as “first order streams”
Sward	Cover of grassy vegetation within a grassland
Vertic Soils	Soils characterised by the presence of swelling and shrinking clays, typically formed where there is a distinct wet and dry period that affects the soils. These soils swell when they become saturated, and shrink again when they dry out, leading to characteristic ‘cracking’ on the surface of the ground

Specialist Declaration

I, Paul da Cruz, declare that I –

- act as a specialist consultant in the field of wetland assessment
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2010; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.

PAUL DA CRUZ

1 INTRODUCTION

Royal HaskoningDHV (RHDHV) have been appointed by Eskom Holdings Soc. Ltd. to undertake wetland assessment study as part of the wider Environmental Impact Assessment (EIA) Studies for the proposed Underground Coal Gasification (UCG) Project near the Majuba Power Station in the Amersfoort area of Mpumalanga. Although an EIA process was previously undertaken for the project, a change in scope has required that the process be redone. The author undertook a scoping-level assessment in October 2009, and an EIA-phase assessment in February 2011. The wetland assessments for both phases have thus been recompleted taking into consideration the new project scope, and this report presents the revised EIA-phase wetland assessment. In addition, following discussions regarding the need to undertake a more detailed delineation of the wetlands (and associated wetland buffers) in the revised study area (i.e. on the Roodekopjes site to the east of the Majuba Power Station access road, and along the proposed UCG service road) that would allow the accurate planning of underground coal gasification activities on the revised development site to be undertaken, and bearing in mind the predominance of vertic soils on the development site to which the standard wetland delineation methodology does not apply, RHDHV were appointed by Eskom to undertake a revised delineation and assessment study in February 2014.

The primary changes in scope in this draft of the report are thus as follows:

- the study area has been reduced and now only encompasses the farm Roodekopjes 67HS (Portions 1, 2, 3 and remaining extent);
- the proposed 140MW plant no longer forms part of the scope of the application;
- the report has been updated to include the results of the revised delineation and assessment of wetlands on the site in February 2014.

This assessment has also assessed an area in which the proposed infrastructure such as wells and associated infrastructure such as roads and pipelines are proposed to be located.

This EIR-level impact assessment will assess the impact of the proposed development on wetlands in the Study Area. In addition, and to support the assessment of the impacts associated with the proposed activity, the study aims to assess the wetlands in the study area in terms of their functionality and general state, and in so doing to enable a prioritisation of 'high-value' wetlands in the study area to be undertaken. The need for a comparative functional assessment of wetlands in the Study Area is derived pertly from comments and requirements for assessment submitted by the Mpumalanga Tourism and Parks Authority (MTPA) – a commenting authority. The Wet-EcoServices programme has been used for this purpose as it provides a framework through which the aspects of functionality of a wetland unit / reach can be determined. A number of field trips to the area over the course of 2010 allowed the wetlands within the large Study Area to be characterised in the field, allowing an in-depth understanding of the physical characteristics and drivers of wetland formation and degradation to be acquired.

Surface water features (including wetlands) are a very important component of the natural environment, as they are typically characterised by high levels of biodiversity and are critical for the sustaining of human livelihoods through the provision of water for drinking and other human uses. Wetlands are sensitive features of the natural environment, and pollution or degradation of a wetland can result in a loss of biodiversity, as well as an adverse impact on the human users which depend on the resource to sustain their livelihoods. As such surface water resources and wetlands are specifically protected under the National Water Act, 1998 (Act No. 36 of 1998) and generally under the National Environmental Management Act, 1998 (Act No. 107 of 1998). It is in this context that the wetlands of the Study Area have been assessed and characterised and the potential impact of the proposed development on these features has been quantified.

1.1 Aims of the Study (Project Terms of Reference)

The aims of the study are to:

- verify the occurrence and typology of wetlands in the Study Area as delineated in the Scoping-phase of the project by desktop methods, and to correct the delineation based on field-based assessment, thus enabling all wetlands in the study area to be mapped
- assess all of the wetlands of the study area in the field
- based on the field assessment gain an understanding of the overarching characteristics of wetlands, including hydrology, vegetation and soils and geology, as well as the pressures (threats) currently acting on wetlands,
- undertake a functional assessment and (high-level) assessment of the state of the wetlands, and in so doing identify the following characteristics of wetlands in the Study Area (as highlighted in the requirements of the MPTA):
    - the size each of the wetland reach assessed
    - the surface roughness of each wetland reach
    - problem areas in each wetland reach
    - land form settings and HGMs of the wetland reaches
    - goods and services provided by each wetland
    - land cover in the surrounding catchment of each wetland reach
    - sediment input into wetland reaches
    - nutrient/toxicant input into wetland reaches
    - biodiversity associated with each wetland reach, including unique communities
- prioritise wetland reaches in the study area that are associated with a high degree of sensitivity, integrity or functionality, thereby feeding into a sensitivity assessment of the Study Area
- assess the impacts of the proposed development on wetlands, and suggest suitable mitigation measures, if relevant, to ameliorate or remove these predicted impacts

1.2 Assumptions and Limitations

Only wetlands within the boundaries of the revised study area were assessed as part of this study, and no downstream or upstream wetlands were assessed / delineated. Assessment undertaken on wetlands in the former wider area, and no longer situated in the study area, has been removed from this report.

This methodology that has been used in this assessment is detailed in a report compiled by the author in December 2013. The delineation methodology presented in that report is based on the best understanding of the dynamics of hydromorphism as it relates to vertic soils in a South African context. It should be noted that no official methodology for the delineation of wetlands in vertic soil settings currently exists. Parts of the methodology utilised for the delineation were adapted from the Department of Water Affairs Wetlands delineation methodology (DWA(F), 2005) as well as the methodology created by Kotze and Marneweck (1999). While the principles of these methodologies have been applied, these have been slightly modified to reflect local conditions in the study area. Please refer to Appendix 1 for the delineation methodology applied.

No parts of the Roodekopjes property to the west and north of the Majuba Power Station access road were included in this assessment. It should also be noted that the wetland extending onto the Roodekopjes site close to the intersection of the Perdekop Road and the Majuba Power Station access road was not included in the assessment.

No detailed modelling of the potential impact of the proposed UCG mining operations on ground subsidence has been provided for assessment. Combined with the lack of detailed groundwater flow modelling, it is thus not possible to accurately assess the wetland-specific impacts of subsidence on groundwater inputs into wetlands on the site. Should this information be made available, a wetland-level assessment of the potential impacts of subsidence would be able to be undertaken.

2 STANDARD DEFINITION OF WETLANDS AND HYDRIC SOILS

The National Water Act defines a wetland as:

"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."

This definition alludes to a number of physical characteristics of wetlands, including wetland hydrology, vegetation and soil. The reference to saturated soil is very important, as this is typically the most important factor by which wetlands are defined.

Another widely used definition of wetlands is the one used under the Ramsar Convention; wetlands are defined as:

"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"

Typically one of the most common methods to identify wetlands is the identification of hydromorphism in soils, and as such wetland soils are termed hydric or hydromorphic soils. Hydric soils are defined by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) as being:

"soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part"

These anaerobic conditions would typically support the growth of hydromorphic vegetation (vegetation adapted to grow in soils that are saturated and starved of oxygen) and are typified by the presence of redoximorphic features.

2.1 Wetland Delineation Methodology for the UCG Site

The wetland delineation methodology for the UCG site as detailed in the Wetland Delineation Methodology Report produced in 2013 is detailed in Appendix 1.

3 LEGISLATIVE CONTEXT

The following section briefly examines the legislation that is relevant to the scope of the wetland assessment. The stipulations / contents of the legislation and policy that is relevant to the study are explored.

3.1 The National Water Act

It is important to note that water resources, including wetlands are protected under the National Water Act 36 of 1998 (NWA). Wetlands are defined as water resources under the Act. 'Protection' of a water resource, as defined in the Act entails:

- Maintenance of the quality of the quality of the water resource to the extent that the water use may be used in a sustainable way;
- Prevention of degradation of the water resource
- The rehabilitation of the water resource

In the context of the current study and the identification of pressures and threats acting on wetlands, the definition of pollution and pollution prevention contained within the Act is relevant. 'Pollution', as described by the Act is the direct or indirect alteration of the physical, chemical or biological properties of a water resource, so as to make it (inter alia)-

- less fit for any beneficial purpose for which it may reasonably be expected to be used; or
- harmful or potentially harmful to the welfare or human beings, to any aquatic or non-aquatic organisms, or to the resource quality.

The inclusion of physical properties of a water resource within the definition of pollution entails that any physical alterations to a water body, for example the excavation of a wetland or changes to the morphology of a water body can be considered to be pollution. Activities which cause alteration of the biological properties of a watercourse, i.e. the fauna and flora contained within that watercourse are also considered pollution.

In terms of section 19 of the Act owners / managers / people occupying land on which any activity or process undertaken which causes, or is likely to cause pollution of a water resource must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring. These measures may include measures to (inter alia):

- cease, modify, or control any act or process causing the pollution
- comply with any prescribed waste standard or management practice
- contain or prevent the movement of pollutants
- remedy the effects of the pollution; and

- remedy the effects of any disturbance to the bed and banks of a watercourse

The above stipulations of the Act have implications for the proposed development; as identified further on in this report the proposed development may be associated with certain direct or indirect impacts on wetlands in the area, some of which may affect the physical characteristics of the wetlands. These impacts are likely to be needed to be licensed under the Act. The National Water Act also stipulates requirements for permitting which would need to be followed.

3.2 The Mpumalanga Biodiversity Sector Plan 2013

The Mpumalanga Biodiversity Sector Plan (MBSP) 2013 has recently been released and replaces the Mpumalanga Biodiversity Conservation Plan completed in 2007 that hitherto provided information on biodiversity sensitivity in the Mpumalanga Province. Although no handbook for the MBSP currently exists, the data is available for assessment and has been analysed in this study. The MSBP assessment comprises of a terrestrial assessment as well as a surface water assessment, with the surface water assessment identifying sensitive surface water features. The MSBP has identified Critical Biodiversity Areas (CBAs) as well as Ecological Support Areas (ESAs) and the following sub-categories under each category.

ESAs:

- ESA – Fish Support Points
- ESA – Water Source Areas
- ESA – Important Sub-catchments
- ESA – Wetland Clusters
- ESA – Wetlands

CBAs:

- CBA – aquatic species
- CBA Rivers
- CBA Wetlands

An analysis of the study area in terms of the MBSP reveals that there are no wetlands of designated importance – either CBA wetlands or ESA wetlands, except for an isolated pan-depression wetland. The Witbankspruit River which drains northwards across the Roodekopjes Site has been designated as a CBA River. This sensitivity associated with the river and riparian corridor has implications for the impacts potentially associated with the UCG process and associated activities as described below.

4 Summary of Findings of the scoping-level wetland ASSESSMENT

4.1.1 Wetland Sensitivity

The Scoping Study concludes that any wetland occurring within the boundaries of the Study Area be considered a sensitive feature of the natural environment. This sensitivity must be equally applied to all wetlands, irrespective of their state or functionality. Buffers surrounding the wetlands were also deemed as being important in a wetland integrity and functionality context.

4.1.2 Potential Impacts

Generic potential issues and impacts on the wetlands that may be caused by or are associated with the life stages of the proposed development (from construction to post closure) for all components of the development including associated infrastructure were scoped and identified.

The array of impacts and issues highlighted in the scoping phase generally included:

- the potential impact of placing mining infrastructure and associated infrastructure such as water treatment plants near wetlands
- general construction-related impacts
- impacts related to mining activities, and particularly to undermining
- impacts related to pipelines
- impacts related to access roads
- impacts related to power lines
- polluted run-off water
- impacts related to irrigation of land with wastewater, and the concomitant hydrological and water quality related impacts on wetlands

Most of these impacts are relevant to the construction phase, while many similarly apply to potential impacts during the operational phase of the proposed development. The potential impacts on wetlands related to the decommissioning of the plant and proposed infrastructure are similar in many aspects to construction-related impacts, if infrastructure such as buildings is physically removed. Any residual impacts of ‘mining activities’ such as development of soil erosion or improperly maintained roads may result in secondary impacts on nearby wetlands through the extension of erosion into the wetland or deposition of silt into the wetlands. Similarly any potential pollutants such as fuels / hydrocarbons left within the mining footprint may cause pollution of surface water resources through stormwater runoff. Potential post-closure impacts would equate to residual impacts resulting from the improper decommissioning of the plant and associated infrastructure or lack of removal of any potential pollutants related to the processes of the plant that may over time enter the water cycle. These potential impacts will be further assessed in this phase of the surface water study.

5 PROJECT DESCRIPTION

5.1 Site Location and Description

The Study Area is located to the south and west of the town of Amersfoort and to the north of the Majuba Power Station. The site is situated in a rural context where agricultural landuse dominates. This area is utilised mainly for crop cultivation and grazing of livestock, although an old disused mine as well as part of the Majuba Power Station and its associated infrastructure are located in the study area. The area is located on the Mpumalanga Highveld (the site is located at an altitude of approximately 1700m above sea level), and is thus characterised by rolling grasslands of the Amersfoort Highveld Clay Grassland vegetation type (. The study area is indicated in the map below.

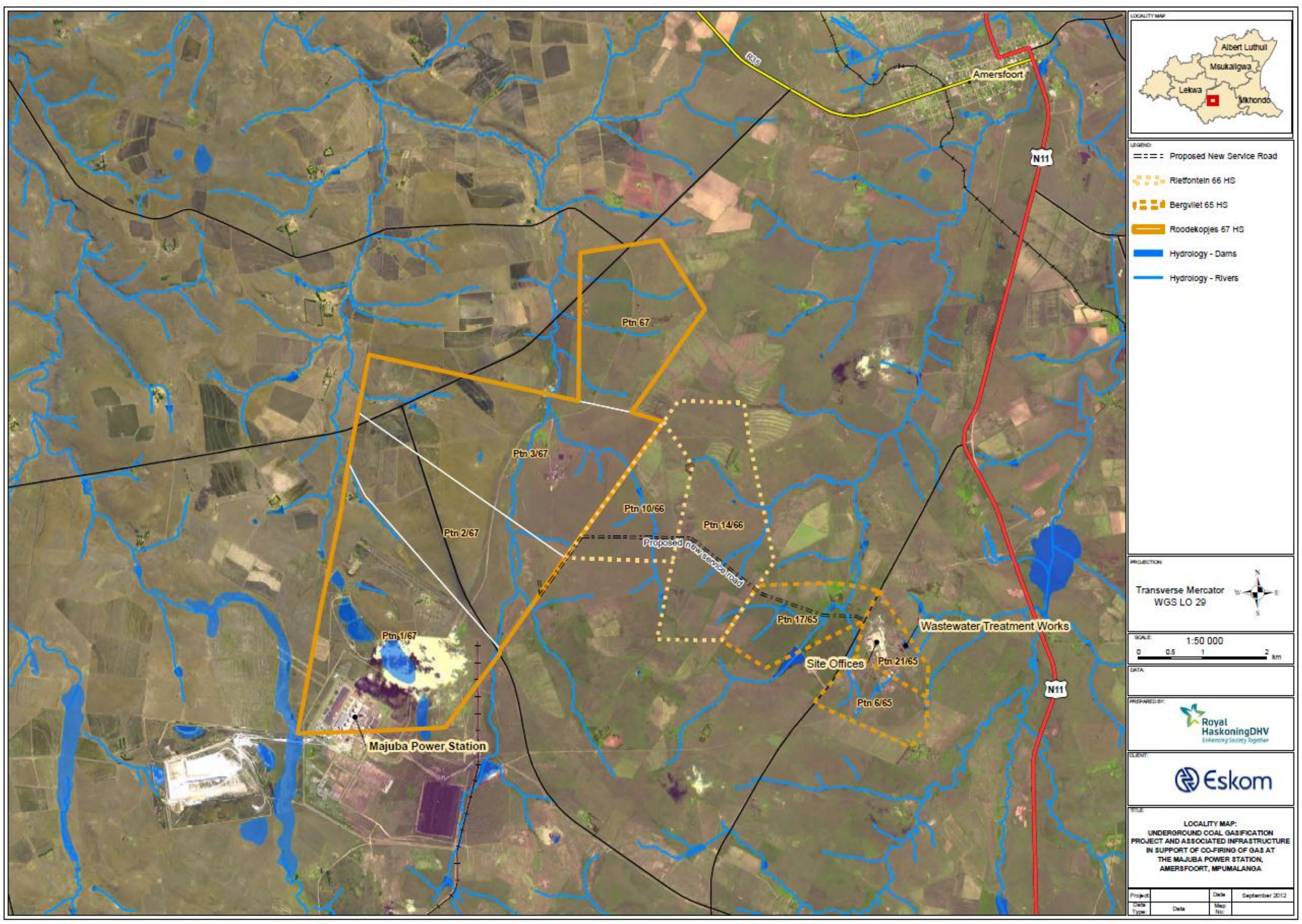


Figure 1 – Study area and site of proposed development

5.2 Project Technical Description

The Underground Coal Gasification (UCG) theory was developed in the former U.S.S.R. and is based on the principle of combusting coal to produce a synthesis gas, without the removal of the coal. The coal to gas conversion process is a controlled combustion process which is kept deep underground therefore minimising the impact of the operations.

The UCG pilot plant will provide for an initial generating capacity of approximately 6 MWe, which is sufficient to co-fire a single burner at the Majuba Power Station. Pending the success of Phase 1B gas production will be scaled up to 70000 Nm3/hr to eventually produce 28 MWe.

Due to the nature of the technology, the Underground Coal Gasification pilot plant will comprise a vast number of activities. A basic flow diagram for the entire process is presented in the Figure below.

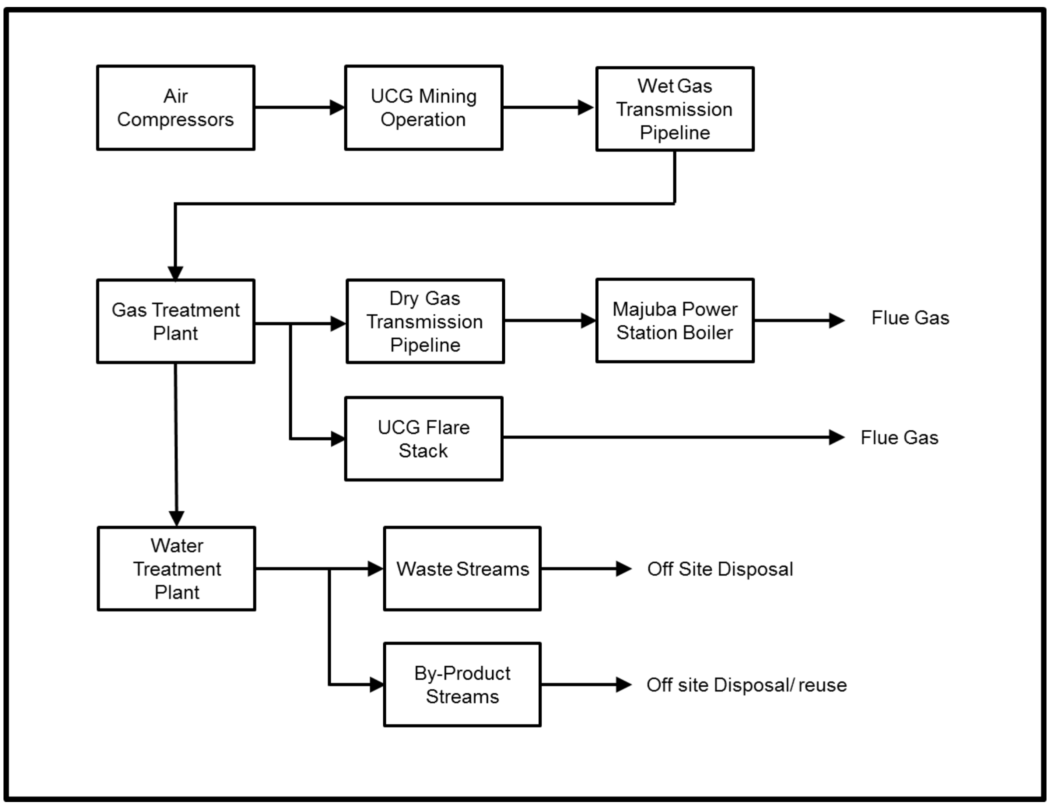


Figure 2 - Block flow diagram for the 70000 Nm^3/hr pilot plant

The UCG technology is based on the injection of compressed air (10 bar gauge) provided by large stand-alone air compressors into the coal seam (approximately 280 – 300 m deep). Four (4) compressors will initially be installed although provision for a fifth will be made in the site layout. Three compressor units will operate continuously, 24 hours/day.

Due to the utilisation of coal, the boundaries of the underground reactor continue to grow until such point at which the system is no longer capable of generating a gas of suitable quality. At this stage the specific system is decommissioned and the mine field then proceeds to the next section of available coal.

The UCG process remains primarily a mining operation and the key components of the mining operation include the drilling, exploration and monitoring wells – also referred to as the gas field. The gas field contains two major components namely the gasifier units and ancillary infrastructure such as access roads, pipelines, manifolds etc. The continuous linkage of wells in the gasifier enables the process to access virgin coal and the monitoring and modelling of the geohydrological, rock mechanics and geological characteristics of the targeted coal seam.

The implementation of gasifier units will be based on the gas input requirements for Phase 1B and 1C (production of 15000 and 70000 Nm^3/hr of syngas respectively). The gasifier unit has an approximate footprint of 50 ha with a maximum height of 15 m and will be operated independently from one another in order to control the gasification processes. A typical gasifier unit is made up of the following components:

- Above-ground air pipeline
- A network of above ground primary gas pipelines
- A secondary gas pipeline located at the border of the gasification unit
- Injection and production wells
- Water monitoring wells
- Air pressure unit
- Pressure measurement units
- One lane gravel assess road
- Wastewater pipeline

The gasifier units will be located across portions of the farm Roodekopjes 67HS (Portions 1, 2, 3 and remaining extent). At this stage it is anticipated that nine (9) gasifier units will be established as part of the mining operations on the farm Roodekopjes 67HS. Preliminary designs for gasifier unit 1 – 3 have been developed, although at present only one gasifier constructed under the auspices of the prospecting right) is operational. The layouts for all future gasifier units will be similar to the layout of gasifier units 1 – 3. Gasifier unit 1 will soon be decommissioned as the underlying coal reserves have been gasified and gasifier unit 2 will be commissioned.

Each gasifier unit will have a production lifetime of approximately 7 – 8 years. The operational lifecycle of a gasifier is dependent on the underlying coal seam thickness and composition. The complete lifecycle for a typical gasifier unit is presented in the table below.

Table 1 – Project Development Phases

Development Stage	Tasks
Pre-Construction Phase	• Identification of a feasible location for the gasifier unit • Detail designing of the gasifier unit and its operational requirements
Construction Phase	• Marking of gasifier unit footprint and location of wells • Construction of a gravel access road to the gasifier unit from the main infrastructure corridor • Drilling of well structures to the underlying coal seam by using a specialised drilling machine • Securing all wells by inserting a steel lining from the surface of the well to the coal seam and sealing it with concrete • Secure all surface pipelines and test for leakages • Secure all additional infrastructure including the air compressor and water monitoring boreholes
Operational Phase	• Commission the gasifier by commencing the sub-surface gasification reaction through high pressure air injection • Operate gasifier through a series of pipelines and pressure units • Syngas to be transported via primary, secondary, and tertiary gas pipelines to the Gas

Development Stage	Tasks
	Treatment Plant • Ongoing groundwater monitoring
Decommissioning Phase	• Depleted underlying coal reserves will give effect to the decommissioning of a gasifier unit and the commissioning of another gasifier unit • Decommission the gasifier and gasification process by closing all injection wells • Seal wells with concrete mixture • Remove all surface infrastructure • Rehabilitate and re-vegetate all disturbed areas • Ongoing groundwater monitoring

5.2.1 Gas Treatment and Surface Plant Infrastructure

Once produced, the syngas is brought to surface through the production wells; the gas is diverted to a common manifold which feeds the wet gas transmission pipeline. This 600 mm pipeline is also accompanied by a 50 mm condensate line which returns condensate collected along the pipeline. The wet gas pipeline feeds the gas treatment plant. A simplified gas treatment plant (GTP) is commissioned and is currently operating at the UCG facility. The extent of the GTP is approximately 30 m x 60 m and consists of the following components:

- Heat exchanger – cooling towers
- Liquid separation vessels
- Emergency gas flare stack – approximate height of 9 m
- Auxiliary pumps, motors and other small equipment

The gas treatment plant removes the liquid portion present in the gas and supplies a further dry gas transmission pipeline with dry gas. This dry gas is either piped to the Majuba Power Station for combustion along with coal or it is flared on site if the boiler is unavailable.

5.2.2 Process Water Dam

The condensate recovered from the gas treatment plant and gas pipeline is pumped into a process water dam (12000 m^3 in size). The dam is lined and has monitoring wells in place to provide an early warning system. This dam is within the gasifier unit 1 footprint. UCG condensate from gasifier unit 1 is currently piped to this dam. Once gasifier unit 2 is in operation, the condensate will also be routed to this dam.

At the 70000 Nm^3/hr gas production scale, the expected quantity of condensate produced is 46000 m^3 per annum. The condensate will be treated to a quality suitable to either:

a) Support local irrigation activities
b) Re-inject the water into the coal seam aquifer
c) Purify to Majuba Raw water quality requirements

As a safety precaution, a dam with sufficient capacity will be constructed in order to cater for- and down-time of the water treatment plant. Dependant on the final destination for the wastewater, the treatment of the condensate will have various levels of unit operations. It is envisaged that for the option of supplying the water for irrigation purposes, the plant will consist of solid sludge filtration, followed by the removal of organic compounds with the use of activated carbon. The resulting largely organic free condensate will pass through a micro-filtration unit after which it will be made available for irrigation purposes.

In addition to the above there are a number of other options for the treatment of the condensate, the main trace elements which require removal are the cations, the ammonia/ phenols and the brine. These water treatment systems can be added on to the basic system in order to meet higher levels of water purification.

5.2.3 Raw Water Dam

A raw water dam (approximately 1.2 million litres in size) is also situated in the gasifier unit 1 footprint between the offices and control rooms and the compressor station. The raw water contained in this dam is not being utilised for any gasification-related processes.

5.2.4 Water Tanks

Two potable water tanks (approximately 10000 litres in combined size) are located within the footprint of the gas treatment plant. The water from these tanks is used in the gas treatment plant cooling tower circuit (process cooling water make-up). The water is sourced from the Majuba Power Station.

5.2.5 Other Infrastructure

Additional infrastructure includes all the components associated with UCG operations but not specifically associated with one of the major operating sections of the plant. Due to the existing pilot plant operations, Eskom has partly developed infrastructure that is discussed in the table below:

Table 2 - Existing infrastructure associated with the UCG pilot plant operations

Infrastructure	Description	Expansion or Decommissioning
Internal Access Roads	• Internal gravel access roads that are lined with agglomerated stones or brick. • Used to access existing infrastructure associated with UCG pilot plant.	
Site Offices	There are two existing site office locations at the UCG site. • Site office 1 is an old farmhouse that was refurbished as offices. Additional workshops were constructed at site office 1 for storage of operating machinery and vehicles. • The existing mining offices on the farm Bergvliet 65HS (portion 21) have been also been converted into site offices – indicated as Site Offices 2 in **Error! Reference source not found.**. In the 1990s underground mining activities commenced on the farm Bergvliet 65HS. After a few years, the mine was closed	All site offices and associated workshop facilities will remain in operation during Phase 1A, 1B and 1C.

Infrastructure	Description	Expansion or Decommissioning
	due to the quality of the existing coal seam as well as mining difficulties. Eskom purchased the existing infrastructure including the offices, workshops and Waste Water Treatment Works (WWTW).	
10m³per day Waste Water Treatment Works (WWTW)	The existing WWTW are located adjacent to Site offices 2, indicated in **Error! Reference source not found.**. The WWTW was constructed as part of the mining operations during the 1990s. The WWTW is used for the treatment of sewage from Site offices 2 and associated employee quarters located on the site.	The WWTW will remain in operation during Phases 1A – 1C.
Site Access and Security	Eskom requires strict site and security access at all power generation facilities. The same access and security points are implemented at the UCG pilot plant site.	Site and security access points will be kept in place for the duration of Phases 1A – 1C.
Above ground fuel storage tanks	Existing 51 m³ fuel storage tanks are located at the UCG site. The tanks provide fuel for vehicles and machinery.	The existing fuel tank capacities may be increased depending on the supply needed for the subsequent project phases i.e. Phase 1C and commercial CCGT.

Internal Access Road Network

Internal access roads will be constructed in order to provide access to the development areas, in accordance with Eskom's phased development approach for UCG. A description of the internal road infrastructure is presented in the table below:

Table 3 – Internal Road Infrastructure

Road Type	Characteristics of the Road and Associated Road Reserve
Primary Road	A new service road will be constructed from the Site Offices 2 (farm Bergvliet 65 HS) to the site of the gas treatment plant.
Secondary Roads	One lane gravel road surface lined with agglomerated stone or brick. Roads will be located between the primary access roads and specific infrastructure components such as a gasifier unit. Secondary roads will be decommissioned when required or if the road is no longer in use.
Tertiary Roads	One lane gravel roads for internal access within the footprint of infrastructure components such as internal roads within the gasifier unit and gas treatment plant. Roads will be decommissioned if the associated infrastructure is decommissioned by Eskom, for the specific phase of the development.
Bridges associated with Watercourse Crossings	Any bridge structure will be designed in such a manner to allow for adequate surface water flow and speed without causing additional erosion. All watercourse crossings will be authorised under the Integrated Water Use License for UCG operations.
Fire Breaks	Fire breaks will be constructed around all existing operating infrastructure in order to protect

	the infrastructure against nature grassland fires. The fire breaks will have a width of 50 meters and be clearly marked on all site lay-out maps.

The project layout is provided in the figure below.

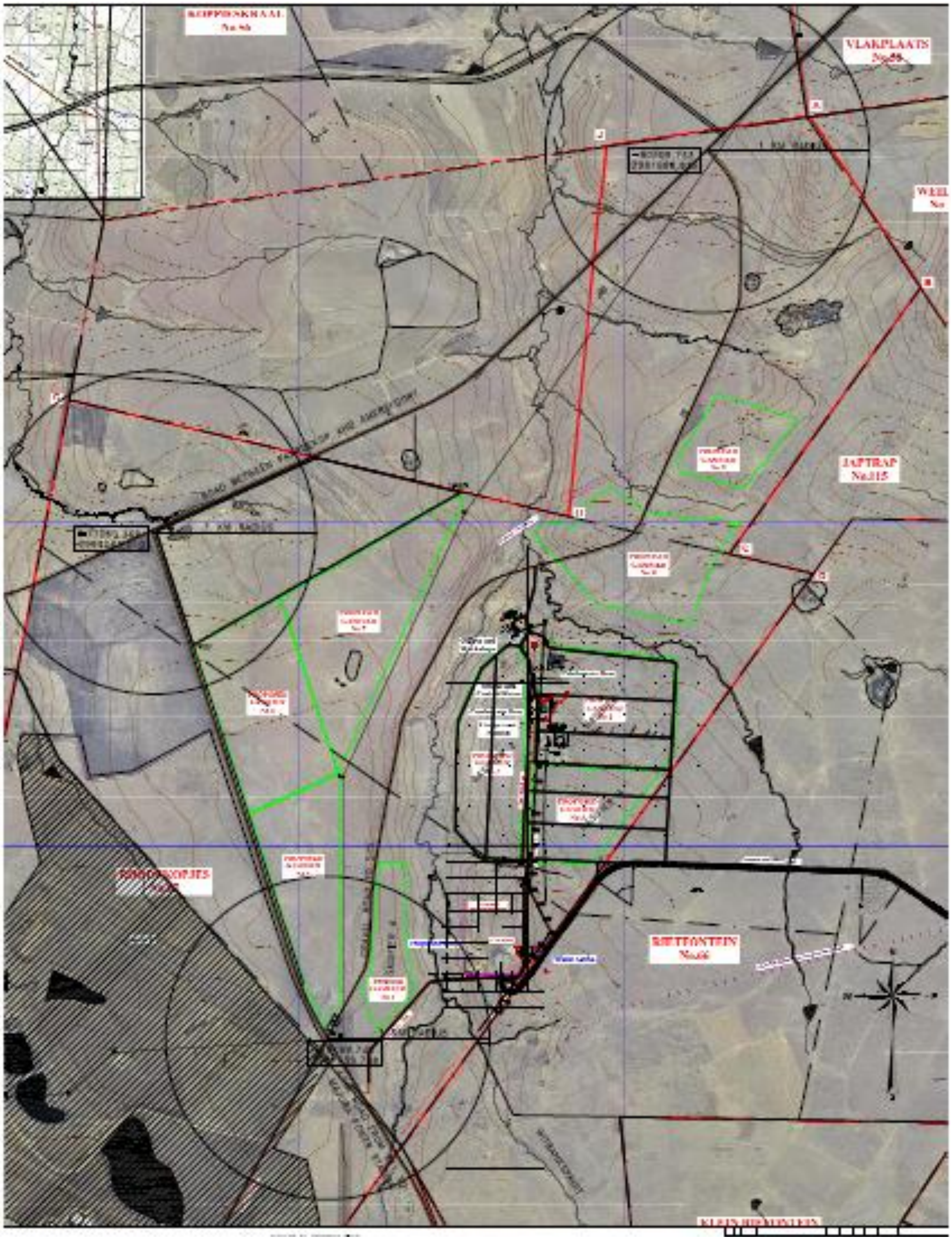


Figure 3 – Proposed UCG Development Layout

6 METHODOLOGY FOR ASSESSMENT

6.1 Wetland Field Assessment and Sampling Methodology

As part of the original study an attempt was made to cover as much of the Study Area's wetland areas as possible. Wetland areas and wetland units were delineated by desktop methodology in the scoping phase of the study. All units were visited in the field, and although a detailed coverage of every wetland unit on foot was not possible, most wetland units were visited at intervals along their length to gain an understanding of their characteristics. Use was made of a GPS to identify important points (e.g. wetland boundaries). These GPS points were converted into a GIS shapefile to allow these points to be mapped and to facilitate the correction of wetland boundaries and the identification of sensitive wetlands in the study area.

As part of the revised delineation methodology, a sampling protocol for all wetlands on the Roodekopjes Site[1] was undertaken in line with the 2013 UCG Site Wetland Delineation Methodology (da Cruz, 2013). Sampling (of either soil and or vegetation) was commenced at the downstream end of each wetland reach (i.e. where the wetland exited the site or joined a larger wetland). Typically the wetland was traversed on foot, and the sampling of sites proceeded upstream. The typical interval between sampling points was 200m, however where significant features were noted (e.g. a narrowing or widening of the wetland, or a definite change in vegetation community), sampling was conducted in the intervening area. The map below indicates the sampling points within the wetlands.

At each sampling point the details of soils and / or vegetation composition were noted in the centre (typically the channel) or in the wettest part of each wetland, where hydric soils and wetland habitat was most likely to occur. The assessment location then moved outwards from the wettest / lowest point in the wetland towards the boundary of the wetland, typically in a cross-sectional transect, to the point at which soils / vegetation indicated that wetland habitat was no longer present. Notes were taken of changes in micro-topography (terrain) and hydrological characteristics of the wetland being assessed.

As a guideline to determine where vertic soils were likely to occur (as based on the occurrence of underlying dolerite geology), the boundaries of the geological strata as they appear on the 1:250 000-scale geological map for the study site were imported into the hand-held GPS used to record sample locations on the site. These boundaries were used as a guideline to determine whether soils and vegetation indicators could be used at the respective sampling sites, however analysis of soils in the field (at each sampling site) was used as the primary methodology to determine the presence of vertic soils, as soil types in the field were found to not completely correspond to underlying geological strata.

[1] Refer to Section 1.2 above (assumptions and limitations) for the extent of the Roodekopjes site on which the revised delineation was undertaken.

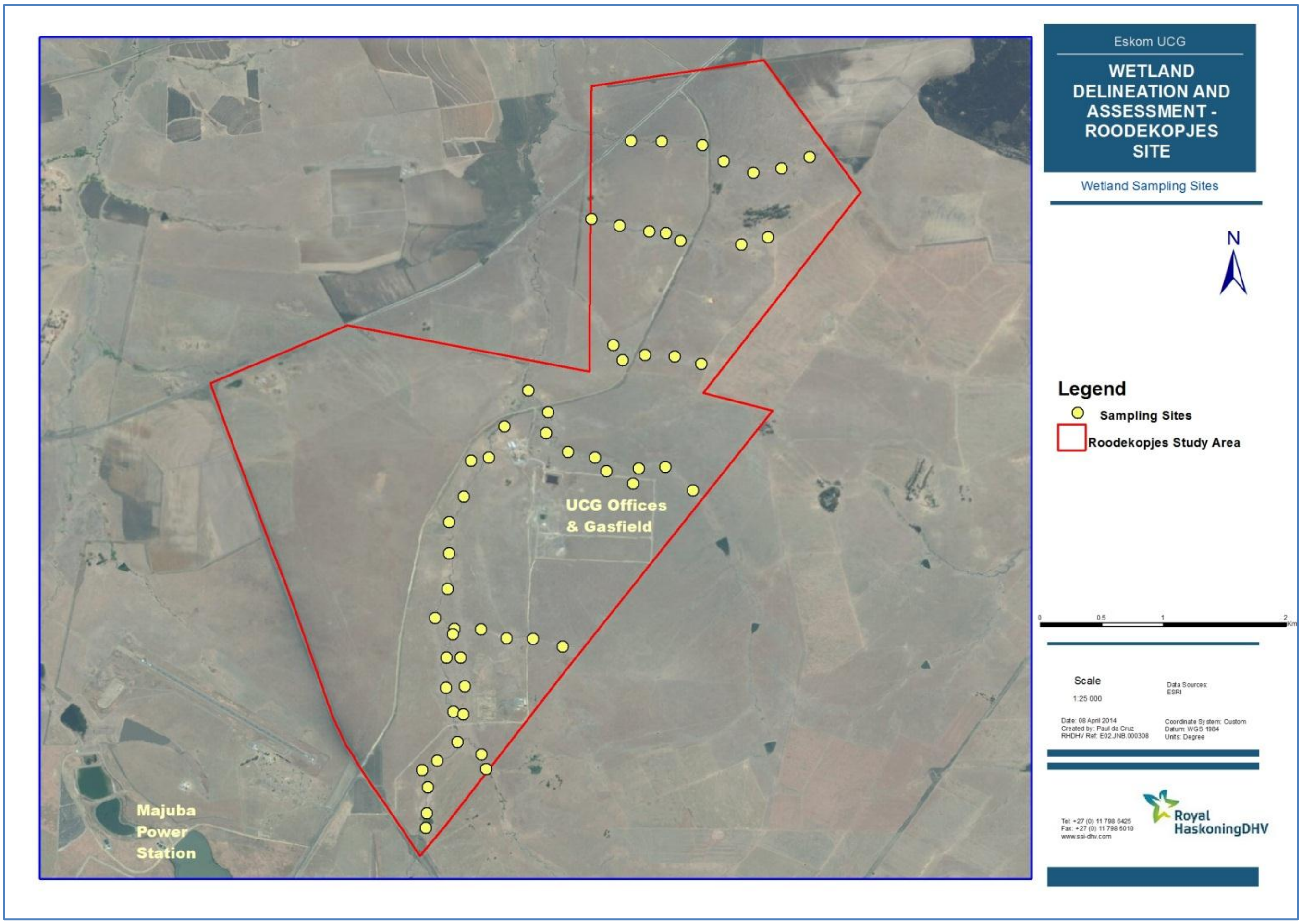


Figure 4 – Wetland Sampling Locations on the Roodekopjes Study Site

6.2 Wetland Delineation Methodology

Please refer to Appendix 1 for the vertic soil-based wetland delineation methodology.

6.3 Identification and Delineation of Wetland Units and Reaches

As part of the original study, once the desktop-based delineation of wetlands was complete, a wetland (GIS) shapefile was created, and divided up into a number of wetland ‘units’. The primary factor used for classifying wetland units was the hydrogeomorphic type of the wetland. Units were also delineated based on physical factors such as the presence of a road crossing the wetland.

As part of the original wetland study (for the purposes of the wetland functional assessment) the study area’s wetlands were divided up into a number of ‘reaches’. A wetland reach typically consisted of a number of wetland units. Due to the very large size of the original study area, it would have been impractical and counter productive to undertake a wetland functional assessment for each wetland unit in the study area, and thus wetlands with a common characteristic were grouped into a reach. Each reach was assigned a number based firstly on the sub-catchment in which it falls (see section 7.1.5 for the Study Area catchment characteristics), and then a number was assigned to that reach; e.g. R_Skulp_1, R_Geel_5..

When the detailed delineation and assessment study for the Roodekopjes Site was commission, an opportunity arose to refine wetland reaches *on the Roodekopjes Site*. Eight (8) reaches were delineated for the Roodekopjes Study Site, with a different naming protocol to the naming protocol applied in the original EIA. The map below shows the revised reaches occurring on the Roodekopjes Study Site.

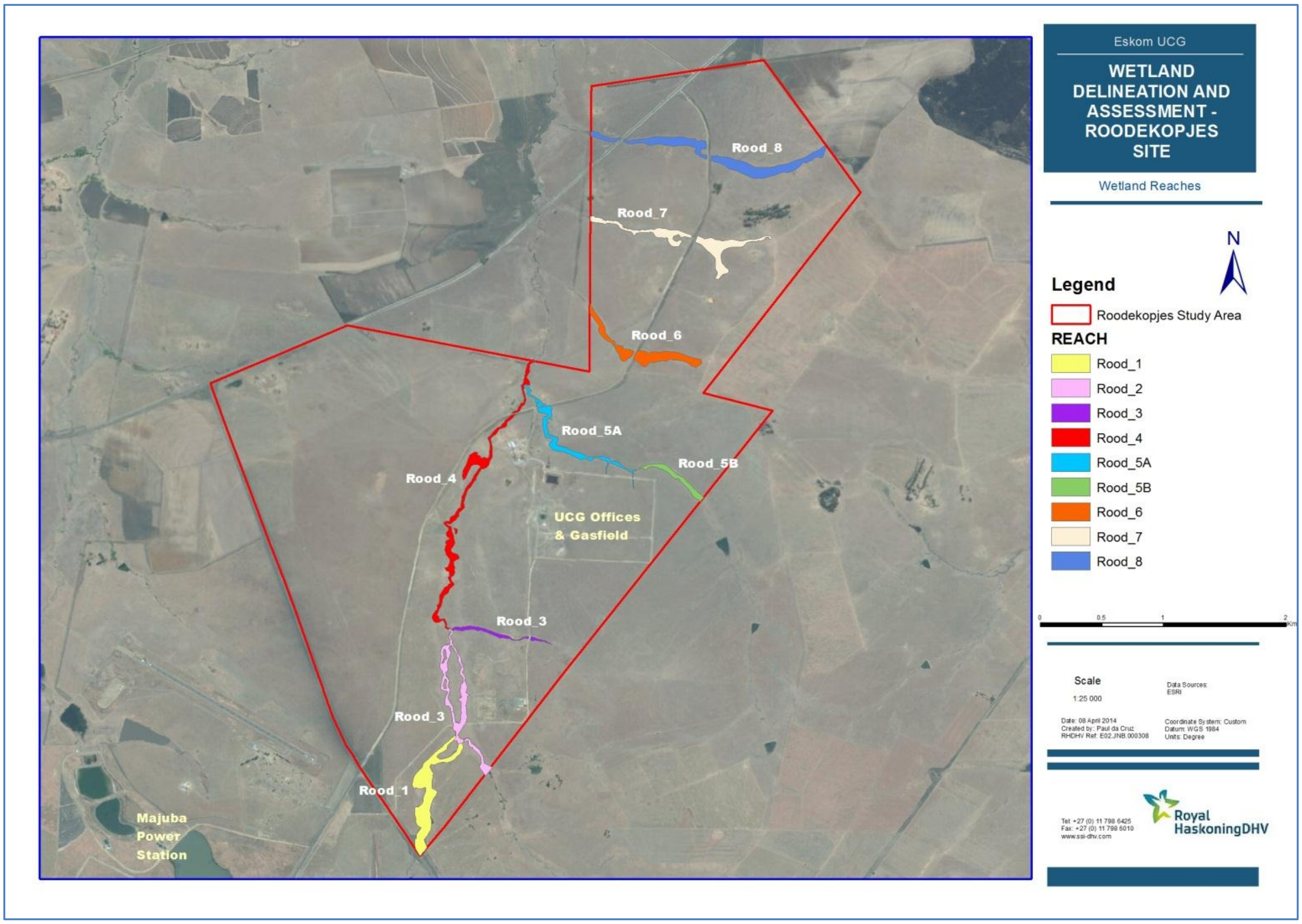


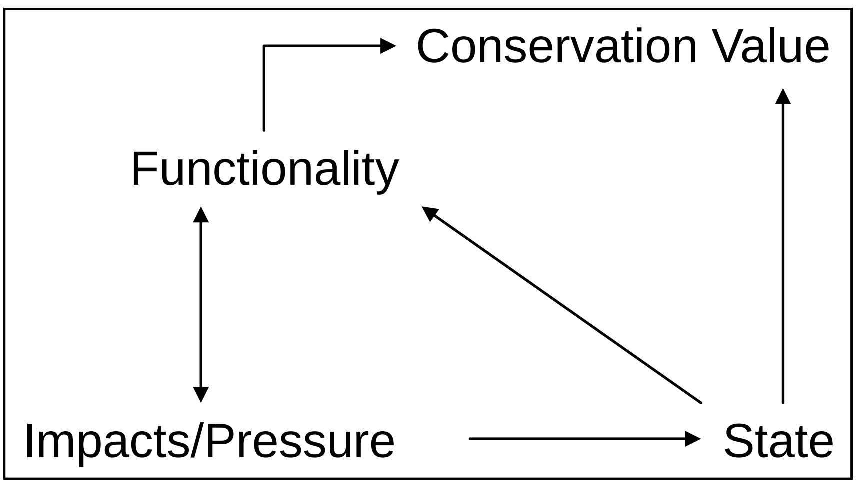
Figure 5 – Revised Wetland Reaches on the Roodekopjes Site

6.4 Wetland Functional and State Assessment

Each wetland reach has been characterised and assessed based on the findings of field assessment and utilising a number of tools as discussed below. In any wider area-based assessment of wetlands, it is very important to assess and characterise wetlands based on three factors:

- Wetland pressures / impacts
- Wetland functionality
- Wetland state

These factors are separate, but closely interlinked as shown in the figure below.



It is very important to understand the links between wetland functionality, pressures and state. As indicated in the figure above wetland state is directly influenced by pressures acting on the wetland. Pressures / impacts may adversely affect the ability of a wetland to perform certain functions, but certain aspects of wetland functionality may be enhanced in that the wetland may be acting to ameliorate the pressure acting upon it. The state and ecological functionality of a wetland can be used to assign level of 'conservation' value or sensitivity to the wetland, and thus to prioritise it. These aspects are discussed in greater detail below.

6.4.1 Wetland Functional Assessment

Wetland functionality was assessed using the WET-EcoServices methodology (Kotze et al, 2005). This methodology has been developed as a tool to identify the different aspects of functionality offered by a wetland. Wetland functionality is multi-faceted and includes a number of different but interlinked aspects such as hydrological functionality, ecological functionality, and socio-cultural functionality. The basis of the methodology is the identification of ecosystem services offered by an individual wetland. Ecosystem services as defined in WET-EcoServices are the direct and indirect benefits that people obtain from ecosystems. These benefits may derive from outputs that can be consumed directly; indirect uses which arise from the functions or attributes occurring within the ecosystem; or possible future direct outputs or indirect uses (Howe et al., 1991). The table below lists the ecosystem services that are assessed through the WET-EcoServices methodology.

Table 4 - Ecosystem services included in WET-EcoServices

<table>
<tr><td rowspan="15">Ecosystem services supplied by wetlands</td><td rowspan="9">Indirect benefits</td><td rowspan="8">Hydro-geochemical benefits</td><td colspan="2">Flood attenuation</td></tr>
<tr><td colspan="2">Streamflow regulation</td></tr>
<tr><td rowspan="5">Water quality enhancement benefits</td><td>Sediment trapping</td></tr>
<tr><td>Phosphate assimilation</td></tr>
<tr><td>Nitrate assimilation</td></tr>
<tr><td>Toxicant assimilation</td></tr>
<tr><td>Erosion control</td></tr>
<tr><td colspan="2">Carbon storage</td></tr>
<tr><td colspan="3">Biodiversity maintenance</td></tr>
<tr><td rowspan="6">Direct benefits</td><td colspan="3">Provision of water for human use</td></tr>
<tr><td colspan="3">Provision of harvestable resources[2]</td></tr>
<tr><td colspan="3">Provision of cultivated foods</td></tr>
<tr><td colspan="3">Cultural significance</td></tr>
<tr><td colspan="3">Tourism and recreation</td></tr>
<tr><td colspan="3">Education and research</td></tr>
</table>

Each wetland reach has been assessed through the WET-EcoServices methodology. It should be noted that following the revision of wetland reaches as part of the detailed delineation study on the Roodekopjes Site, the wetland functionality assessments for these reaches was revised, and this revised functionality assessment for each reach has been reported on in this report. For the affected wetland reaches outside the Roodekopjes Site, the original functionality assessment for the reaches has been retained. In the following sections outlining the findings of the assessment of each wetland reach, the output diagram indicating the ecosystem services offered by the reach as produced by the WET-EcoServices assessment is included. A table outlining the aspects of functionality offered by the wetlands in the reach is included. WET-EcoServices does not provide an overall assessment of wetland functionality, thus professional judgement has been used to assign each reach into one of three classes of functionality. This overall assessment of functionality has been used to inform the wetland prioritisation assessment.

6.4.2 Wetland State Assessment

Health of the wetland equates to wetland state as referred to in this study. As part of the original wetland study the WET-Health methodology (a tool that has been designed by the Water Research Commission to assess the health or integrity of a wetland) was used as the basis on which to determine the state of each reach in the study area, and a high-level assessment of wetland state based on professional judgment was undertaken.. As part of the undertaking of the revised delineation and assessment study for the Roodekopjes Site that resulted in the revision of wetland reaches, the wetland state assessments for these reaches was revised, and this revised state assessment for each reach has been reported on in this report. As all of the reaches on the Roodekopjes Site are channelled valley bottom reaches, the WETLAND-IHI tool has been used in order to determine wetland state of individual reaches. The (WETLAND-IHI tool has been developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The output scores from the WETLAND-IHI model are presented in the standard DWAF A-F ecological categories, and provide a score of the Present Ecological State of the habitat integrity of the wetland system being examined. The figure below indicates the PES (state) categories as assessed using the WETLAND-IHI methodology. For the reaches outside of the Roodekopjes Site, the original high level state assessment has been utilised.

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

Figure 6 – PES Categories assigned by the WETLAND-IHI Tool

6.5 Wetland Prioritisation and assigning of wetland buffers

A number of wetland characteristics were used in the undertaking of the wetland prioritisation (sensitivity) assessment in order to assign buffers to individual wetland reaches. These included level of wetland functionality, wetland state, the presence / absence of important biodiversity features, as well as underlying geology. The primary aim of the prioritisation (sensitivity) exercise was to allow a wetland buffer of differing size to be assigned to individual wetland reaches based on the sensitivity of the reach. The methodology for assigning buffers based on the evaluated sensitivity of the wetland was formulated as part of the original EIA wetland assessment. Following the commissioning of the revised wetland delineation and assessment study for the Roodekopjes site, this methodology was applied to the wetlands assessed, except for one respect where it was altered – relating to wetlands falling into the very high sensitivity class; the original methodology stipulated that the entire catchment of the wetland be included as the buffer, however this has been altered to a buffer of 200m. The buffer classes are indicated below.

Table 5 – Buffer Widths according to Sensitivity Class

Class of Wetland Sensitivity	**Buffer**
Very High	**A 200m buffer** should be included as part of the buffer
High	**A 100m buffer** beyond the boundaries of the wetland
Moderately High	**A 50m buffer** beyond the boundaries of the wetland
Moderate	

6.6 Identification of Surface Water Impacts and Mitigation Measures

All potential impacts that could be caused by the proposed development that would affect wetlands have been identified. Mitigation measures to either ensure that the identified impact does not materialise, or to ameliorate / limit the impact to acceptable levels have been stipulated.

7 FINDINGS OF ASSESSMENT

7.1 Study Area Biophysical Characteristics and how these relate to / affect wetlands

7.1.1 Climate

The greater study area lies to the south of the Mpumalanga province situated predominantly on the Highveld where the Grassland biome covers much of the Mpumalanga province. The climate is highly seasonal in terms of precipitation with rainfall mainly occurring in the summer months. The mean annual precipitation for the area is in the vicinity of around 700mm. This high seasonality of precipitation has implications for the hydrology of the area as discussed below. The area typically experiences mild summer temperatures, whilst winters are generally cold with a very high incidence of frost (Mucina & Rutherford, 2006). The high incidence of frost is also an important driver of vegetation within wetlands, which along with fire is responsible for much winter die-back of vegetation, including wetland vegetation.

7.1.2 Geology

The geology of the Study Area is a significant driver in terms of wetland occurrence as well as form and other physical characteristics in the Study Area, as wetlands occurring in areas of different geology display differing characteristics.

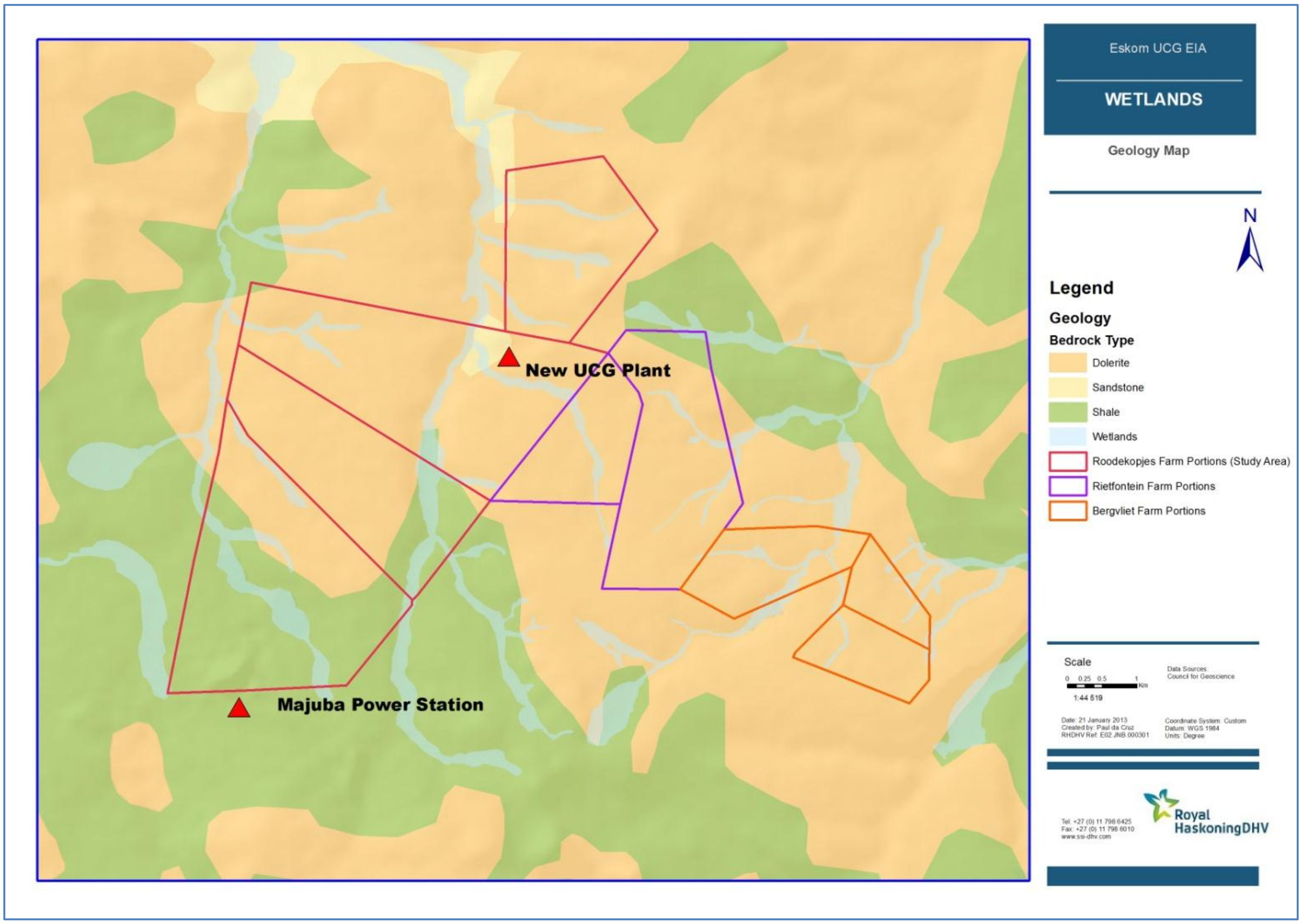


Figure 7 – Geology of the Study Area

The Study Area is primarily underlain by dolerite, an intrusive igneous rock. Dolerite originates from lava that significantly intruded into the sedimentary Karoo Supergroup sediments that cover much of the interior of South Africa (including the south-eastern Highveld in which the Study Area is located) in the Jurassic period. Dolerite intruded extensively into the older sedimentary geology in this area to the degree that it dominates the geological make-up of the area. Smaller parts of the study area are underlain by shale and mudstone of the Volksrust Formation (part of the Ecca Group) and a few very small areas in the northern parts of the study area are underlain by sandstone of the Vryheid Formation (Ecca Group). The shales are found mainly in the southern parts of the wider study area and dominate the geology to the south-west of the Roodekopjes Site. Where dolerite has intruded into the sedimentary geology it often takes the form of sills (where it invaded horizontally between sedimentary beds) and dykes (where it invaded in a vertical plane into the sedimentary geology). A geohydrology report for the Roodekopjes Site (Golder Environmental, 2009) reports that the dolerite at the surface on the Roodekopjes Farm near the first wells and old UCG offices is the upper end of a thick sill that intruded over the sandstone found at a greater depth. Another sill occurs between the uppermost layer of sandstone and the coal seam at greater depth (Golder Environmental, 2009). These doleritic features are often important in the development and creation of wetlands, as described below.

The geological makeup of the area is important as it affects the geomorphological make-up of the landscape. This relates to the relative erodibility of the igneous (dolerite) rock as opposed to the sedimentary rock; dolerite is much more resistant to weathering than the sedimentary sandstones and weathers much more slowly. This has affected the landscape of the area in that the landscapes in the doleritic areas are slightly different from those in the areas of sedimentary geology. Where rivers and streams have to cross dolerite, in particular dolerite sills, the drainage has often cut relatively deep, narrow valleys into the landscape. This phenomenon is present to the west of the development (Roodekopjes) site in the Palmietspruit valley where the river and its tributaries have cut relatively deeply incised valleys into the landscape. Importantly, this has a critical bearing on the geomorphology of the drainage in the wider area and on the Roodekopjes Site (as illustrated in the figures below), as wetlands, where they exist are typically narrow, linear features that extend from valley bottoms up into the upper parts of valley heads. In certain areas underlain by dolerite geology, the valley bottom takes the form of a river channel rather than a wetland, and only rocky substrate and very little or no wetland habitat exists. In the tributaries of many of the larger streams in the area, wetlands in the higher valleys and valley heads are relatively narrow in width, many being less the 50m wide. Wetland vegetation (see the ensuing sections for a description of wetland soils) is typically limited to the centre of the valley bottom into which a (stable) gulley has cut into the deep vertic soils.

This can be contrasted with wetlands on sandstone geology. The landscapes underlain by sandstone geology are typically shallower and less incised than those underlain by dolerite. As a result wetlands are typically wider, less channelised, and are much more likely to be characterised by areas of diffuse flow in which moribund vegetation often occurs. An excellent example can be seen on the farm Rietfontein just to the north-east of the Rietfontein Farm Portions (in the reaches R_Riet_3 and 4 under the old reach delineation). The head of this tributary is underlain by sandstone geology, while the lower reaches (before the tributary joins the valley bottom) traverse dolerite. The wetland areas underlain by sandstone are typically much wider than the dolerite traversing wetlands. They are characterised by a flatter slope which has given rise to a much wider, more diffusely flowing wetland (without a channel) and an extensive wetland seepage area in the valley head. As soon as the wetland traverses underlying dolerite, the wetland changes to become a much narrower wetland with limited patches of wetland soil and vegetation in the valley bottom, as indicated by the map and pictures below.

Figure 8 - Relatively narrow wetland and channel in dolerite geology in the downstream reach R_Riet_3

Figure 9 - View from the centre of the wide valley head wetland in upstream reach R_Riet_4 in sandstone geology; note the flat, un-channelised wetland

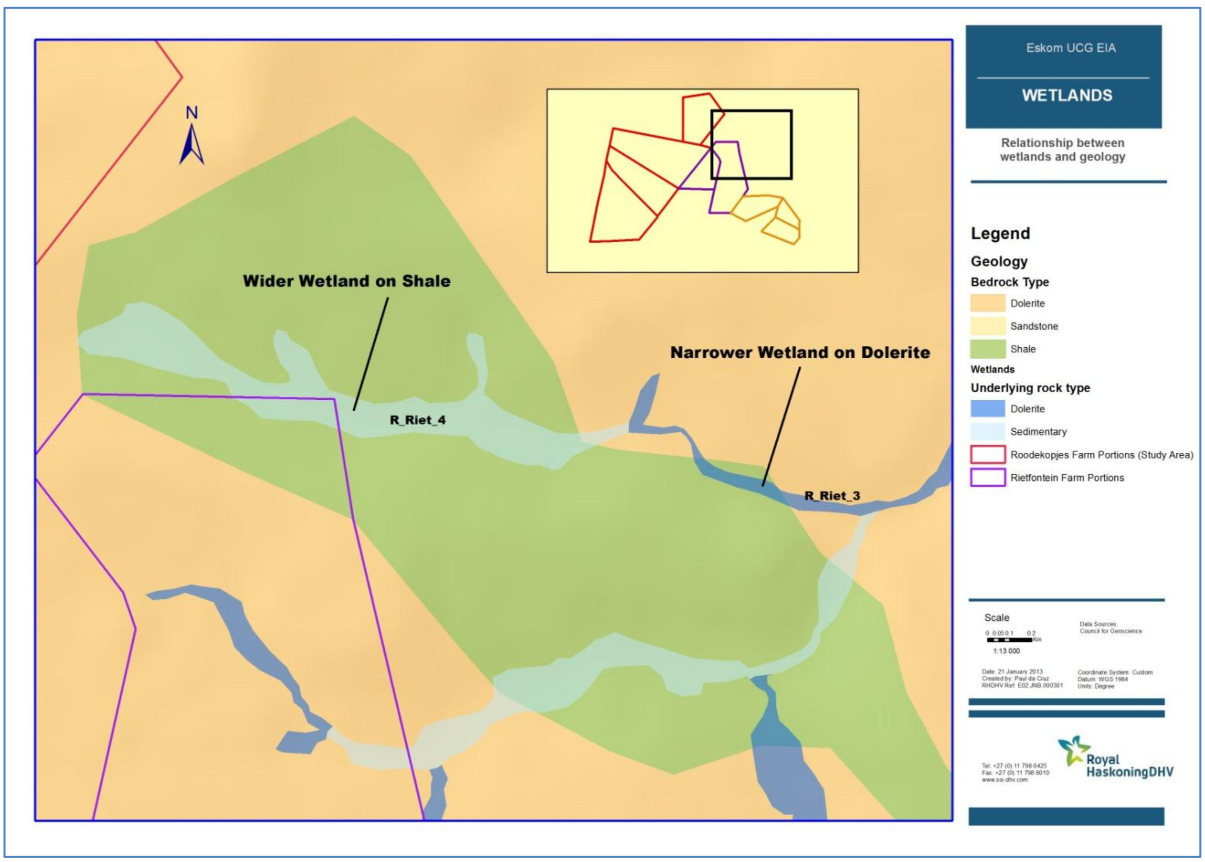


Figure 10 – Map showing the differing extent of wetlands on dolerite vs. shale

It is important to note that all of the floodplain wetland units in the wider area (former study area) occur on sandstone or shale geology. Many of the wider un-channelled valley bottom wetlands also occur in similar geology. These areas of sandstone or shale geology are typically surrounded by areas of dolerite geology and doleritic features such as dykes. The presence of these features is likely to be responsible for the formation of floodplain wetlands. As an example the wide floodplain of the Witbankspruit to the north of the Zonderhout Road to the north of the Roodekopjes Site is bounded to the north by a prominent dolerite ridge (likely a dolerite dyke, or edge of a deep sill). It is thought that the presence of this dyke acts as an effective dam or impoundment, blocking or slowing the flow of water to create a meandering channel. In another example, a low dolerite ridge at the downstream end of Reach R_Riet_6 (outside of the development site to the west of the Bergvliet Farmstead and the N11 highway) which constricts the wetland and tapers it at its downstream end is expected to act in a similar way to slow down water flow in the valley bottom, being responsible for the presence of extensive marshy areas of wetland habitat to the south.

Figure 11 - view to the a low dolerite ridge (dyke) shown by the arrow which tapers the downstream end of the wetland reach R_Riet_6 resulting in extensive marshy areas upstream in the foreground of the picture

Geology has a very important influence of soils, which is described further on. It is also a critical factor in the land use that typically occurs around wetland areas in the Study Area. As areas underlain by dolerite geology are typically characterised by highly vertic clay soils which are not suitable for crop cultivation as well as extensive areas of bedrock outcropping, crop cultivation does not typically occur in these areas. Soils derived from sedimentary geology are more suitable for crop cultivation, hence in these areas the catchments of any of these wetlands have been transformed from natural grasslands to areas of dryland crop cultivation, whereas in areas underlain by dolerite geology the catchments of wetlands are typically natural grasslands. This has an important bearing on the functionality of wetlands in the respective areas, as discussed further on in this report. Geology is very closely interlinked with groundwater which is discussed in the next section.

7.1.3 Groundwater and Wetland Hydrology

A report undertaken by Golder Environmental in April 2009 for the component of the Study Area around the first wells drilled (on the farm Roodekopjes) indicate that there are three distinct aquifers in the Study Area; a shallow aquifer (from surface level to approximately 70bgl), an intermediate aquifer and a much deeper aquifer. The shallow aquifer is of importance in a context of wetlands, as the other two aquifers are too deep to have any hydrological connectivity to the surface. This shallow aquifer is thought to occur across the Roodekopjes Site (Golder Environmental, 2009).

The report indicates that groundwater flow patterns in the shallow aquifer mimic the topography; i.e. groundwater flows were observed to be directed towards the Witbankspruit valley bottom that drains northwards across the Roodekopjes Site (reach Rood_4) and a valley bottom tributary that is located to the north of the UCG gasfield (reach Rood_5). In the part of the Study Area sampled by the Golder Report, this shallow aquifer consists of the uppermost dolerite sill and weathered / fractured Karoo sediments which underlie it. The study found that the piezometric groundwater level follows the topography; i.e. groundwater levels are deepest on interfluves and shallowest in valley bottoms. In the area in which boreholes were sampled the piezometric groundwater levels were observed to be between 17m and 35m below the surface. This mimicry of groundwater flows and levels to terrain entails that groundwater discharge areas would primarily be located in valley bottoms. Importantly in this way the report concurs with the observation in this study (see below) that groundwater discharge into wetlands occurs in the upper parts of valley bottoms and valley heads.

The Golder report also states that interfluves are groundwater recharge areas. The presence of vertic soils that occur across most of the Study Area may be a limiting factor in the recharge of groundwater into the ground. These soils are highly impermeable when wet, and thus preclude the vertical movement of rainwater into the ground, with much rainwater being directed as overland flow into the drainage systems, rather than sub-surface flow, as described in section 7.1.4 below.

The groundwater dynamics as reported for the upper aquifer that occurs across the Study Area are presented in the diagram below (taken from Golder, Environmental, 2009).

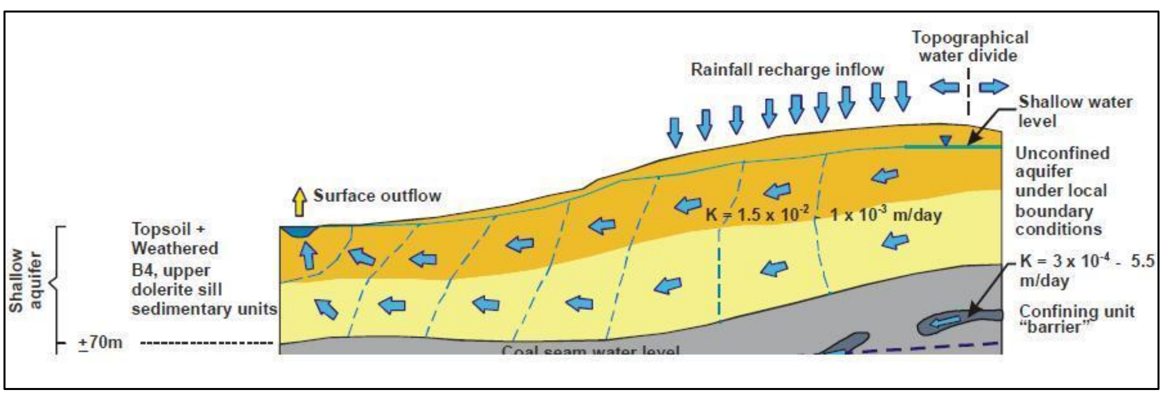


Figure 12 - Conceptual hydrogeological model for the upper aquifer in the Roodekopjes Farm adapted from Golder, 2009

Groundwater discharge is a very significant factor in terms of the surface hydrology of wetlands and rivers in the Study Area. This is borne out by field observations undertaken as part of this study, through which trends of hydrological input to wetlands were able to be identified. In many of the wetlands in the Study Area, especially in the first order wetland tributaries and valley heads, groundwater discharge to the surface of the wetland was observed. This typically occurred in distinct 'seepage areas', often at the head or uppermost part of the wetland. It is not known what factors (other than their presence at low points in the landscape) control the emergence of groundwater discharge. However the localised and patchy distribution of these seepage areas suggests that local geological formations are important in the direction of groundwater flows to the surface. In many of the upper valley head wetlands surveyed as part of the original wetland study in the wider study area seepage areas only existed above a certain contour and appeared to be associated with the outcropping of dolerite. Local doleritic features such as sills, or fractures within the bedrock above which or along which groundwater flows may be responsible for these distinct seepage areas. Such seepage areas were noted to occur in most of the wetland reaches on the Roodekopjes Site. .

Figure 13 - Seepage areas (indicated by patches of darker vegetation) in a valleyhead seep) in the Palmietspruit catchment to west of the revised study area

Figure 14 - Clear groundwater discharge in the valleyhead seep wetland reach R_Pal_10

One of the field surveys of wetlands in the western part of the former study area conducted in August 2010 revealed that flows within the Palmietspruit and Geelklipspruit catchments originated almost exclusively from base flow (i.e. groundwater discharge). It was unlikely to have rained in the Study Area for a number of months at the time of the survey, but both the Geelklipspruit and Palmietspruit rivers were flowing, fed by groundwater discharge that appeared to originate in the various tributary wetlands of these two rivers. This close relationship between groundwater discharge and surface water flows during the dry season is very important in the context of the hydrological and ecological state and functioning of rivers and wetlands in the Study Area. The perennial nature of the rivers in the area is likely to be due to the input of groundwater baseflow into the rivers in the dry season.

The relationship between groundwater and surface water is also very important from a socio-cultural perspective; it was observed that apart from artificial watering points, the groundwater seepage areas described above are the only areas of water availability for livestock away from the main rivers in the Study Area. In a number of areas across the Study Area, these springs and seeps were observed to supply water to human households. In addition these seepage areas are likely to be important to livestock in another way as the first re-growth of vegetation in the late winter early spring that precedes the first rains is likely to occur in this area. These seepage areas are likely to be important to sustaining livestock at a time when green (higher protein) grass is generally absent in the area.

The groundwater flow patterns and dynamics may be disrupted by subsidence that could be caused by the collapse of the coal seam associated with the UCG process (see section 9.1 below). This may constitute a significant impact on the wetlands and hydrology of the area considering the functionality associated with the groundwater discharge into wetlands as described above.

7.1.4 Soils and Land Types – Nature of Vertic Soils

As the majority of the wider area is underlain by dolerite, most of this area is associated with highly vertic soils. In these areas there is homogeneity of soil type along the catena, with the vertic soils being uniformly present from crest to valley bottom, irrespective of location within the landscape or location within or outside of wetland areas. This is unusual, as many parts of the Highveld are characterised by a distinct sequence of soil forms from the valley bottom (in which wetlands are located) to the non-wetland midslopes and up to the crest. The wetland soil forms in the valley bottom are distinct from the other soil forms in the non-wetland areas around, and upslope of them, and this allows the wetland areas to be differentiated from the non-wetland parts of the landscape. This is not the case in many parts of the wider area.

Figure 15 - Cracking on the surface of vertic soils

Vertic soils are characterised by the presence of swelling and shrinking clays. They typically form where there is a distinct wet and dry period that affects the soils. These soils swell when they become saturated, and shrink again when they dry out, leading to characteristic 'cracking' on the surface of the ground. There are two main formation processes for vertic soils: the first is in low lying positions where vertic soils form due to the accumulation of base rich weathering products, and requiring a distinct period of seasonal (winter in this case) drying to form the swelling clays. The second is on varying, but mainly flat, topography due to the weathering of basic igneous parent materials (Johan van der Waals, pers. comm.). The second formation process is thought to be the main reason for the predominance of vertic soils in the Study Area as these vertic soils are found from crest to valley bottom. These vertic soils are typically dark black in colour in the upper parts of the profile (the vertic A horizon), and are often associated with the presence of lime modules.

Figure 16 - An example of a Vertic A Horizon

The Soil Classification Working Group lists two soil forms that are characterised by a vertic A; the Arcadia soil form – a vertic A horizon over unspecified material and the Rensburg soil form which is characterised by a vertic A horizon underlain by a G horizon. The Rensburg Soil Form is listed as a wetland soil form by the DWA wetland delineation guidelines, while the Arcadia form is not. While a detailed mapping of soil forms has not been undertaken by either this study or the agricultural potential study undertaken as part of the wider EIA specialist studies, soil forms were considered during the field surveys undertaken for this study. Both soil forms were found within the wetlands in the wider area. While Rensburg Soil forms (i.e. the presence of a secondary G horizon) were found in certain parts of the Study Area, most wetland soil profiles that were examined did not display a lower G horizon and displayed uniform black vertic soils to a depth of up to 2-3m below ground level.

Figure 17 - An example of a Rensburg soil form on the Rietfontein Farm Property to the south of the proposed service road alignment. Note the depth of the G horizon (>0.5m bgl)

Vertic soils, even those that appear in wetlands, do not typically display redoximorphic features in the form of yellow or red/orange mottles. This is due to their high (alkaline) ph ≥8. Thus the usual soil wetness indicators do not apply to many of the wetlands in the study area. This was true for most wetlands in the Study Area, including the larger valley bottoms in which clear wetland vegetation and habitat was found to exist.

The absence of an upper soil horizon showing signs of wetness (i.e. the absence of redoximorphic features in these soils) coupled with the uniformity of soils from valley bottom to crest make wetland delineation based on soil characteristics alone in these parts of the Study Area highly problematic. Soil wetness and soil form characteristics cannot be used to practically delineate wetland areas as the entire landscape could be either delineated as a wetland, or non-wetland. As a result a separate delineation methodology for wetlands in areas of vertic soil predominance has been developed, as detailed in Appendix 1. .

7.1.5 Drainage and catchments

The development site straddles two quaternary catchments, both of which form part of the Upper Vaal River catchment. The western part of the site is located within catchment C11J, part of which is drained by the Witbankspruit, a stream that forms a tributary of the Upper Vaal River to the north of the site (the Witbankspruit flows northwards across the Roodekopjes property). The area to the east of the Roodekopjes Site falls within the quaternary catchment C11E, that of the Skulpspruit. The Skulpspruit which flows to the east of the site forms a tributary of the Rietspruit, itself a tributary of the Upper Vaal. These two quaternary catchments can be further divided into a number of smaller catchments.

All wetlands and rivers on the site drain into the Upper Vaal River. This factor is relatively important in a catchment management context as the Vaal River is critical in the supply of water to South Africa's most densely populated area and economic hub i.e. Gauteng.

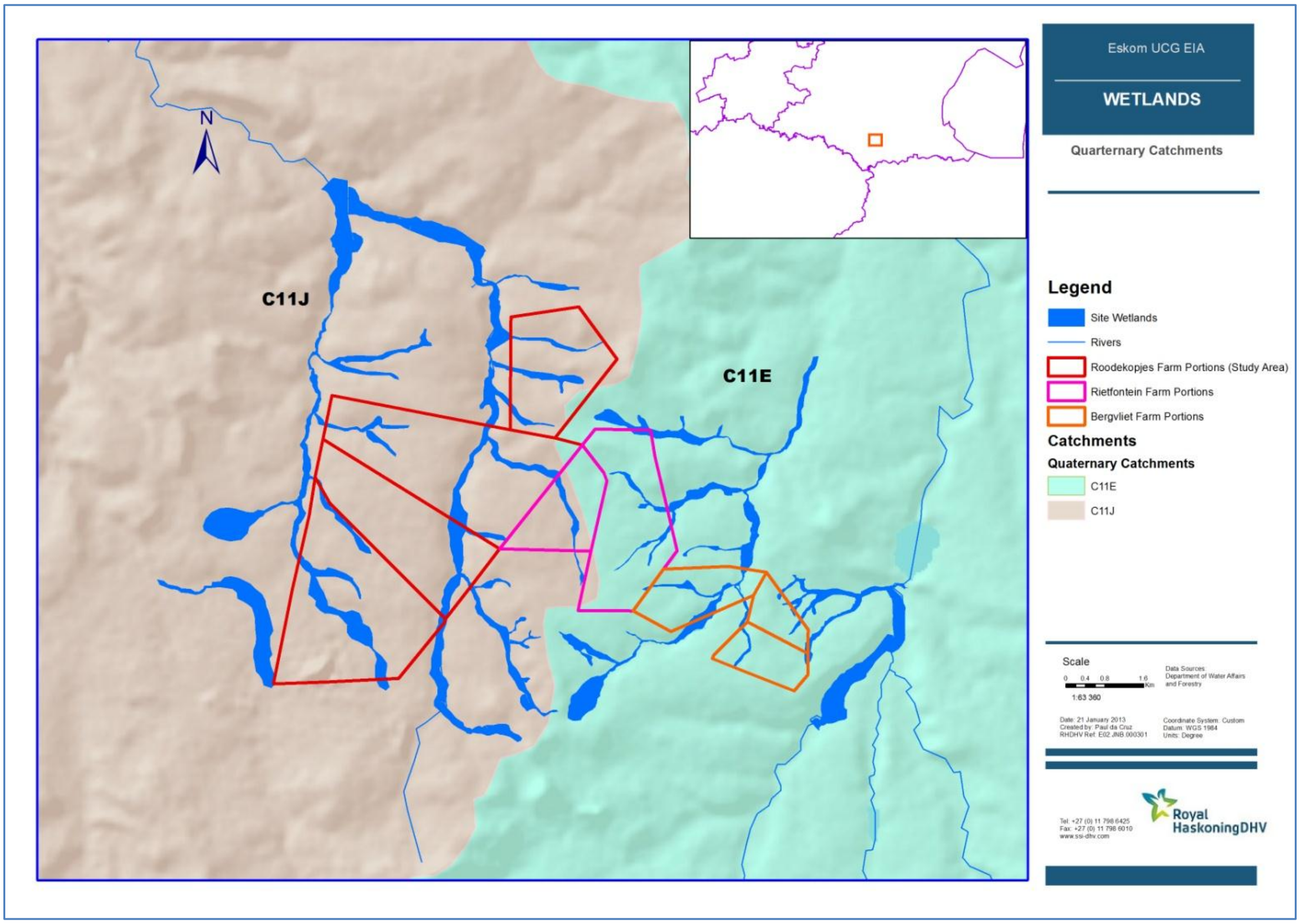


Figure 18 – Quarternary Catchments in the study area

7.2 Study Area Wetland Characteristics

7.2.1 Wetland Hydrogeomorphic Forms

Wetlands can be found all across a landscape. The landscape can be divided up into a number of units (refer to the figure below), each of which can contain wetlands. Wetlands occurring on these different terrain units typically differ in terms of their formative processes and hydrological inputs, and thus differ in terms of their functionality.

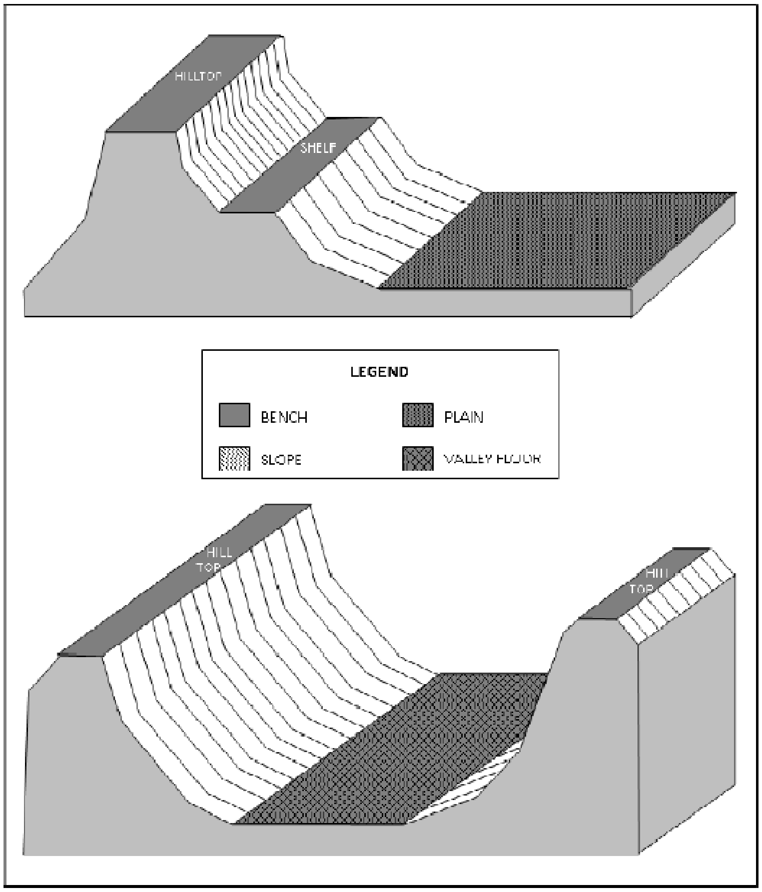


Figure 19 - Different Terrain units on which wetlands can be found (SANBI, 2009)

The wetland hydrogeomorphic (HGM) approach to wetland classification which uses hydrological and geomorphological characteristics to distinguish primary wetland units has been used to classify wetland types in South Africa (Kotze et al, 2005; SANBI, 2009). This approach has been used, and the classification system was updated a few years ago as part of the National Wetland Classification System for South Africa (SANBI, 2009). Under this classification system there are a number of different types of terrestrial (as opposed to marine) wetlands, most of which occur across the wider area:

- Channel
- Channelled Valley-Bottom Wetland
- Un-channelled Valley-Bottom Wetland
- Floodplain Wetland
- Hillslope Seep
- Valleyhead Seep

A number of different wetland hydrogeomorphological forms occur on the Roodekopjes Site, with the most commonly occurring type of wetland being the channelled valley bottom form. Certain valley bottom wetlands were noted to be un-channelled, particularly in the upper parts of a number of valley bottom tributaries of the Witbankspruit in slightly less incised terrain than the lower parts of the valley. The heads of the valley bottom tributaries on the site can be classified as valleyhead seep wetlands, but have been included as part of the valley bottoms.

A number of hillslope seepage compartments were noted in association with certain of the valley bottom wetlands on the site, typically occurring on the margins of these wetlands at the point where the terrain transition from the valley bottom to the footslope occurs. These were typified by a different hydrological regime (groundwater seepage-fed) to the adjacent valley bottoms (fed by flows within the channel and surface flows from the surrounding catchment). This revised assessment has concluded that no true floodplain wetlands occur on the site, although floodplain-like features do occur along a certain reach of the Witbankspruit to the north of the gas pipeline crossing of the stream.

As described in section 7.1.2 above the original wetland report for the previous (larger) UCG site, underlying geology has an important controlling influence on the extent of wetland occurrence on the site, and this was confirmed on the Roodekopjes site; over most of the site where dolerite bedrock occurs, valley bottom and valleyhead seepage wetlands are narrow features, often limited to a narrow macro channel and the immediate surrounds, due to the more incised nature of topography, and due to the outcropping of bedrock. In the southern part of the site where shale is the underlying geology, the terrain becomes less incised and the Witbankspruit (the primary watercourse / wetland on the study site) and a tributary drain a wider and less incised valley, forming a wider valley bottom. This has allowed the development of a more meandering channel as compared to the downstream reaches of the river that traverse doleritic geology, as well as the development of floodplain-like features in the valley bottom. Typically wetlands in areas of shale geology are wider and more characterised by depositional processes, more so than for wetlands in areas of doleritic geology.

7.2.2 Wetland Hydromorphology (Hydrology and Geomorphological Processes)

Wetlands are typically dynamic features of the natural environment, especially as they are associated with the movement of water which is a very important formative factor in a macro- or micro-landscape context. The geomorphology and more specifically, the hydromorphology (i.e. geomorphology as it relates to hydrological processes) of wetlands is thus a critical aspect of the physical characteristics of wetlands.

As described by the different hydrogeomorphic forms, different wetlands have different hydrological regimes. A key distinction can be made in terms of the surface hydrology of wetlands in the area; i.e. whether these are channelled or un-channelled. The majority of wetlands in the wider area contain some sort of channelled flow, sometimes in conjunction with diffuse flow. A large proportion of wetlands in the area are either valleyhead seep or valley bottom wetlands in which the bulk of the ‘wetland habitat’ (i.e. distinct wetland plant species and saturated area) occurs within the confines of, or immediately adjacent to a relatively narrow macro channel. This is most common in doleritic areas of homogenous vertic soils across the catena. Flow within these wetlands is strongly channelled, or if diffuse, across a very narrow width of between approximately 20m and 40m. Most of these types of wetlands appeared to be morphologically stable, i.e. they were relatively well vegetated and did not display excessive erosion in their bed or banks. Many of these wetlands displayed a relatively low ‘scarp’ erosion face at the top of the macro channel bank.

Figure 20 - Typical narrow valley bottom wetland on the farm Rietfontein near the old mine

Sub-surface flow is more complex, as this involves groundwater discharge. The vertic soils that predominate in the wider area become relatively impermeable on becoming saturated. This means that subsurface water is unlikely to move through the soils either vertically or on a horizontal plane (downslope), and the component of shallow subsurface flow that it is an important component of the hydrological cycle in other parts of the Highveld is likely to be less important in this area (Johan van der Waals, personal communication). This would mean that water inputs to wetlands from upstream or the surrounding catchment during the wetter summer months would take the form of surface flows. Field assessments during, and immediately after a period of precipitation (on December 3, 2010 – rain had fallen in the area intermittently for roughly a 24-hour period) seemingly indicated this phenomenon. A significant degree of surface water runoff was noted, not only in wetland areas, but in the surrounding grassland. This has implications for the hydrology of wetlands, as the hydrograph is likely to show a distinct increase in flows during and immediately after periods of rainfall, with a concomitant fall once the rainfall event has stopped. This surface sheet wash / runoff is likely to enter many of the channelled wetlands and be transported down the system. Only in wetlands where significant areas of wide, un-channelled wetland habitat (especially those areas containing moribund vegetation), and in those wetlands which have significant depressions would this flow be attenuated for longer periods.

Figure 21 - Overland flow in the catchment of a wetland immediately after a prolonged period of rainfall

This hydrological characteristic of the Study Area is likely to be partly responsible for the widespread evidence of significant flood / spate flows along the bigger drainage systems in the wider area. Wrack has been observed in many of these valley bottom / floodplain systems either well away from the channel into which low flows are confined, or at a significant height above the normal water level. As an example, at a point on the Palmietspruit to the west of the Roodekopjes Site and south of the Perdekop Road, wrack deposited by flooding was observed at least 3-4m above the low flow water level. In this an area much wider than the immediate channel would have been inundated. It is not known whether the flood events which deposited this wrack represent significant flood events, or are a relatively common phenomenon. However it appears that significant responses of fluvial systems in the area to prolonged precipitation are marked.

Figure 22 - Flood wrack in a willow tree along the Palmietspruit south of the Perdekop Road in the original study area

In these periods of flood flows, the wetland areas surrounding the primary channel will be inundated. Any depressions that occur alongside the channels will thus be filled. Surveys conducted in the drier winter months (June and August 2010) indicated that certain of these depressions, where they occurred, were filled with water. These depressions are likely to be important in a context of providing water for livestock and water-dependent biota in the drier wetland months.

Figure 23 - Water-filled depression in the Witbankspruit valley bottom

The origin of certain of these depression features alongside channels is not known. However it is highly likely that livestock (primarily cattle) playing an important part in their maintenance as depressions and even their enlargement. As these areas are often the only source of water away from the river channel (which itself can be difficult to access) cattle tend to drink from these depressions very readily. The clayey mud within the depression becomes highly trampled with the associated destruction of wetland vegetation, keeping these areas bare. As they dry out, the exposed soils become desiccated, and prone to erosion. This process keeps the depressions un-vegetated and may even contribute to their enlargement if the exposed soils are washed away.

Erosion is a significant factor in the morphological characteristics of wetlands in the Study Area. Erosion is an important factor that it can have a significant effect on wetlands, altering their state / integrity and affecting their functionality. Erosion is a natural process that is inherent to most fluvial systems, and the erroneous assessment that erosion is a negative or unnatural phenomenon can be made. The presence of erosion in a wetland is not necessarily a negative factor, in particular in the context of naturally channelled wetland HGM forms as erosion is an inherent part of natural channel development. The key factor in terms of the assessment of erosion is whether it is artificial, or unnaturally accelerated. In this context, the presence of erosion that alters to the hydrology and biological (especially vegetative) composition of a wetland, thus adversely affecting the integrity of the wetland, should be seen as negative. This is particularly valid if the cause of the erosion is human-induced (anthropogenic).

Erosion has been observed in one form or another in most of the wetlands in the wider area. The most commonly encountered form of erosion is the headcut, with an associated gulley (donga) downstream of it. Headcuts were observed in many wetlands, in particular valleyhead seeps where a soil profile exists (the presence of bedrock outcropping tends to preclude erosion). It is not certain whether these headcuts are natural features, or symptoms of accelerated erosion within the wetland; evidence that suggests that both factors may be valid is present in the area. In many wetlands, headcuts occurred within wetlands where a distinct change in the slope / profile of the wetland was evident, in which the downstream wetland area was much steeper. In these cases, headcuts may be a natural morphological feature. On the other hand there is much evidence to suggest that the presence of cattle, in particular the over-stocking of farms / camps greatly contributes to accelerated headcut erosion. In many wetlands, the area just above (upstream) of the headcut was noted to be highly trampled as cattle use this area to drink water where it 'daylights'. As described above this trampling destroys the vegetation which would normally retard the backward progression of the headcut by binding the soil, resulting in wet, exposed soil which is easily eroded.

In the wider area there are many examples of headcuts that are eating back into parts of wetlands that have diffuse flow and thus healthy, moribund wetland vegetation. These headcuts have altered the state of the downstream portion by lowering the water table and channelising the flow, thus ultimately causing a change in vegetation composition (often associated with the replacement of wetland hydrophytes with terrestrial / non-wetland species). Left unchecked, these headcuts will result in the loss of the wetland habitat upstream and adversely affect the hydrological and ecological functioning of the wetland reach.

Figure 24 - Example of a headcut eating up into an area of diffuse flow in a wetland on the Rietfontein farm east of the Roodekopjes Property. Note the impact of the cattle trampling in the foreground

There is also evidence that cattle are contributing to the retreat back of channel banks. In many areas cattle trampling was evident on banks down which they move to cross or access channels. This leaves the channels exposed and mobilises the sediment, allowing it to be washed down the channel as silt. There is thus much evidence to suggest that cattle are contributing to the channelisation of wetlands.

Figure 25 - Evidence of sediment mobilisation and bank erosion caused by through cattle movement

7.3 Results of Wetland Delineation on the Roodekopjes Site

7.3.1 Result of analysis of soil-based indicators

Due to the predominance of vertic soils over most of the site, with the exception of the southern-most area and a small area to the north of the UCG site offices, analysis of soil was limited to the parts of the site where non-vertic soils were encountered.

In areas of sandstone geology that occur in a small area of the northern part of the site (to the north of the UCG site offices), iron mottling was typically encountered in the upper soil horizons, extending down into (and becoming increasingly common in) the lower horizons. Melanic soils were recorded, forming as the topsoil horizon in parts of this area of sandstone geology along both the Witbankspruit (Rood_4) and in the lowest reaches of the valley bottom tributary (Rood_5). Moving outwards away from the channel of the tributary of the Witbankspruit (Rood_5), soils were noted to be less clayey, with much less iron mottling, and mottling only present at the top of the profile. In other areas sampled, the presence of a G horizon in the top 50cm of the soil profile was the primary indicator of hydromorphy which identified the presence of hydric soils. G horizons were encountered in places along the Witbankspruit, and in certain sample locations within a hillslope seepage wetland area adjacent to the main Witbankspruit channel to the south-west of the UCG site offices. Where no G horizon was present, mottling was nonetheless present at greater depths within gleyed (grey) soils to indicate redoximorphic conditions.

It is important to note that in these areas vegetative indicators (as explored below) strongly indicated the presence of hydric conditions, with extensive stands of obligate hydrophytes such as *Leersia hexandra,* and the presence of obligate wetland sedge species such as *Juncus exsertus*.

It is important to note that in these areas the G horizon and other shallower soil profiles where no G horizon was encountered occurred above sandstone bedrock. Sandstone bedrock in these areas (especially in the context of the hillslope seepage area to the south-west of the UCG site offices) is possibly an effective aquiclude that prevents the downward movement of water through the profile and allows overlying soil horizons to become saturated. In this seepage area soils of differing depths above the underlying sandstone were encountered – from sandstone outcropping at the surface (creating a 'break' of the slope on the midslopes above the valley bottom) to a depth greater than 50cm below ground level.

Figure 26 – Iron mottling within gleyed soils

Figure 27 – Soils from a G horizon in the hillslope seepage wetland adjacent to the Witbankspruit

In areas where vegetation composition was noted to change (i.e. where obligate wetland species stopped being dominant), soil characteristics generally changed too, in terms of the disappearance or much lesser predominance of redoximorphic features. Topsoil horizons were noted to be browner and less organic in character, with the absence of both iron mottling and a gleyed matrix in lower horizons, or with mottling noted at depths too great to be indicative of true hydric soils.

Down-cutting of the channel in the Witbankspruit channel allowed the soil profiles along the stream to be examined. To the south of the UCG site offices, vertic soils predominate in spite of the presence of underlying shale extending northwards past where the tributary Rood_3 joins the stream. Along much of the channel the upper vertic soils are underlain by a G horizon at significant depth (c1.5-2m below the level of the macro channel bank). In these settings (as explored below), hydrophytes were typically restricted to the lower levels of the channel where the degree of hydrological activation was at its greatest, while a much lesser density of hydrophytes was encountered at the top of the macro channel bank.

Figure 28 – Soils from a G horizon within the channel of the Witbankspruit

In the core area of shale occurrence (to the immediate north of, and south of the gas pipeline bridge crossing of the Witbankspruit), the most commonly-occurring underlying horizon at the low flow level was noted to be a soft plinthic B horizon.

Figure 29 – Soft plinthic B soils to the north of the gas pipeline crossing of the Witbankspruit

The channel of the Witbankspruit in the reach Rood_1 was noted to be shallower and less incised than the downstream reaches, reflecting the presence of underlying shale geology. Here the channel was typically 1-1.5m deep, with shale bedrock exposed at the low-flow level. Vertic soils were underlain by a G horizon which was situated directly above the shale bedrock layer.

Away from the channel, soils were sampled in a seepage area to the south-west of the gas pipeline crossing, where extensive sedges and other hydrophytes occurred just before the start of the footslopes. The soils sampled were noted to be characterised by a brown Orthic A upper horizon, underlain in one sample location by a G horizon at c45cm bgl, and by an underlying horizon characterised by a more gleyed lower horizon with increased iron mottling that overlay what appeared to be hard plinthic material or bedrock.

Figure 30 – Soil Profiles along the Witbankspruit in an area of shale geology – note the (gleyed) G horizon overlying the shale bedrock

7.3.2 Result of Vegetation Indicators

The Study Area lies in the south-eastern part of the Mpumalanga Highveld where the grassland biome is predominant. Grassveld vegetation thus characterises the entire Study Area. Most of the Study area falls within the Amersfoort Highveld Clay Grassland vegetation type, with a part of the Western Study Area falling into the Soweto Highveld Grassland Vegetation type (Mucina & Rutherford, 2006). The landscape of the predominant vegetation type is typically characterised by undulating plains covered with short closed grassland, largely dominated by *Themeda triandra* (Mucina & Rutherford, 2006). Only in small parts of the Study Area, such as along rocky dolerite ridges, do very small and isolated patches of shrubs occur. No naturally-occurring trees occur in the Study Area, probably due to the presence of fire as a driver of vegetation, entailing that grassland is the climax vegetation, and due to the presence of vertic in which trees would not easily be able to grow. Only in areas around historical farmsteads where exotic trees were planted, do significant groves of trees occur.

7.3.2.1 Species occurrence

Due to the predominance of vertic soil occurrence across most of the site (even in certain parts of the site underlain by sandstone or shale geology), vegetation indicators were the primary indicator utilised to delineate wetlands on the site. Grass and sedge species encountered at each sample location were carefully identified, and notes were taken regarding the dominant species. This was done in order to determine whether hydrophytes or non-wetland species were the dominant species at each sample location, and thus to conclude whether the area was a wetland or not. Table 2 below indicates the most commonly recorded grass and sedge species recorded on the site, their facultative / obligate status according to Kotze and Marneweck (1999), and the site-specific status (if altered from that of Kotze and Marneweck).

In the context of hydrophilic status, obligate wetland (ow) species almost always grow in wetlands (>99% of occurrences) and facultative wetland (fw) species usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas.

Table 6 – Wetland Hydrophytes and other common non-wetland grass species recorded in wetlands on the Roodekopjes Site

Species	**Wetland Status (Kotze and Marneweck, 1999)**	**Site Status**
Agrostis lachnantha	Obligate Hydrophyte	Obligate Hydrophyte
Andropogon appendiculatus	Facultative Hydrophyte	Facultative Hydrophyte
Andropogon eucomis	Facultative Hydrophyte	Facultative Hydrophyte
Aristida bipartita	Non Wetland Species	Non-wetland species
Arundinella nepalensis	Facultative Hydrophyte	Obligate Hydrophyte
Eragrostis spp.	?	Facultative Hydrophyte
Eragrostis plana	Facultative Non-Wetland Species[2]	Facultative Non-Wetland Species
Helictotrichon turgidulum	Facultative Hydrophyte	Facultative Hydrophyte
Hemarthria altissima	Facultative Hydrophyte	Facultative Hydrophyte
Imperata cylindrica	Facultative Non-Wetland species[3]	Facultative Hydrophyte
Leersia hexandra	Obligate Hydrophyte	Obligate Hydrophyte
Panicum repens	Obligate Hydrophyte	Obligate Hydrophyte
Paspalum dilatatum	Facultative Hydrophyte	Facultative Hydrophyte
Paspalum distichum	Obligate Hydrophyte	Obligate Hydrophyte
Pennisetum sphacelatum	Obligate Hydrophyte	Facultative Hydrophyte
Pennisetum thunbergii	Obligate Hydrophyte	Facultative Hydrophyte
Phragmites australis	Obligate Hydrophyte	Obligate Hydrophyte
Setaria sphacelata var. Torta	Facultative Hydrophyte	Facultative Hydrophyte
Themeda triandra	Non Wetland Species	Non-wetland species

[2] This species is listed as being a facultative non-wetland species in a wet climate, as is the case in the study area
[3] This species is listed as being an facultative non-wetland species in a wet climate, as is the case in the study area

Species	**Wetland Status (Kotze and Marneweck, 1999)**	**Site Status**
Carex glomerabilis	Obligate Hydrophyte	Obligate Hydrophyte
Cyperus denudatus	Obligate Hydrophyte	Obligate Hydrophyte
Cyperus difformis	Obligate Hydrophyte	Obligate Hydrophyte
Cyperus longus	Facultative Hydrophyte (?)	Facultative Hydrophyte (?)
Fuirena pubescens	Obligate Hydrophyte	Obligate Hydrophyte
Kyllinga erecta	Facultative Hydrophyte	Facultative Hydrophyte
Mariscus / Cyperus congestus	Facultative Hydrophyte	Facultative Hydrophyte
Pycreus nitidus	Obligate Hydrophyte	Obligate Hydrophyte
Schoenoplectus brachyceras	Obligate Hydrophyte	Obligate Hydrophyte
Schoenoplectus decipiens	Obligate Hydrophyte	Obligate Hydrophyte
Scirpoides burkei	Facultative Hydrophyte	Facultative Hydrophyte
Juncus exsertus/oxycarpus	Obligate Hydrophyte	Obligate Hydrophyte
Typha capensis	Obligate Hydrophyte	Obligate Hydrophyte

Almost universally across the site in all geological and wetland hydrogeomorphic form settings, the grass species *Leersia hexandra* was encountered within the wettest parts of wetlands, often forming dense, dominant stands. This species is an exclusively wetland grass species and is considered in the context of the local area to be indicative of permanently, or at the very least seasonally-inundated conditions. The dominant presence of the species is notable in the context of the dominant occurrence of vertic soils on the site – in spite of the drying of these soils, they appear to retain sufficient moisture content to support large colonies of this species. The species typically forms dense stands over a large area in which it is the predominant species; it is highly grazed by livestock and thus over parts of the site that are grazed it was not noted to reach a mature form; however where cattle were absent (e.g. in the camp in which hillslope seepage wetland to the south-west of the UCG site offices is located), it formed dense tall stands. It occurred commonly along all of the channelled wetlands in the study area; in the context of the Witbankspruit and its channelled valley bottom tributaries on the site that were clearly channelled, *Leersia hexandra* was confined to the bed of the channel, often occurring in small bands along the margin of the channel. In valley bottom settings which were less clearly incised / channelled, the species tended to occur in stands in the wetter low points, and particularly on the margins of water-filled longitudinal depressions in these settings (e.g. on the floodplain-like components of the Witbankspruit valley bottom (Rood_2) to the north of the gas pipeline crossing point). Due to the exclusive location of this species in only the wettest parts of wetlands on the site and this species' dependence on seasonal inundation at least, the presence of this species is considered very strongly indicative of wetland soils and habitat in a context of vertic soils.

Another very common species encountered in all wetlands on the site is *Paspalum dilatatum*. This species is not native to South Africa, but has extensively colonised wetlands. Kotze and Marneweck (1999) list this species as an obligate hydrophyte, however experience in the context of the site indicates that although the species is typically encountered in the wettest parts of wetlands, it does also occur on the margins of wetlands, as well as in disturbed locations such as alongside roads, and in dense stands in artificially wet locations, e.g. at stormwater outlets in locations far away from wetlands. For this reason this species has been classified as a facultative hydrophyte and was recorded as the dominant or co-dominant species in both the wettest parts of wetlands (e.g. channels), as well as in the less inundated parts of wetlands away from the low points, or e.g. on channel banks.

Figure 31 – Dense stand of the obligate hydrophyte *Leersia hexandra* in the hillslope seepage wetland to the south-west of the UCG site offices in reach Rood_4

The most commonly-occurring sedge species that was noted to occur universally across wetlands on the site was *Mariscus (Cyperus) congestus*. This is listed as a facultative wetland species by Kotze and Marnewecke (1999), a status which corresponded to its occurrence on the site, being primarily located in wetlands, but also occurring on the margins of wetlands and even in non-wetland habitat where suitable moist conditions (e.g. at stormwater discharge areas) were present.

No other sedge species were as widely distributed across the site, although *Fuirena pubsecens* and *Schoenoplectus decipiens* were encountered in many of the wetlands, and proved to be reliable indicators of wetland habitat. Two *Cyperus* species were typically encountered on the edge of water - standing (in the case of longitudinal depressions) or flowing (in the case of the Witbankspruit and certain tributary wetlands) – *Cyperus denudatus,* and *Cyperus longus,* the latter of which was most commonly encountered along the Witbankspruit. *Schoenoplectus brachyceras* was typically encountered on the margins, or within longitudinal depressions, appearing to be highly associated with standing water.

Two of the Pennisetum species are listed as being obligate hydrophytes – *Pennisetum thunbergii* and *P. sphacelatum.* Both species (especially the latter) occur commonly across most of the site, with *P. thunbergii* forming dense stands or clumps, typically on the banks of channels in wetlands within doleritic / vertic soil settings, also occurring away from the wettest parts of the wetland onto the surrounding footslopes. *P. sphacelatum* was encountered on the margins of wetlands; in channelled wetland settings this species was typically encountered on top of the macro-channel bank, extending some way outwards away from the wetland channel, occurring alongside other non-hydrophytes as detailed below. In less channelised settings, it occurred commonly within the wetter parts of wetlands alongside other typical hydrophytes, but also extended laterally away from the centre of the wetland into areas that would not typically be classified as wetlands in terms of their terrain setting and degree of hydrological activation. For this reason both species have been altered to be facultative wetland species.

Figure 32 – Extensive stands of Pennisetum sphacelatum in the reach Rood_7 to the west of the UCG access road

A certain *Eragrostis* species was noted to commonly occur on the margins of many of the wetlands on the site, and in particular in the drier parts of the un-channelled valley bottoms on the site. This species has been unable to be correctly identified, although it could be *Eragrostis lappula* or *Eragrostis planiculmis,* both of which are hydrophytes. The general location of this species on the drier margins of wetlands suggested that it was it was likely to be a facultative hydrophyte. This species has been referred to as *Eragrostis spp.* below

Although not having been included as in the list of (grass, sedge or rush) determinant species, a number of other plant species were commonly recorded across wetlands on the site, and were noted to be co-dominant in terms of coverage at certain sites, especially in the wettest parts of wetlands. These species were generally taken to be further confirmatory of the presence of wetland habitat. These species included two Persicaria species – *Persicaria lapathifolia* and *Persicaria senegalensis*, which were typically associated with standing water in depressions or along channels. Other species including *Sium repandum*, and *Limosella spp*. were commonly encountered in the wettest parts of wetlands. *Monopsis decipiens* was typically noted to occur in the moist grassland sward of the wetland margins. The bulbous species *Crinum bulbispermum* was encountered within many of the valley bottoms. Although mostly noted to occur within wetlands, it did occur outside of wetlands, and in parts of wetlands with a very minimal degree of hydrological activation (e.g. on the top of macro channel banks). *Ranunculus multifidis* and *R. baurii* were also encountered in certain wetlands.

7.3.2.2 Interrelationships between species occurrence, hydrology and wetland physical templates

Despite most wetlands on the site being channelled valley bottoms, there is variance in terms of the physical template of the wetlands which has a resultant effect on the vegetative composition of these wetlands and the lateral extent of wetland habitat within them. This variance is also effected by the underlying geological substrate, and is particularly pronounced along the length of the Witbankspruit as it traverses the site, with different reaches of the river differing in terms of lateral extent of wetland, presence / absence of floodplain features and depth (degree of incision) of the channel.

Figure 33 – Witbankspruit channel north of the gas pipeline crossing

Where wetlands occur in areas of doleritic geology in which vertic soils are almost exclusively predominant, wetlands mostly occur as narrow, deeply channelised features. The vegetation composition in these channelised settings as it relates to the differing degree of hydrological activation laterally across the wetland is the most reliable indicator of the extent of wetland habitat where vertic soils occur uniformly within the landscape. The site survey was conducted in mid-late summer after a short dry period (approximately 4 weeks of little to no rainfall – Mike Beeslaar, pers. comm.), and thus the level of flows in the channels was taken to be representative of a low flow scenario. In the channelled valley bottom settings on the site – i.e. the Witbankspruit as it traverses the lower reaches of the valley bottom tributary to the north of the UCG Site Offices (Rood_5A), and the lower reaches (west of the UCG site access road) of the northern wetlands on the site (Rood_6-8) – the typical hydrophytes were noted to be *restricted to the channel bed and lower banks.* This included species such as *Leersia hexandra, Paspalum dilatatum* and *Agrostis lachnantha* - the most common grass species in this context. Other hydrophytes occurring in / on the margins of the active channel included the universally-occurring *Mariscus / Cyperus congestus* and *Juncus exsertus* (an obligate hydrophyte), which was most typically encountered on the margins of stream channels on the site. Small stands of *Typha capensis* and even the occasionally-occurring *Phragmites australis* reed are further strong indications of permanently inundated wetland habitat in channel beds. The limiting of obligate hydrophytes to the channel is indicative that the permanently / seasonally-inundated wetland area is largely restricted to the channel bed in these settings.

Along the middle reaches of the valley bottom wetland to the north and north-east of the UCG site offices (Rood_5A), the extensive outcropping of bedrock in the channel and on the steep slopes of the valley prevents the growth of vegetation in the wetland, and the physical template is characterised by bare rock outcrops and discontinuous pools of water within the channel. Within these settings hydrophytes are limited to small areas where soil of sufficient depth occurs, and there is a sharp transition from the channel to the catchment of the wetland. Limited areas of wetland habitat occur in these parts of this valley bottom.

Figure 34 – View of the valley bottom Rood_5A in a reach characterised by extensive dolerite outcropping and limited wetland habitat

Where the channel was typically steep-sided (i.e. sloping up from the channel bed to the top of the macro-channel bank), the channel banks were vegetated by a mix of hydrophytes, in particular *Imperata cylindrica,* and non wetland species such as *Eragrostis plana* and *Aristida bipartita.* The difference in elevation between the channel bed and the top of the macro-channel bank which was noted to range from 1.5m to 3-4m (in the case of some reaches of the Witbankspruit) is representative of greatly differing levels of hydrological activation. The channel bed is permanently hydrologically activated, hence the presence of obligate hydrophytes in the channel and along its margins. The rise in elevation of the steep-sloped banks results in a much lesser degree of hydrological activation at these levels. Along certain reaches terraces / benches in the channel banks were noted to support a mix of facultative hydrophytes, in particular *Paspalum dilatatum, Pennisetum sphacelatum, Mariscus congestus* as well as *Eragrostis plana.* At the top of the macro channel it is unlikely that the degree of hydrological activation resulting from spate flows in the channel reaching these levels is sufficient to support obligate hydrophytes. The top of the macro channel bank and adjacent ground away from the channel was typically characterised by a mix of non-wetland species such as *E. plana* and *A. bipartita* mentioned above as well as *Themeda triandra,* and *facultative hydrophytes,* in particular *Pennisetum sphacelatum, P. thunbergii* and *Mariscus congestus.* Overtopping of the banks of channels appears to be at the least an annual event, particularly in the context of the low permeability of the vertic soils in the catchment of these wetland systems. This is borne out by the presence of flood wrack that was observed along many of the reaches of these channelled valley bottom systems on the terraces away from the top of the macro-channel bank. It is believed that the annual (or more commonly occurring) flooding of the top of these channel banks is only sufficient to support facultative hydrophytes. Typically this assemblage (of a mix of facultative hydrophytes and non-wetland species) was noted to extend for a certain distance beyond the edge of the macro channel bank, until a point at the start of the footslopes where non-wetland species became predominant, and where certain species not associated at all with wetlands (e.g. *Cymbopogon pospichilii, C. excavatus, Elionurus muticus* and *Schizachyrium sanguineum*) were found to occur.

Figure 35 – Water-filled depression located away from the main channel of the Witbankspruit

Along the Witbankspruit, evidence of hydrological activation, and thus formation of wetland habitat away from the main channel through the process of overtopping of the channel banks was visible in the form of shallow longitudinal depressions that were noted to occur along certain stretches of the river, even in those reaches occurring in doleritic geology. The presence of shallow depressions is related to the presence of meanders in the main channel, as these typically occur at the 'start' of a meander – i.e. where water flowing in the channel would reach the outer bank at the start of the meander. It is expected that spate flows overtop the channel at this point and flow into the adjacent area. These longitudinal depressions are typically linked to the channel downstream. The creation of these depressions may have been aided through the movement of livestock or other large animals prior to human settlement of the area, as trampling of wet soils by animals attracted to this area may have facilitated the erosion of substrate from this area. These depressions typically occurred as a series of longitudinal un-vegetated (seasonally water-filled) depressions within a lower-lying area running parallel to the main channel and linked at both its upstream and downstream end to the channel.

A range of hydrophytes – mainly facultative hydrophytes – were noted to predominate the vegetation composition in these depressions. The most commonly occurring and dominant species is these depressions occurring adjacent to and within the un-vegetated (water-filled) depressions were noted to be sedge species such *Cyperus denudatus* (ow) and *C. longus* (fw), as well as *Schoenoplectus brachyceras* (ow) and *S. decipiens* (ow). Other hydrophytes recorded as being dominant in the intervening low-lying areas included *Imperata cylindrica*, *Andropogon appendiculatus* (fw), *Pennisetum thunbergii* as well as *Eragrostis spp.* The dominance of these hydrophytes entails that these depression areas have been included as part of the wetlands on the site (as associated with the main valley bottom wetland of the Witbankspruit).

Figure 36 – Water-filled depression away from the Witbankspruit channel in reach Rood_2

Similar depression features occur on a much larger scale along the reach (Rood_2) of the Witbankspruit between the gas pipeline crossing and the point at which the valley bottom tributary Rood_3 enters the stream from the east. This reach of the Witbankspruit (and the reaches south to the site boundary) are located within an area of underlying shale geology, and this can be seen in the topography of the valley bottom compared to the valley to the north, which in this reach is much wider and less steep-sided than the parts of the valley bottom located in dolerite geology to the north. In the area to the north of the gas pipeline crossing, depression features that are very similar to depressional floodplain-like features are located at a distance (100m) away from the main channel. While the entire lateral extent of this reach of the Witbankspruit is not sufficiently inundated / hydrologically activated to be classed as a floodplain, the depression features located away from the channel are well-developed and were noted to be much more prominent than the depression features situated immediately adjacent to the channel to the north. The hydrogeomorphological driver for the formation of this depression feature on the floor of the valley bottom in this area could be related to two factors; firstly the Witbankspruit joins another valley bottom draining the area to the east, resulting in a potentially large amount of water being channelled into a small area within the valley bottom during flood events. Secondly the presence of an outcropping of bedrock which results in a low spur located just to the west of the confluence between the Witbankspruit and a tributary near the crossing of the gas pipeline forces spate flows from the two converging channels to flow into the area to the east of the downstream channel.

The depression features in this reach (Rood_2) consisted of a series of long water-filled depressions that are flanked by thick stands of *Leersia hexandra,* along with other hydrophytes such as *Agrostis lachnantha* and *Hermathria altissima.* In its lower reaches the depression forms a channel-like depression within which obligate hydrophytes such as *Leersia hexandra* and *Typha capensis* grow, before it re-enters the channel.

This longitudinal depression feature is fed by floodwaters from the Witbankspruit and a tributary that appear to overtop the banks just to the south of the gas pipeline crossing, although there is no distinct flow path in this area. Nonetheless the co-dominance of certain hydrophytes – i.e. a combination of *Schoenoplectus decipiens* and *Paspalum dilatatum*, along with large stands of *Pennisetum thunbergii* – along with *Eragrostis plana* in this area to the north-east of the gas pipeline crossing was sufficient to identify this area as wetland habitat.

Figure 37 – Lower end of the depression filled with stands of *Typha capensis,* with *Eragrostis plana*-dominated macro-channel bank

The intervening area between the longitudinal depression and the main channel along the length of the reach (Rood_2) was found to be predominantly characterised by non-wetland species, thus entailing that the entire lateral extent of the valley bottom is not part of a wider floodplain. A flat terrace exists between the main channel and the depression the east. The dominant vegetation species on this terrace was found to be *Themeda triandra,* with the less dominant species being *Eragrostis plana, Pennisetum sphacelatum, Aristida bipartita*, and *Andropogon appendiculatus*. Although the presence of these hydrophytes may be indicative of wetland habitat, the dominant coverage of *Themeda triandra* and *Eragrostis plana* in this area suggests that this area is not hydrologically activated for sufficient periods of time for the development of wetland habitat. The presence of the longitudinal depression running to the east of the main channel is likely to be responsible for the spate flows that overtop the main channel of the Witbankspruit not flooding into this area and thus not creating conditions suitable for the development of wetland habitat on this intervening terrace.

Figure 38 – Typical wetland habitat in un-channelled reach of the valley bottom wetland Rood_8 in the northern part of the site

Other wetland areas in the study area displayed an un-channelled form, particularly the upper reaches of valley bottom wetlands in the study area. Rather than a defined, continuous channel, these upper parts of the valley bottoms are rather characterised by an un-channelled physical template, with the presence of discontinuous, periodically water-filled longitudinal depressions. Such un-channelled cross-sectional profiles were encountered in the upper reach of the valley bottom to the north of the UCG site offices (Rood_5). As this wetland enters the Roodekopjes property from the east, it takes the form of a wide un-channelled wetland in very gently undulating terrain. However at a point to the east of the UCG site offices the wetland runs over an outcrop of dolerite, downstream of which the valley becomes much deeper and more incised. Due to the terraced outcropping of bedrock the wetland habitat effectively disappears for a short stretch.

Figure 39 – Isolated depression at the head of the Rood_7 wetland

Similar un-channelled wetland reaches occur in the upper parts of the other tributaries the drain into the Witbankspruit from the east, including the reach crossed by the gas pipeline (Rood_3), and the three reaches to the north of the UCG site offices (Rood_6,7 & 8). Due to the predominance of vertic soils in these wetlands, vegetative composition was used to delineate these reaches. Vegetatively, the low-lying central parts of the cross-sectional profile were found to be similar to the depressions and channels described above. Stands of *Leersia hexandra* were noted to fringe or occupy the periodically water-filled depressions, being replaced by dense clumps of *Pennisetum thunbergii* in wetlands with a drier hydroperiod. Analysis of the lowest-lying (wettest) parts of the cross-sectional profile of reaches where no depressions were present revealed that hydrophytes such as *Leersia hexandra, Agrostis lachnantha, Paspalum dilatatum, Andropogon appendiculatus* and the obligate hydrophyte sedges *Schoenoplectus decipiens* and *Carex glomerabilis (*in certain locations*)* were (co-)dominant. Areas located slightly away from the central / lowest lying areas, i.e. within the transitional areas between the valley bottom and the footslopes consisted of a sward (co)dominated by *Pennisetum sphacelatum* and *Paspalum dilatatum* in most cases, along with irregular occurrences of *Setaria sphacelata var. torta* and the sedge *Fuirena pubsecens* (ow). A transitional boundary between this vegetative assemblage to a shorter sward dominated by non-wetland species, in particular *Eragrostis plana* and *Themeda triandra* was taken to be the boundary of the wetland, although it should be noted that *Pennisetum Sphacelatum* and *Paspalum dilatatum* did remain present (though not dominant in terms of coverage) into what was delineated as non-wetland area in certain cases.

Figure 40 – Vegetation on the boundary of a valley bottom wetland (Rood_7), dominated by *Eragrostis plana*, with *Pennisetum sphacelatum* and *Mariscus congestus* commonly occurring

Groundwater seepage areas were encountered on the margins of the upper reaches of certain of these wetlands in the study area, and were not only confined to wetlands in areas of shale geology (as described above).In spite of their location at the start of the footslopes not being typically associated with a degree of hydrological activation sufficient to result in wetland habitat creation the vegetative composition (and soil characteristics in some areas) identified these seepage areas as being wetlands. The dominance of hydrophytes (many of them obligate hydrophytes) in these settings is indicative of another source of water input in the form of groundwater seepage other than overland flow from the surrounding slopes or input from the main channel. Along with stands of *Leersia hexandra* and *Agrostis lachnantha,* sedge species were found to commonly occur and be co-dominant in terms of coverage in these seepage areas, with the obligate hydrophyte *Fuirena pubsecens* being particularly common in this setting. Other obligate hydrophyte sedge species encountered commonly in such seepage areas on the periphery of wetlands included *Pycreus nitidus*, along with the facultative species *Mariscus congestus*, and *Kyllinga erecta*. The grass species *Arundinella nepalensis* was also almost exclusively encountered within seepage areas, occurring in dense stands on the peripheries of certain wetlands such as the upper reaches of Rood_8 in the northern-most parts of the site, as well as within a small hydrologically-isolated seepage area located away from the Witbankspruit channel south-west of the UCG Site Offices (Rood_4).

Figure 41 – Sedges and other hydrophytes within a seepage compartment on the peripheries of Witbankspruit valley bottom wetland south of the gas pipeline crossing

Lastly, the status of the two narrow watercourses that drain the sloping ground in the northern part of the UCG gasfield can be discussed. These two drainage lines occur in an area of doleritic geology, where the bedrock outcrops in many places, and are very narrow drainage features of not more than 5m in width. Analysis of the vegetative composition in these two watercourses revealed that only in their lower reaches (i.e. from the valley bottom wetland (Rood_5A) to the most northerly access road on the gasfield) would these two watercourses qualify as wetlands, and even so being characterised by a very marginal hydroperiod. This is indicated by the absence of any obligate hydrophytes within these two drainage systems, and the limited presence of facultative hydrophytes such as *Pennisetum thunbergii* and *Paspalum dilatatum* where suitable substrate occurs.

Maps indicating the boundaries of the wetlands on the Roodekopjes Site are presented below.

7.3.3 Roodekopjes Site Wetland Delineation Maps

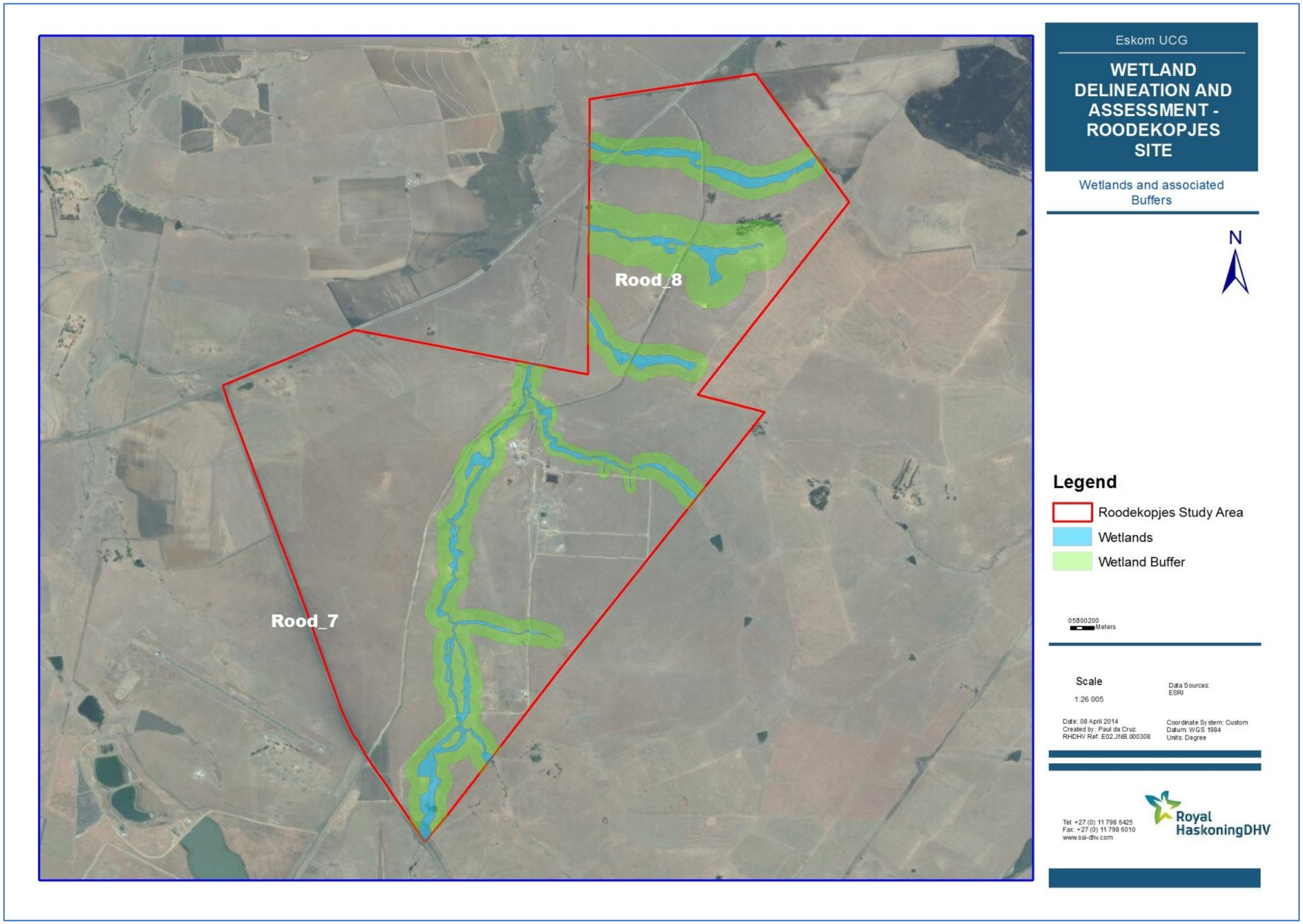


Figure 42 – Wetland Reaches and associated buffers

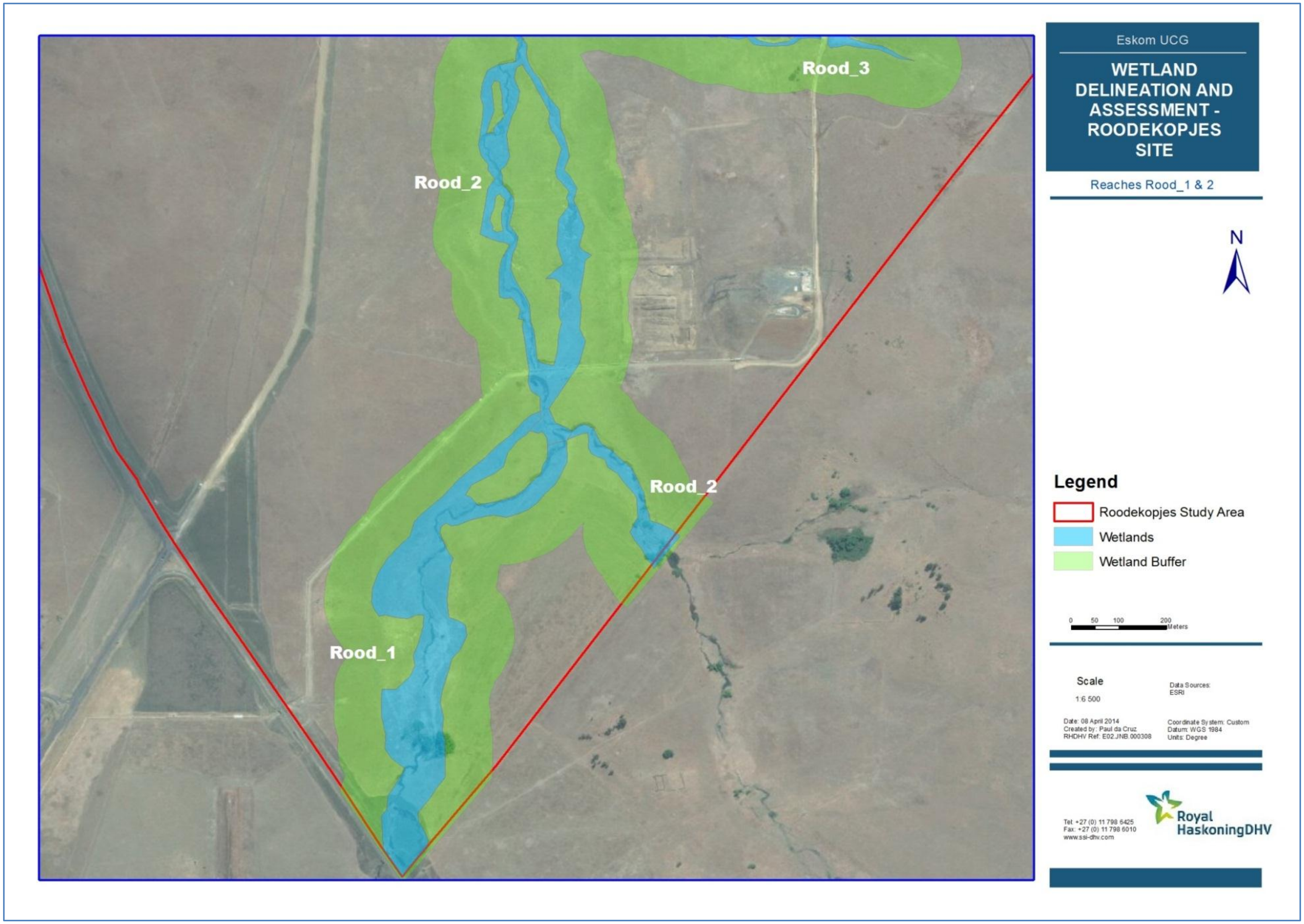


Figure 43 – Wetland Reaches Rood_1 & 2

Figure 44 - Wetland Reaches Rood_3 & 4

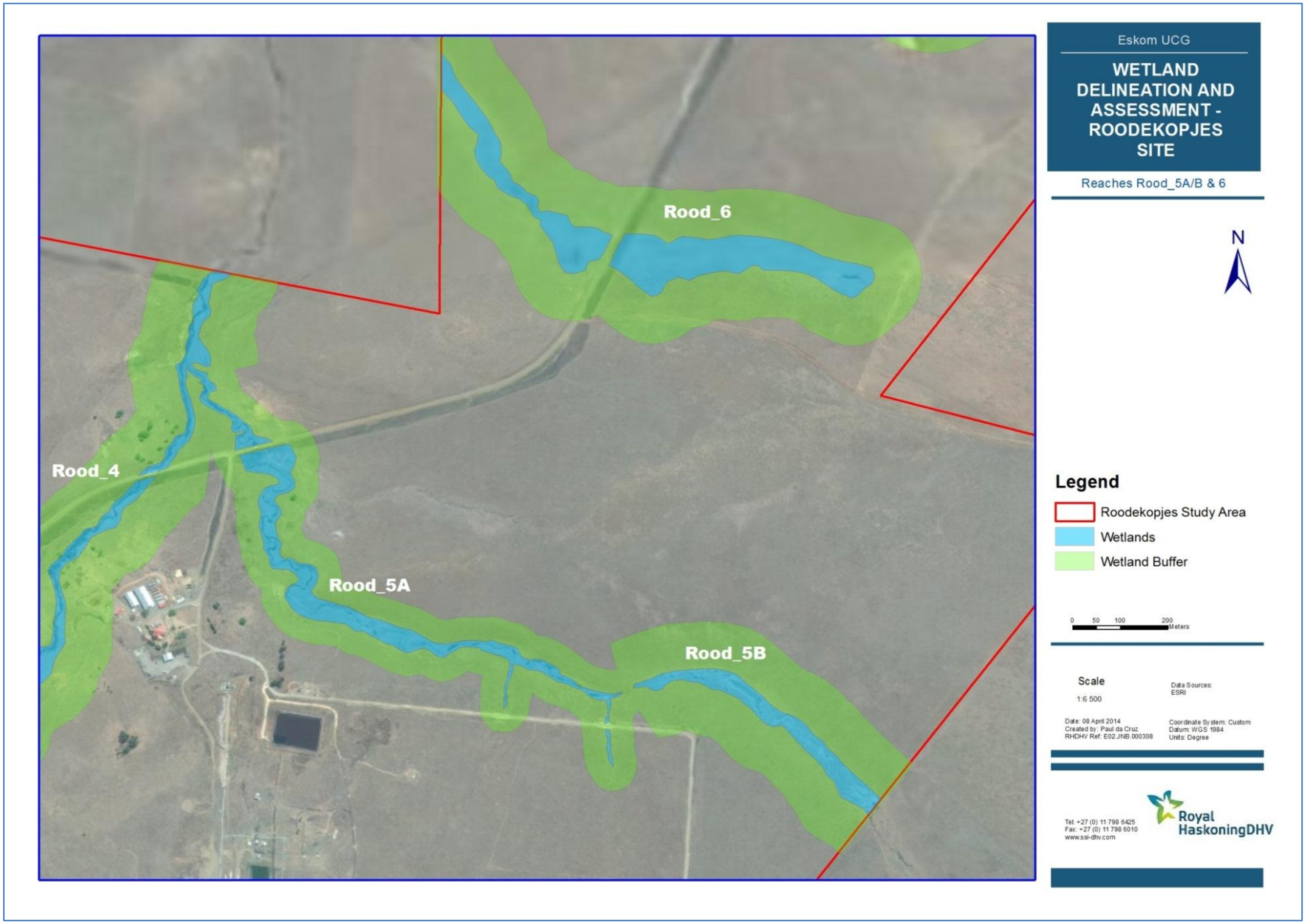


Figure 45 – Wetland Reaches Rood_5 &6

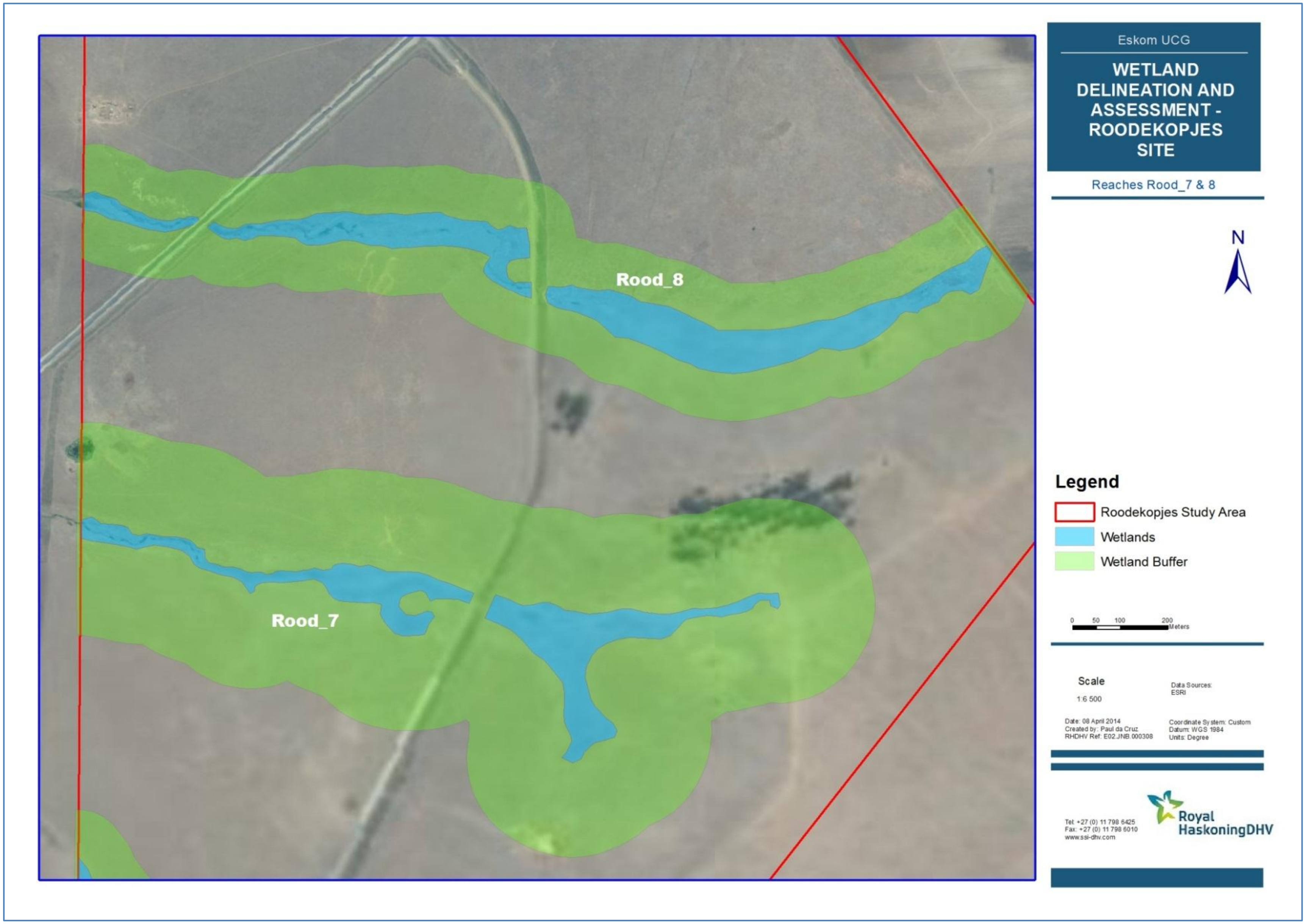


Figure 46 – Wetland Reaches Rood_7 & 8

7.4 Results of Wetland Delineation along the proposed Service Road

Part of the scope of works of the assessment was to delineate wetlands crossed by the proposed service road that would link the UCG offices at the abandoned mine to the east of the Roodekopjes site with the existing gasfield and UCG site offices to the west. The delineation based on vegetative indicators (the entire length of the proposed service road is located within doleritic geology and thus predominant vertic soils) indicated that two of the crossings (Crossings 4 and 5) previously identified as part of the Water Use Licence Application were not crossings of wetlands, and that two further crossings were not crossings of surface water features at all (Crossings 3 and 7). The crossings of wetlands are discussed below.

7.4.1 Crossing 1

The closest wetland crossing to the disused mine is an incised channelised valley bottom. Due to the incised nature of the wetland, it is a very narrow feature with all wetland habitat being located between two channel banks. However the crossing is located across a meander which runs parallel to the road alignment, thus effectively widening the crossing. Vegetation on top of the two macro channel banks consists of a mix of *Eragrostis plana* and *Themeda triandra* which are co-dominant. These are not hydrophytes, thus entailing that no wetland habitat occurs beyond the two channel banks. Vegetation adjacent to the channel consisted of a mix of the hydrophytes *Agrostis lachnantha, Paspalum dilatatum, Fuirena pubsecens,* as well as the non-hydrophyte *Eragrostis plana*. A depression occurs parallel to the channel, in which *Leersia hexandra* and *Mariscus congestus* were noted to occur.

Figure 47 – View of the Crossing 1

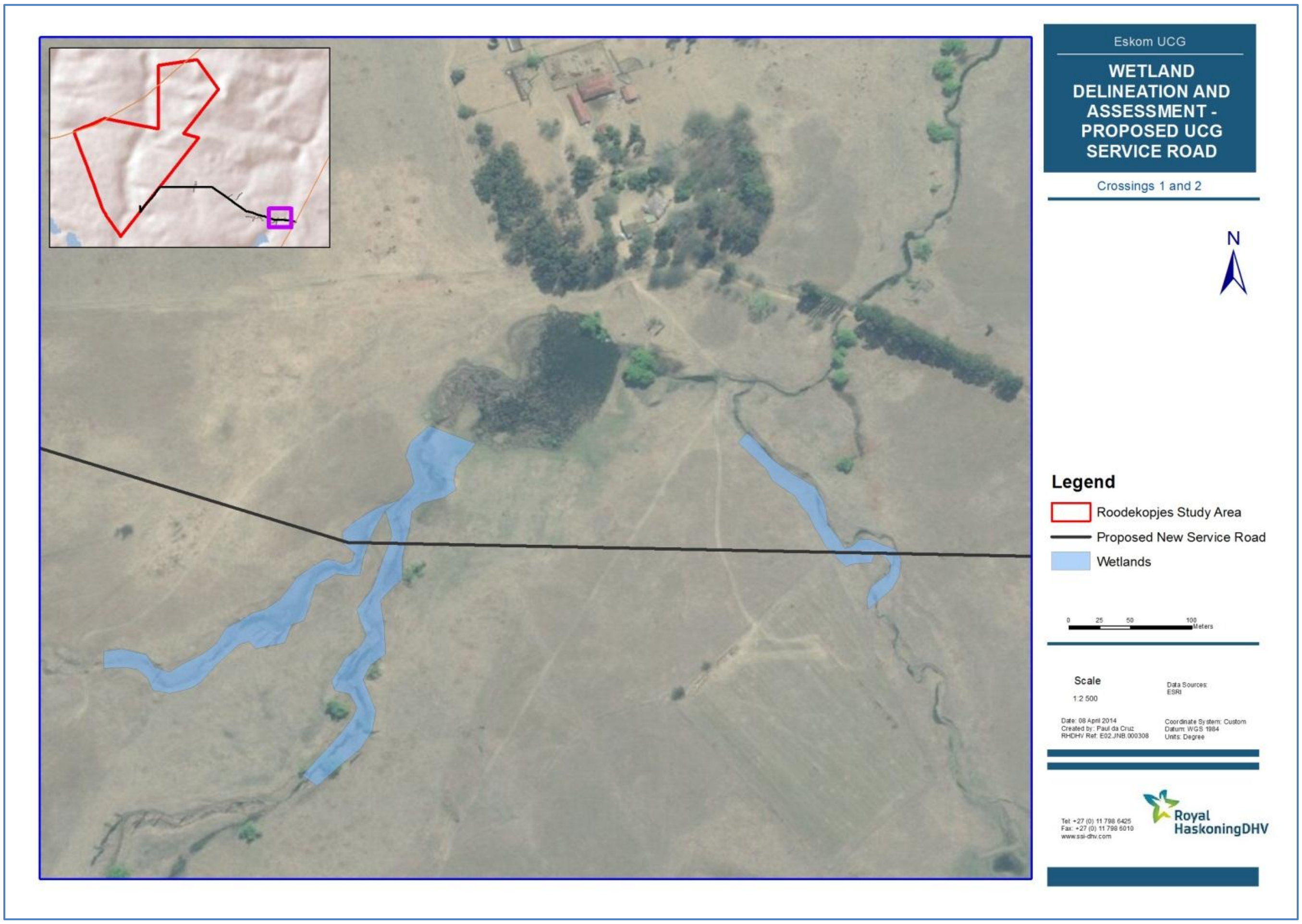


Figure 48 – Crossings 1 and 2 along the proposed UCG Service Road

7.4.2 Crossing 2

Crossing 2 represents a crossing of ***two*** valley bottoms that converge just downstream of the proposed road crossing point, thus effectively there are two wetland crossings in very close proximity. Both valley bottom wetlands were noted to occur in an incised channelised setting with the channel bed between each set of respective macro-channel banks comprising the wetland habitat. In the western-most channel the most common species were the hydrophytes *Pennisetum sphacelatum, Helictotrichon turgidulum, Agrostis lachnantha* and *Mariscus congestus.* A terrace located just above the channel consisted of a mix of *Eragrostis plana, Paspalum dilatatum* and *E. spp*. This terrace is likely to be sufficiently hydrologically activated to allow the formation of wetland habitat, and thus was considered to be marginal wetland habitat. The sides and top of the macro-channel bank, including the "island" between the two channels was covered by a sward that consisted almost exclusively of the non-wetland species *Eragrostis plana*, and thus was not considered to be wetland. The vertical height differential between the channel bed and the top of the macro-channel banks was considered of sufficient distance to ensure that the top of the macro channel banks and adjacent terrace would seldom be hydrologically activated, thus not being able to support hydrophytes. The more easterly channel consisted primarily of *Leersia hexandra* and *Agrostis lachnantha,* two obligate hydrophytes. On the basis of vegetative composition, wetland habitat was identified to occur in two narrow bands separated by a higher-lying area of non-wetland habitat.

Figure 49 – View east across the two wetland channels crossed at Crossing 2

7.4.3 Crossing 4

Crossing 4 is a very shallow, poorly defined drainage feature located high up in the catchment of a valley bottom wetland. Two shallow 'erosion heads' are present just upslope of the crossing point. Analysis of the vegetation at this crossing point revealed that the dominant species in terms of coverage was *Eragrostis plana,* a non-hydrophyte, with a few specimens of the grass species *Paspalum dilatatum* and of the sedge *Fuirena pubsecens.* The predominance of a non-hydrophyte indicates that this part of the drainage feature is insufficiently hydrologically activated to be categorised as a wetland. The vegetation in the immediate catchment of the feature is dominated by the non-hydrophyte grass species *Themeda triandra, Eragrostis plana* and *Aristida bipartita.* The drainage feature only becomes a wetland at a point downstream of the crossing where it intersects another watercourse draining the area to the north-west.

It should be noted however that the watercourse at the crossing point is nonetheless still classified as a water course as defined by the National Water Act (57 of 1999), as the feature would periodically carry overland flow / surface drainage from the upslope area.

Figure 50 – Shallow watercourse at Crossing 4

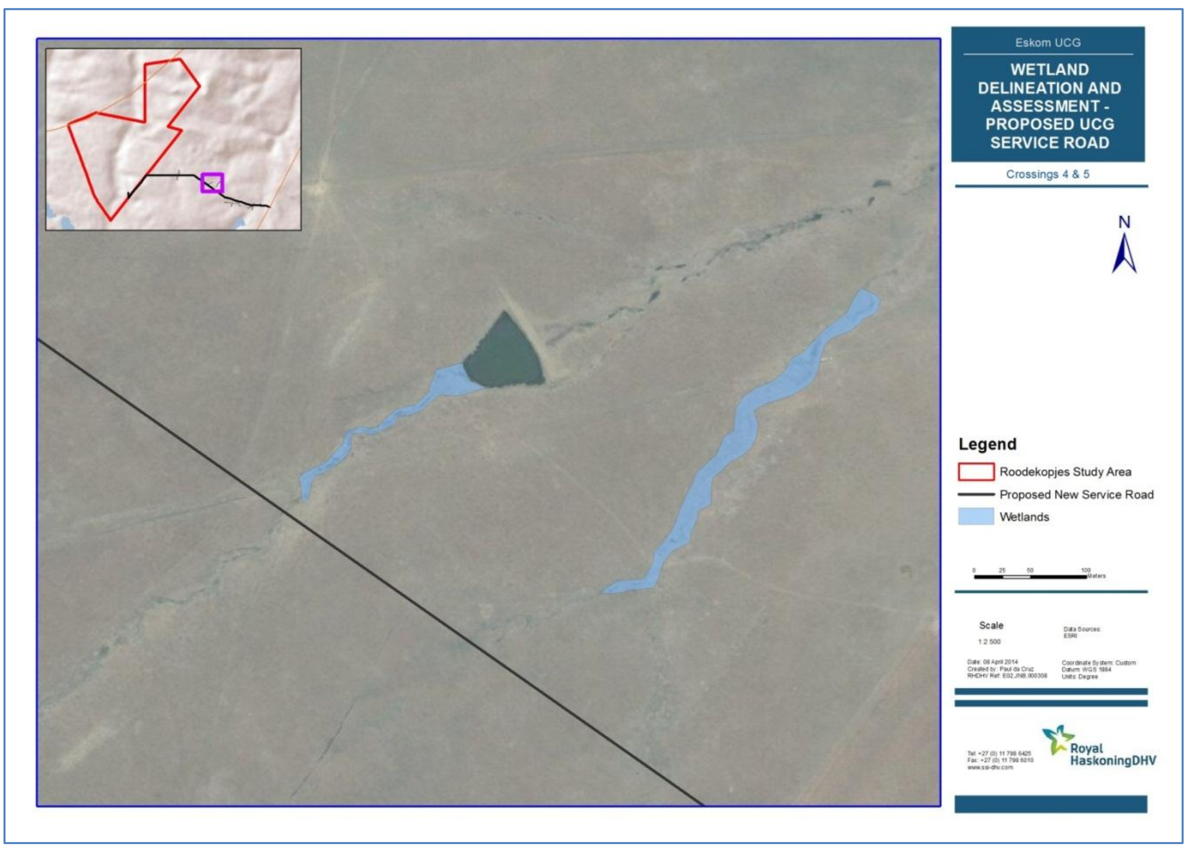


Figure 51 – Crossings 4 and 5 along the proposed UCG Service Road

7.4.4 Crossing 5

Crossing 5 is located at the head of a valley bottom wetland (valley head) upstream of a small farm dam. At the crossing point the drainage line is a very narrow feature characterised by the extensive outcropping of dolerite bedrock just below, or at the surface. This factor results in very shallow soils that have been eroded by surface water drainage to form the shallow drainage feature.

The vegetation composition at the crossing point is comprised predominantly of *Eragrostis plana* (a non-hydrophyte), with lesser concentrations of *Paspalum dilatatum* and *Mariscus Congestus.* The vegetation coverage in the immediate catchment of the feature is similarly dominated by *Eragrostis plana.* This suggests that wetland habitat is not present at the crossing point itself. Only downstream of the crossing point where the drainage feature becomes slightly more incised, and where the vertic soil profiles are deeper, do the obligate hydrophyte *Agrostis lachnantha* and *Typha capensis* appear. A spring (seepage area) actively discharging groundwater into the wetland was noted downstream of this point. The input of groundwater, rather than overland flow only, marks the start of the wetland area and a sufficient degree of hydrological activation to create wetland soils. The drainage line at the crossing is has accordingly not been delineated as being a wetland, with the vegetative composition indicating the degree of hydrological activation at this point being insufficient to facilitate the development of hydric soils.

It should be noted however that the watercourse at the crossing point is nonetheless still classified as a water course as defined by the National Water Act (57 of 1999), as the area carries overland flow / surface drainage from the upslope area.

Figure 52 – Watercourse at Crossing 5, with dominant *Eragrostis plana* vegetation

7.4.5 Crossing 6

The proposed service road would cross the valley bottom wetland that occurs on the Roodekopjes site as the wetland reach Rood_5 along an upstream reach at Crossing Point 6. Similarly to the upstream part of the reach on the Roodekopjes site (Rood_5B), the valley bottom wetland at this point is naturally un-channelled, although the road is proposed to cross the wetland upstream of the point where it has been dammed, and thus the crossing would traverse the uppermost shallows of the dam.

The presence of the dam has artificially altered the hydrology and thus vegetative composition of the of the wetland, as it has created a permanent open body of water, thus allowing the colonisation of the dam's upper reaches by obligate hydrophytes such as Schoenoplectus decipiens and another water dependent species *Persicaria lapathifolia* that typically grows in shallow water. Assessment of the wetland just upstream of the dam where the natural cross-sectional profile remains revealed that the dominant species in the lowest-lying parts of the wetland (between two flanking bank-like miniature erosion faces) was the hydrophyte *Agrostis lachnantha* with a lesser concentration of *Paspalum dilatatum,* indicating that this lowest lying area contains hydric soils. The immediate catchment of the wetland beyond the small erosion faces (onto the gentle footslopes) was completely dominated by the non-hydrophyte *Eragrostis plana,* indicating that the wetland is restricted to the lowest-lying area between the two erosion faces.

Figure 53 – Crossing Point 6 at the upstream end of a dam

In order not to create a significant impact on the wetland – as excavation of saturated wetland soils and the presence of standing water is highly conducive to the creation of silt that can pollute downstream reaches of the wetland – and in order to ensure the stability of the road, it is recommended that consideration be given to breaching the downstream dam and restoring the natural hydrological regime of the wetland immediately downstream of the crossing point.

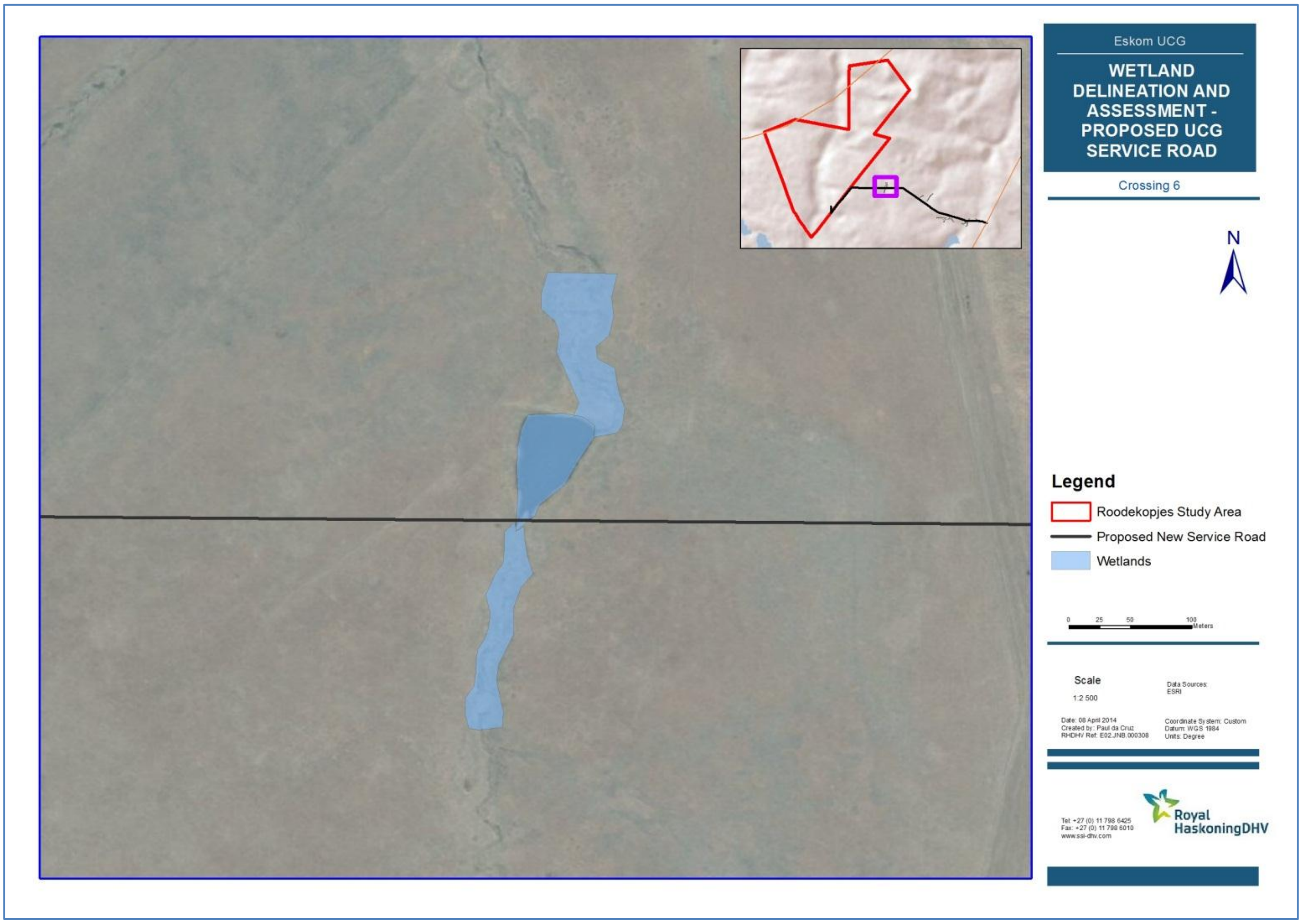


Figure 54 – Crossing 6 along the proposed UCG Service Road

The assessment of potential impacts relating to the proposed service road is explored in section 9.3.3 below.

8 STUDY AREA WETLAND INVENTORY – RESULTS OF FUNCTIONAL AND STATE ASSESSMENT

Following the revised delineation and assessment study for the Roodekopjes Site, the wetland functionality and state assessment for the wetland units on the Roodekopjes Site has been revised. As such the revised functionality and state assessments for the Roodekopjes Site are reported on in this report. For the potentially affected wetlands outside of the Roodekopjes Site, the original functionality and high level state assessments have been retained.

8.1 Skulpspruit (Rietfontein Farm) Catchment

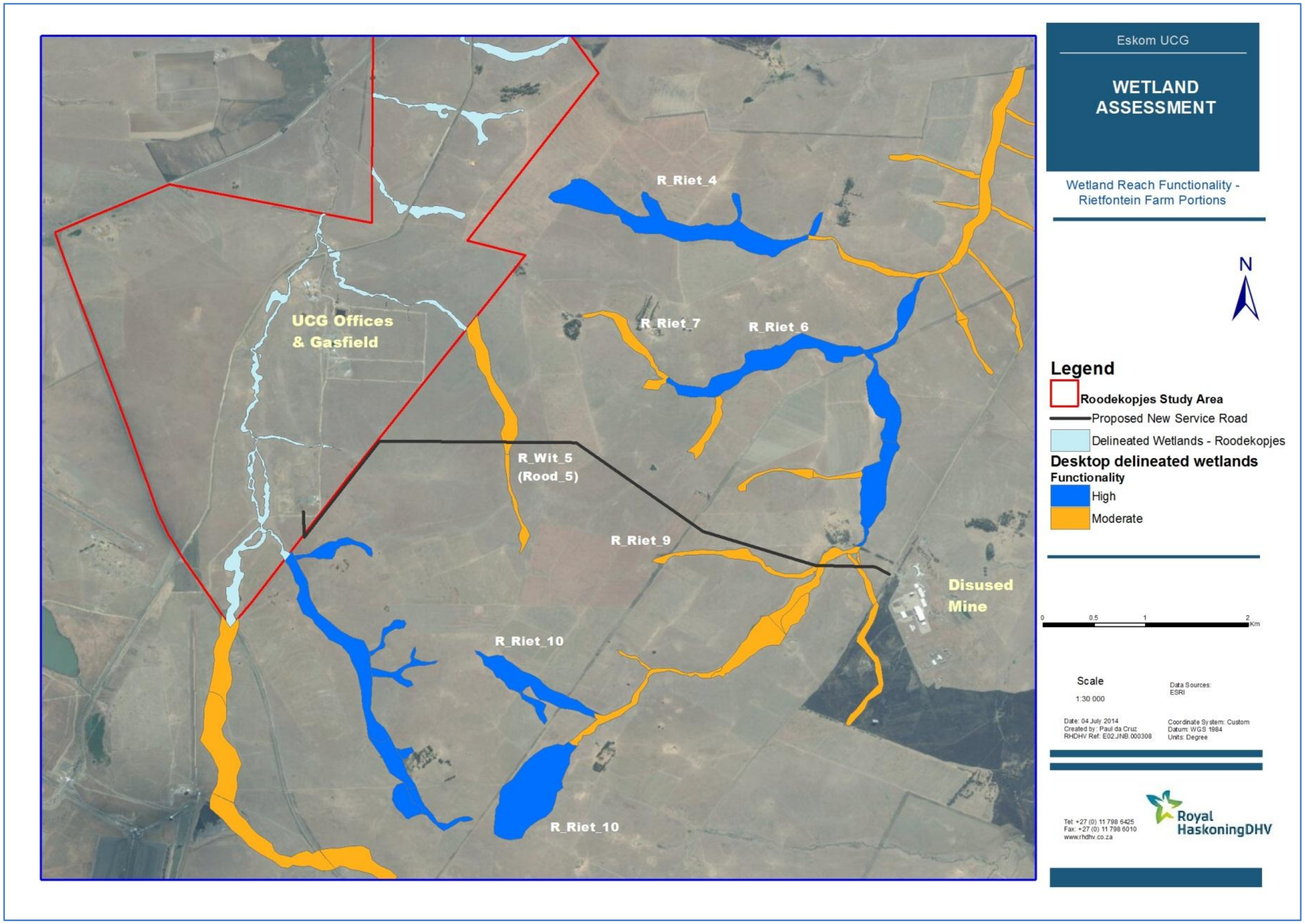


Figure 55 – Functionality of Wetlands on the Rietfontein Farm Portions

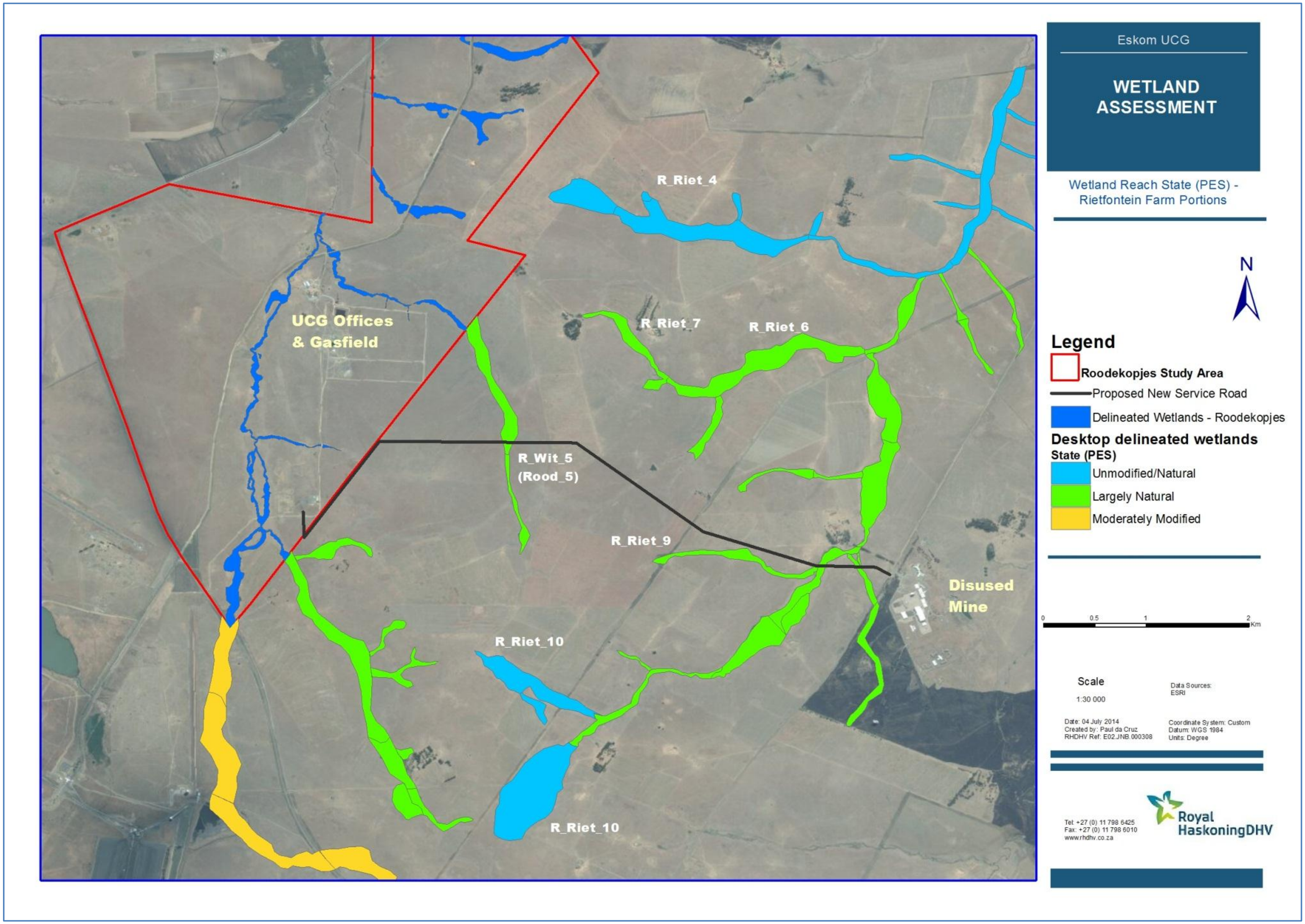


Figure 56 – State of Wetlands on the Rietfontein Farm Portions

8.1.1 R_Riet_4

Wetland unit size (Ha)	42.512
Terrain unit (HGM form)	Valley bottom (un-channelled) and associated valleyhead seeps, hillslope seep (connected)
Underlying Geology	Shale
Land uses in catchment	Livestock Grazing
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control Habitat for Red Data species, and presence of charismatic species
Overall State of Wetland	Natural / Unmodified
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Habitat suitable for the Red Data-listed Metisella meninx butterfly Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	Very High

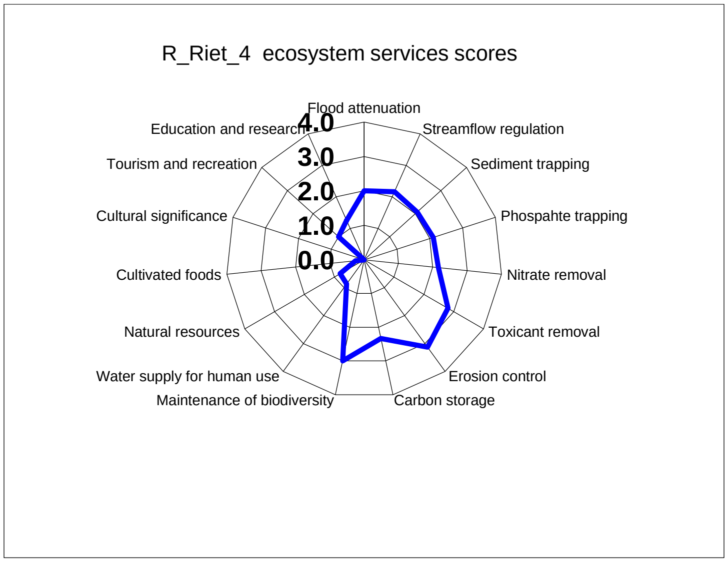


Figure 57 - View of the wide un-channelled valley bottom wetland in the upper parts of the reach

8.1.2 R_Riet_6

Wetland unit size (Ha)	59.747
Terrain unit (HGM form)	Valley bottom (channelled)
Underlying Geology	A small area of shale in the downstream part of the reach, primarily Dolerite
Land uses in catchment	Livestock Grazing, some areas of cultivated pasture
Threats / pressures (problem areas in the wetland unit)	Chronic cattle trampling in wet areas Headcut erosion and associated gulley formation (wetland channelisation)
Main aspects of wetland functionality	Erosion control Maintenance of biodiversity Source of water and grazing for cattle
Overall State of Wetland	Largely Natural
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment Habitat for Red Data species (Leersia hexandra) Suitable habitat for waterfowl
Wetland Reach Sensitivity	High

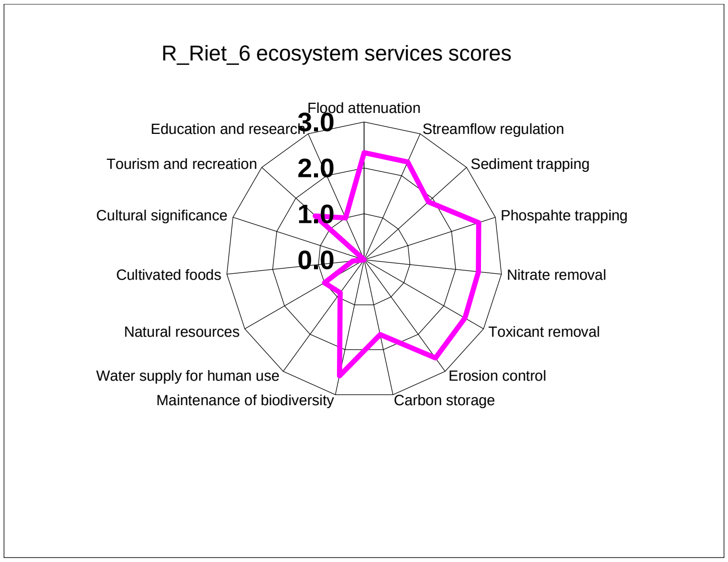


Figure 58 - Chronic cattle trampling immediately upstream of a headcut

Figure 59 - Shallow dam north of the Skaapkraal Farmstead with extensive *Leersia hexandra* stands

8.1.3 R_Riet_7

Wetland unit size (Ha)	23.173
Terrain unit (HGM form)	Valley bottom (channelled) and associated valleyhead seeps
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing, some areas of cultivated pasture
Threats / pressures (problem areas in the wetland unit)	Chronic cattle trampling in wet areas Cattle overgrazing leading to invasion of pioneer species Headcut erosion and associated gulley formation (wetland channelisation) Roads in wetlands causing preferential flow Too frequent burning regime → veld recently burnt (midsummer)
Main aspects of wetland functionality	Erosion control Source of water and grazing for cattle
Overall State of Wetland	Largely Natural
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the	Ecological linkages between wetland and

wetland unit	associated natural catchment
Wetland Reach Sensitivity	Moderate

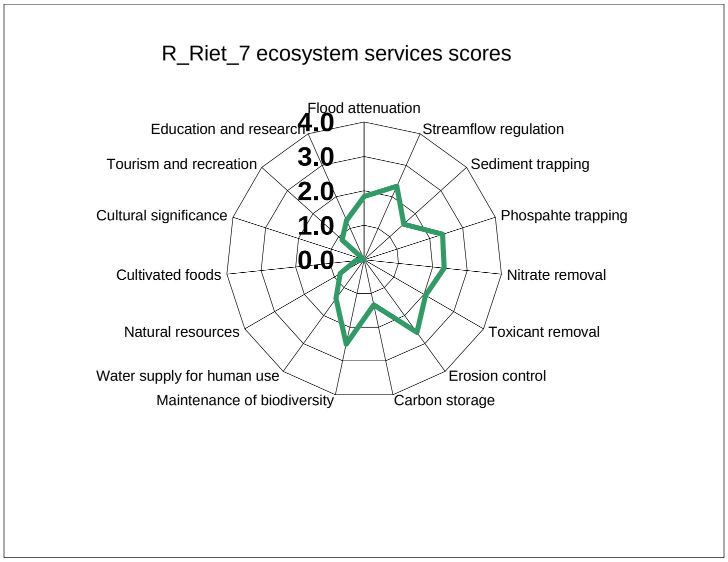


Figure 60 - Upper part of one of the valleyhead seep wetlands in doleritic terrain

8.1.4 R_Riet_8

Wetland unit size (Ha)	31.451
Terrain unit (HGM form)	Valley bottom (channelled) and associated hillslope seepage wetland
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing, a small area of quarrying
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas causing soil loss and exacerbating channelisation of wetlands Loss of wetland habitat and alteration of hydrological regime due to large dam
Main aspects of wetland functionality	Erosion control Source of water and grazing for cattle Suitable habitat for Red Data Species (*Leersia hexandra)*
Overall State of Wetland	Largely Natural
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment Suitable habitat for Red Data Species (*Leersia hexandra*)
Wetland Reach Sensitivity	High

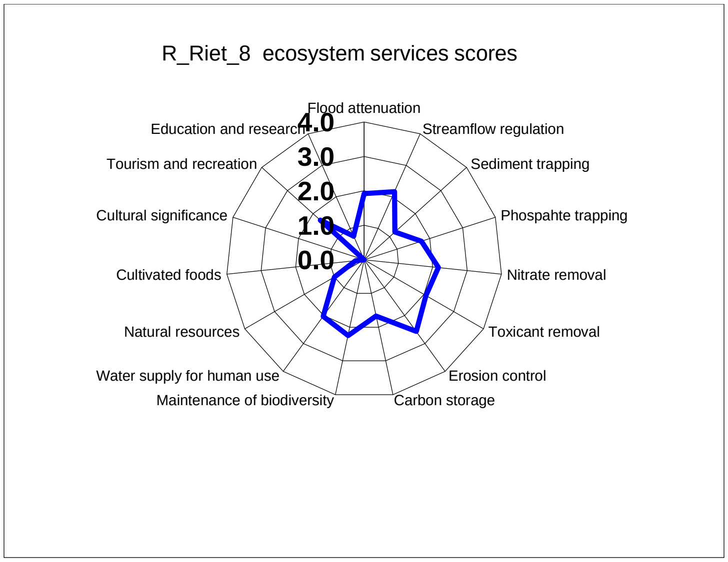


Figure 61 - *Leersia hexandra* stands in the channelled valley bottom

8.1.5 R_Riet_9

Wetland unit size (Ha)	20.304
Terrain unit (HGM form)	Valley bottom (channelled), valleyhead seep and hillslope seepage wetland
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing, a small area of quarrying, some cultivated pasture, industrial (former mine)
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Alteration of hydrological regime due to road that bisects one of the wetland units
Main aspects of wetland functionality	Erosion control Source of water and grazing for cattle
Overall State of Wetland	Largely Natural
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	Moderate

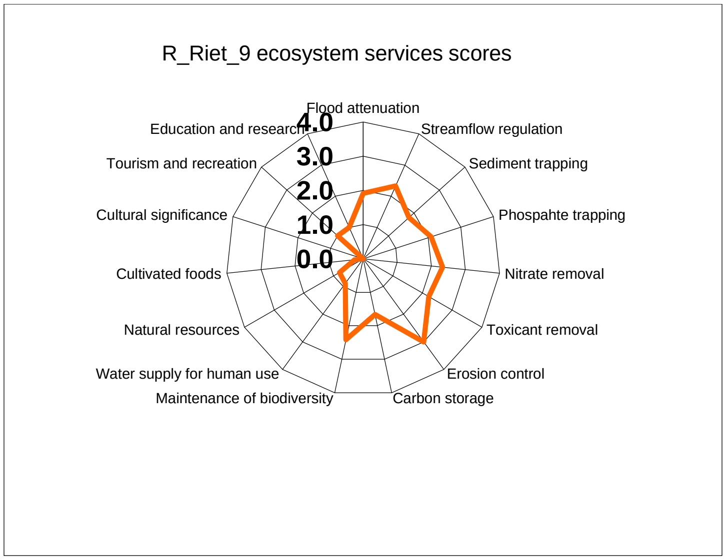


Figure 62 - Seepage wetland area near the Skaapkraal farmstead; note the relatively high degree of surface roughness of the vegetation

8.1.6 R_Riet_10

Wetland unit size (Ha)	54.289
Terrain unit (HGM form)	Valleyhead seep and hillslope seepage wetland
Underlying Geology	Primarily dolerite, shale in part of the reach
Land uses in catchment	Livestock grazing
Threats / pressures (problem areas in the wetland unit)	Too frequent burning regime in catchment → part of catchment had recently been burnt (summer burning)
Main aspects of wetland functionality	Erosion control Carbon Storage Nitrate Removal Maintenance of Biodiversity Streamflow Regulation Source of water and grazing for cattle
Overall State of Wetland	Natural / Unmodified
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment Habitat for Red Data Species
Wetland Reach Sensitivity	Very High

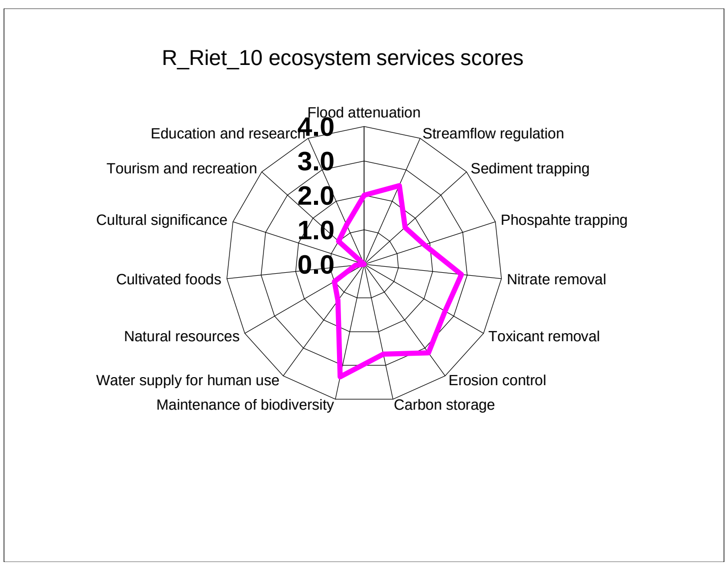


Figure 63 – View of Extensive seepage area from the immediate catchment

8.2 Roodekopjes Site (Witbankspruit Sub-catchment)

Figure 64 – Functionality Assessment for wetlands on the Roodekopjes Site

Figure 65 – Assessment of state (PES) of wetlands on the Roodekopjes Site

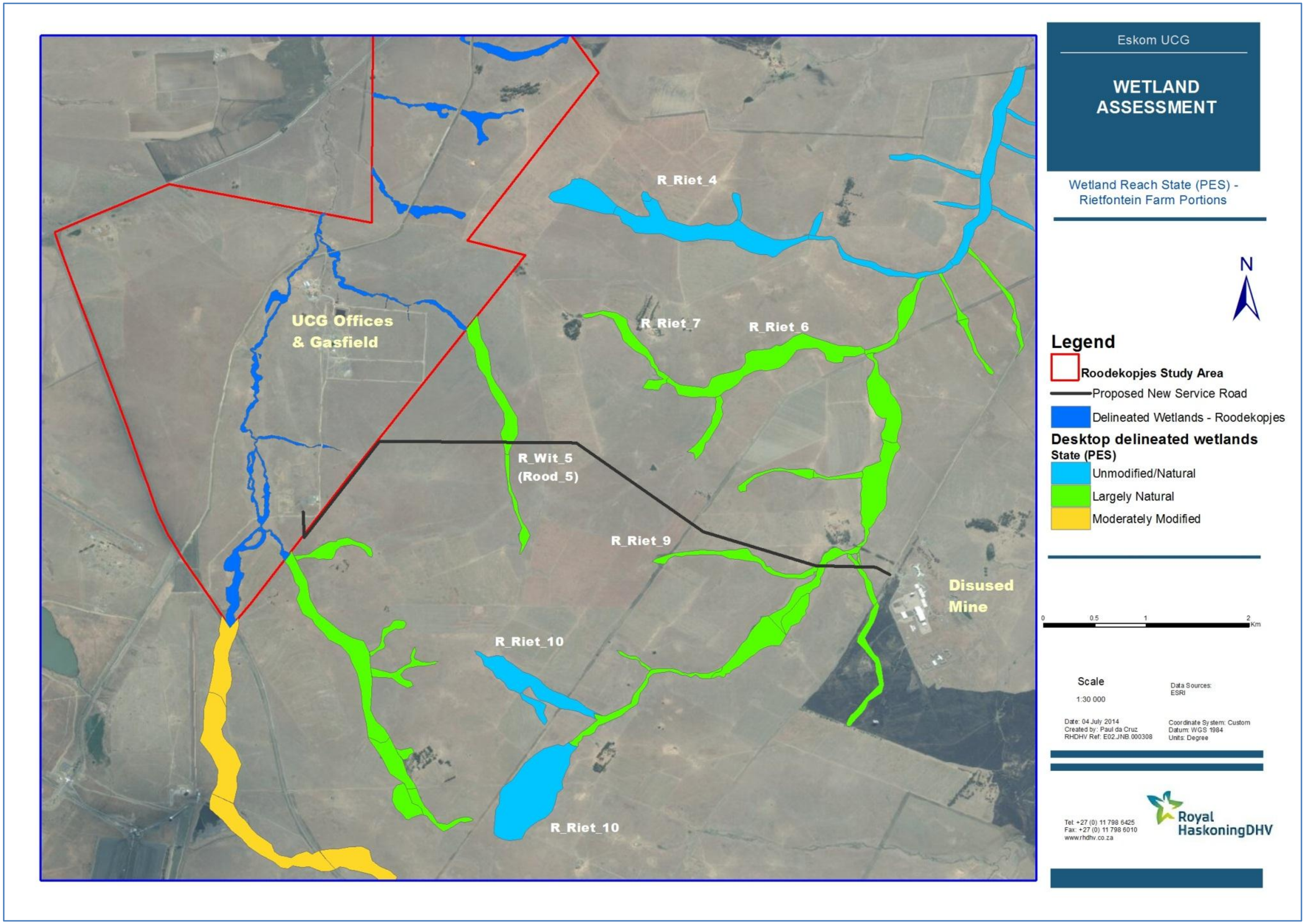
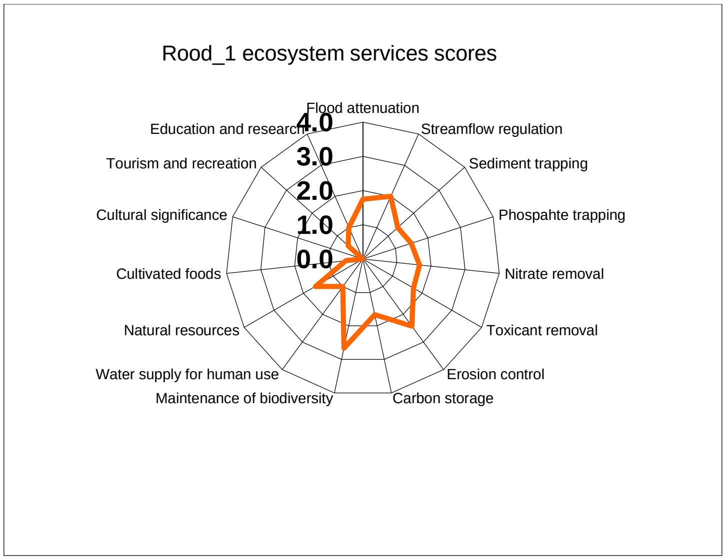


Figure 66- Wetland State on the Rietfontein Site

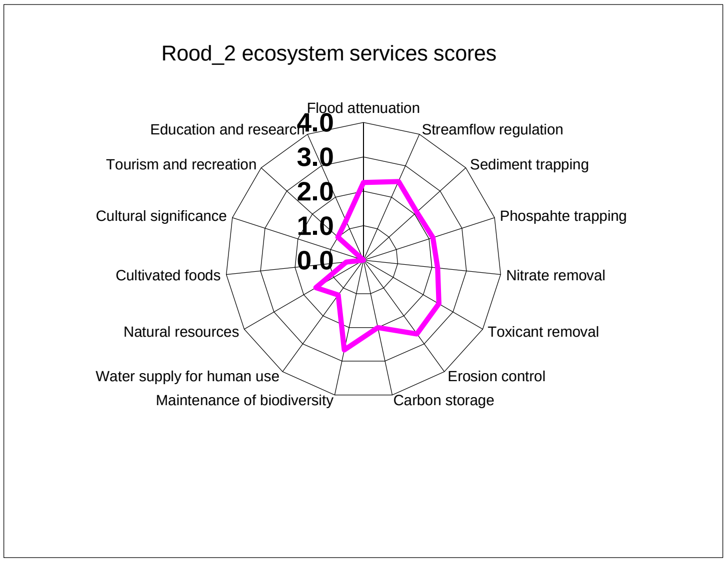
8.2.1 Rood_1

Terrain unit (HGM form)	Channelled Valley bottom and associated seepage compartments
Underlying Geology	Shale
Land uses in catchment	Livestock Grazing, Industrial (power generation)
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control
Overall State of Wetland	Largely Natural (A/B)
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Habitat suitable for the Red Data-listed *Metisella meninx* butterfly Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



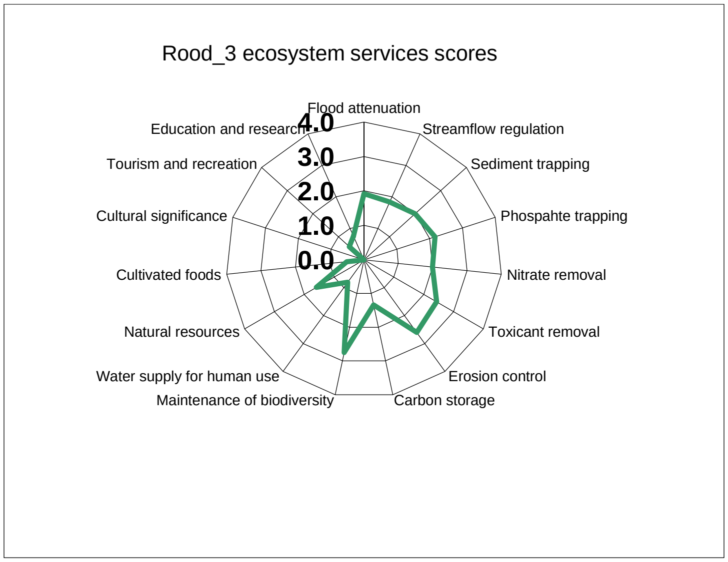
8.2.2 Rood_2

Terrain unit (HGM form)	Channelled Valley bottom
Underlying Geology	Shale
Land uses in catchment	Livestock Grazing, Industrial (power generation)
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Erosion of pipeline crossing structure casing siltation in downstream section of the wetland
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control Toxicant Removal Flood attenuation
Overall State of Wetland	Largely Natural (A/B)
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Habitat suitable for the Red Data-listed *Metisella meninx* butterfly Natural open water utilised by waterfowl Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



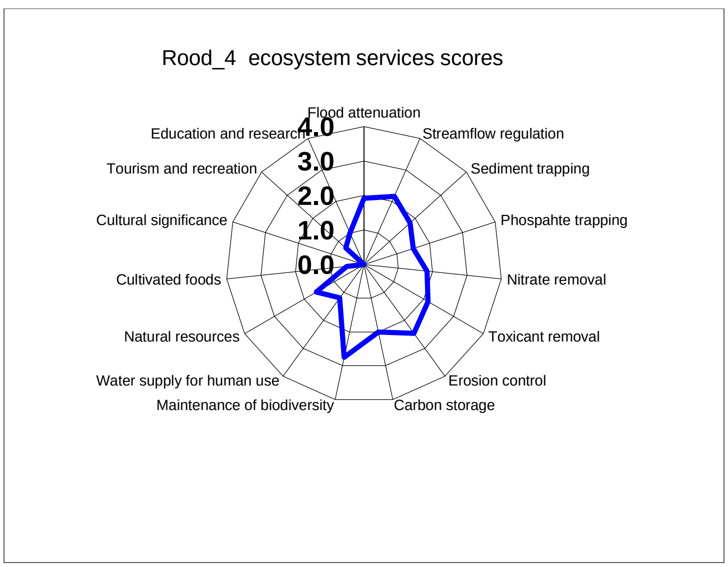
8.2.3 Rood_3

Terrain unit (HGM form)	Channelled / Un-channelled Valley bottom and associated valleyhead seep
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Erosion of pipeline crossing structure casing siltation in downstream section of the wetland Accelerated channel erosion in certain reaches of the wetland
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control Toxicant Removal
Overall State of Wetland	Un-modified / Natural (A)
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



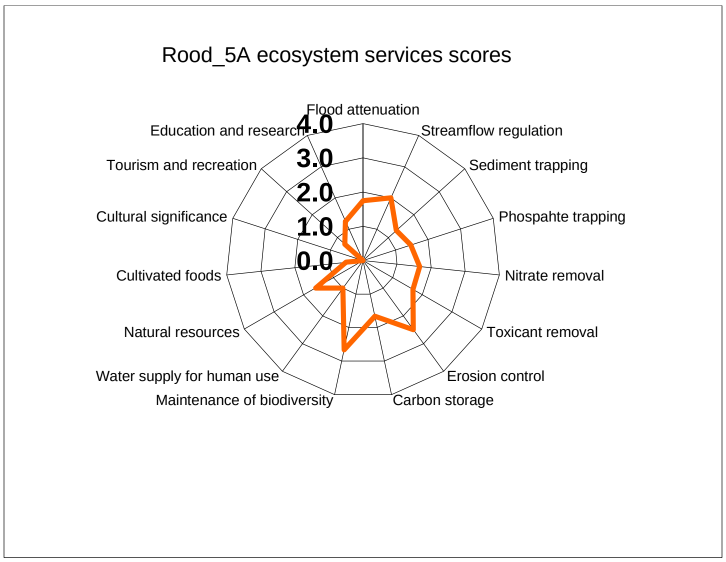
8.2.4 Rood_4

Terrain unit (HGM form)	Channelled / Un-channelled Valley bottom and associated valleyhead seep
Underlying Geology	Dolerite (some sandstone in northern part of reach)
Land uses in catchment	Livestock Grazing Underground coal gasification
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control
Overall State of Wetland	Largely Natural (A/B)
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Habitat suitable for the Red Data-listed *Metisella meninx* butterfly Habitat suitable for Marsh Owl (*Asio capensis*) and Grass Owl (*Tyto capensis*) Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



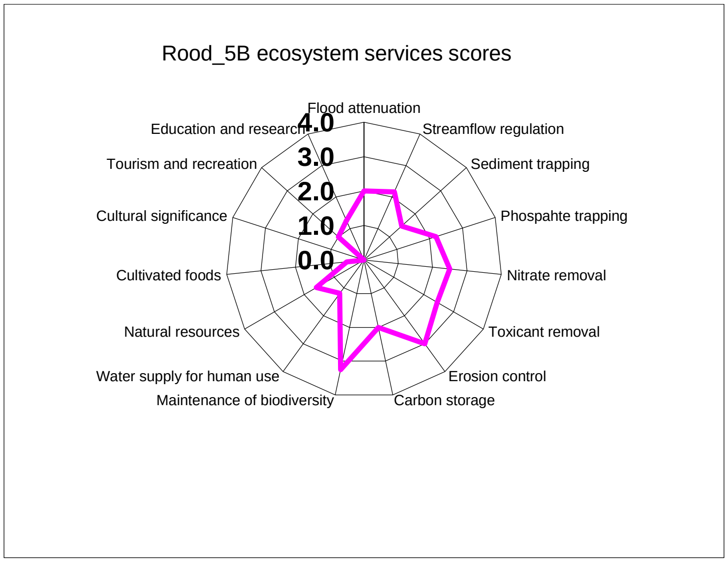
8.2.5 Rood_5A

Terrain unit (HGM form)	Channelled Valley bottom
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing Underground coal gasification
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas
Main aspects of wetland functionality	Maintenance of biodiversity Erosion control
Overall State of Wetland	Largely Natural (A/B)
Overall Degree of Functionality of Wetland	Moderate
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment,
Wetland Reach Sensitivity	Moderately High



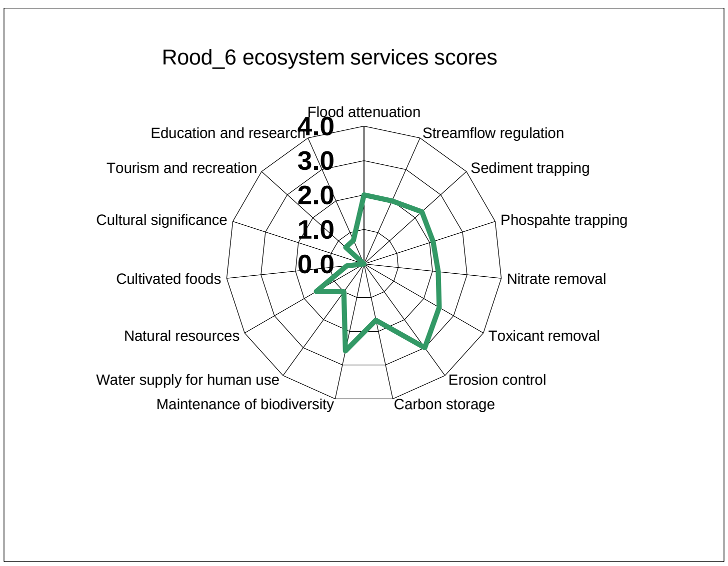
8.2.6 Rood_5B

Terrain unit (HGM form)	Un-channelled valley bottom
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing Underground coal gasification
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas
Main aspects of wetland functionality	Nitrate Removal Toxicant Removal Maintenance of biodiversity Erosion control
Overall State of Wetland	Largely Natural (A/B)
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment Habitat suitable for the Red Data-listed *Metisella meninx* butterfly Habitat suitable for Marsh Owl (*Asio capensis*) and Grass Owl (*Tyto capensis*)
Wetland Reach Sensitivity	High



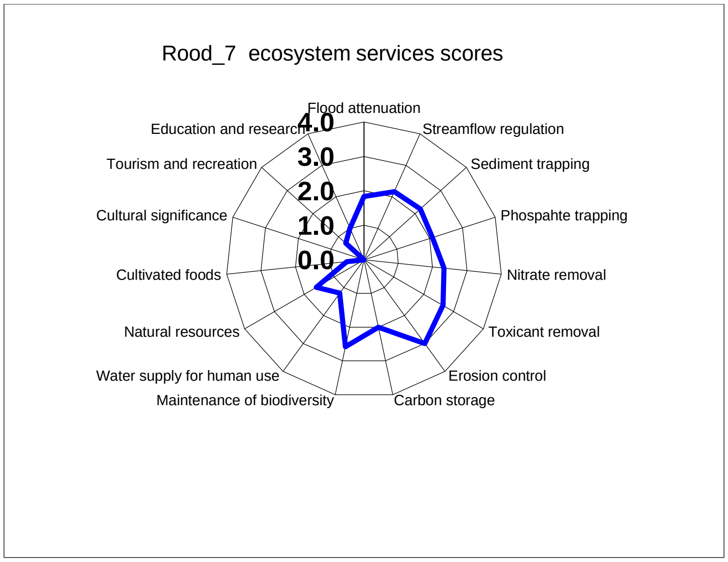
8.2.7 Rood_6

Terrain unit (HGM form)	Un-channelled valley bottom
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Siltation due to railway construction activities
Main aspects of wetland functionality	Sediment Trapping Nitrate Removal Toxicant Removal Maintenance of biodiversity Erosion control
Overall State of Wetland	Un-modified / Natural (A)
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



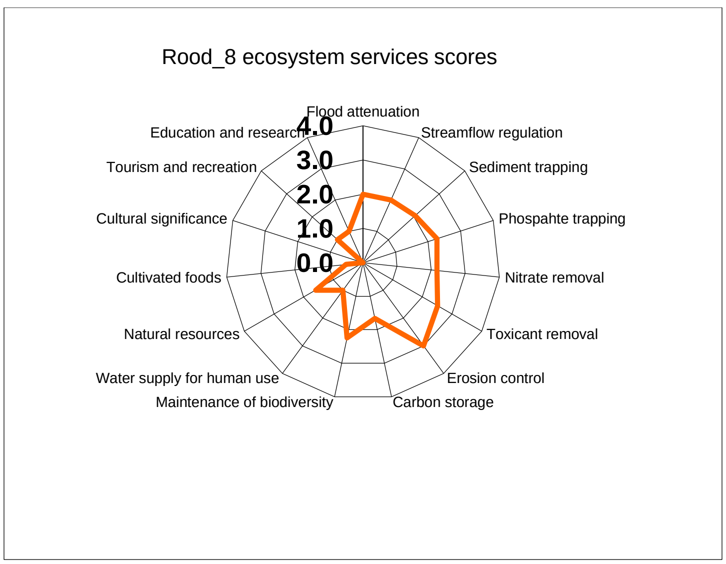
8.2.8 Rood_7

Terrain unit (HGM form)	Un-channelled (and partially channelled) valley bottom
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Siltation due to railway construction activities
Main aspects of wetland functionality	Streamflow Regulation Sediment Trapping Nitrate Removal Toxicant Removal Maintenance of biodiversity Erosion control
Overall State of Wetland	Un-modified / Natural (A)
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment Habitat suitable for Marsh Owl (*Asio capensis*) and Grass Owl (*Tyto capensis*)
Wetland Reach Sensitivity	Very High



8.2.9 Rood_8

Terrain unit (HGM form)	Un-channelled (and partially channelled) valley bottom
Underlying Geology	Dolerite
Land uses in catchment	Livestock Grazing
Threats / pressures (problem areas in the wetland unit)	Cattle trampling in wet areas Siltation due to railway construction activities
Main aspects of wetland functionality	Phosphate Trapping Nitrate Removal Toxicant Removal Maintenance of biodiversity Erosion control
Overall State of Wetland	Un-modified / Natural (A)
Overall Degree of Functionality of Wetland	High
Important biodiversity features in the wetland unit	Ecological linkages between wetland and associated natural catchment
Wetland Reach Sensitivity	High



8.3 Overall comment on Study Area Wetland Functionality, Pressures and State

A review of all of the wetland reaches assessed indicates that there are a few aspects of wetland functionality that are common to most wetlands in the Study Area. The first aspect is erosion control. In spite of their condition / state, one of the highest-scoring ecosystem services in the Wet-EcoServices assessment was erosion control. This is a result of a number of factors, most important of which are:

- the high erodibility of the dominant soils (vertic soils) as discussed above
- the relatively high degree of overland flow that tends to occur in the Study Area once soils become initially saturated and thus relatively impermeable
- the relatively good vegetation cover in the wetlands in the Study Area

In most of the wetlands assessed, the vegetation cover in the wetlands was noted to be high. This is a critical factor in preventing loss of erodible soils. Luckily the nature of land use in most parts of the Study Area has entailed that there has been a relatively low human impact footprint in the wetlands in the Study Area.

However one factor is counteracting this; the vast majority of disturbance of soil in the wetlands within the Study Area relates to the presence of livestock, in particular cattle. In most cases a direct link between the effects of cattle trampling (that results in the destruction of wetland vegetation cover and thus the corresponding exposure and desiccation of wetland soils) was evident at active headcuts and in areas of accelerated bank erosion. The presence of water exacerbates the problem; cattle are drawn to these 'wetter' parts of the wetland to both drink and graze the vegetation which is naturally greener than surrounding areas. The wet soils are easily trampled, and the presence of actively flowing water allows exposed soils to be easily washed away. These parts of wetlands are often critically important in biodiversity context as they are typically areas of diverse and often moribund vegetation, providing important habitat for a number of faunal and floral species.

In the light of the above it must be noted that cattle, and more importantly the likely overstocking of cattle in parts of the area, is the single most important degradation factor in wetlands in the Study Area. The removal of livestock from parts of the area if these areas are to be 'mined' through the UCG process would likely be beneficial for the wetlands in the Study Area, as discussed below. However the impact of cattle on wetland functioning should be contextualised; the predominant land use in the area – livestock rearing – has allowed much of the Study Area to remain in a largely natural condition, and thus has allowed many of the natural ecological linkages and processes to be maintained. This context can be compared to a context of other types of landuse such as extensive cultivation or forestry, urbanisation or mining where the level of transformation of the landscape is much higher.

The nature of the interrelationship between land use (livestock rearing) in the area and wetlands is illustrated in the importance of wetland areas to livestock. The nature of the climate in the area, i.e. the highly seasonal rainfall pattern and the very cold, frosty winters has an impact on the dry season / winter-time availability of both water and fodder for cattle. There is typically very little rainfall in this time and the presence of frosts result in vegetation die-off and a resultant decrease in the amount of protein available for livestock in the veld. In these dry winter months, wetlands are typically the only natural source of water and fodder for cattle, as wetland grasses tend to stay greener for longer into the drier months, and tend to display the first emergence of green shoots before the onset of the rains.

The groundwater-fed nature of many wetlands in the Study Area is thus a critical factor contributing to the ecosystem services in this regard. Wetlands and the associated rivers into which they feed are an important source of water for cattle. The presence of groundwater-fed baseflow that occurs in these rivers and wetlands year-round is an important factor in sustaining the livestock rearing industry. This hydrological characteristic of rivers and wetlands is also critical for sustaining the biodiversity in wetlands, especially aquatic species and certain plant species which rely on wetlands being permanently inundated.

This 'maintenance of biodiversity' ecosystem service is very important to the conservation of fauna and flora in the Study Area. As noted in the sections above, many of the wetlands that are permanently or highly seasonally inundated contain (often extensive) stands of the grass *Leersia hexandra*. These stands of this grass provide habitat for the Red Data-listed butterfly *Metisella meninx*, and are thus a critical component of the natural habitat in the Study Area. Other important species, especially certain large bird species like storks, flamingos and Marsh Owls were identified within wetlands in the wider area (former study area). In this context, the less common wetland types such as floodplains and wide un-channelled valley bottom wetlands are very important as habitat for these species. It should be noted that many of these less common wetland types are limited to areas of sedimentary geology, and thus wetlands underlain by geology of this type should be prioritised for protection.

Geology plays a similarly important causal role in another important factor of maintenance of biodiversity, i.e. the ecological linkage that exists between wetlands and their surrounding catchments. Areas where natural grassland catchments still exist in a largely intact state in the catchment of wetlands are typically underlain by dolerite geology. The widespread outcropping of dolerite bedrock as well as the presence of strongly vertic soils has precluded the transformation of many catchments to crop cultivation, thus allowing the retention of ecological linkages and processes between wetlands and surrounding grasslands.

Through their physical characteristics, many wetlands have been identified to play an important role in the trapping of sediments, as well as phosphates, nitrates as well as toxicants. Certain of the wetlands in the Study Area are surrounded by areas of active crop cultivation and planted pasture (especially those within sedimentary geology). In certain cases, these fields extend close to, or even into the wetland boundary. These areas of cultivation are likely to be fertilised, and thus may be feeding nitrates and phosphates, as well as silt, into the downstream drainage systems. The downstream wetlands, especially those containing diffuse flow and moribund vegetation are very important in this context.

Most of the wetland reaches were listed as being in a largely natural condition in the tables above, with the categories of 'natural / unmodified' or 'largely natural' being assigned to most of the reaches. This is due in a large part to the land use-related factors listed above. This is an important factor that needs to be taken into account in assigning areas of environmental sensitivity to the Study Area. This has implications for the overall assessment of wetland loss in the context of the sub-catchments. Due to the nature of land use and the low human footprint in the Study Area, it has been assumed that there has been a relatively low level of wetland and wetland habitat loss in the sub-catchments of the Study Area. Problem areas in wetlands typically remain relatively localised and large parts of many of the Study Area's wetlands remain highly intact. This status quo needs to be taken into account in the planning of proposed UCG-related mining activities in the Study Area.

8.4 Wetland Prioritisation and Sensitivity

The wetland reaches in the Study Area have been subjected to a prioritisation exercise in order to assign a level of sensitivity to respective wetland reaches. The prioritisation / sensitivity assessment has taken into account the following factors:

- Level of Wetland Functionality
- Wetland State
- Presence / Absence of important biodiversity features
- Wetland HGM being a rare type (in the context of the study Area)
- Geology underlying the wetland

In terms of how important biodiversity features were characterised, the following characteristics were deemed to be important biodiversity features:

- Wetland / aquatic Red Data Species present
- Habitat suitable for Red Data Species
- Charismatic species recorded or habitat suitable for charismatic wetland species (e.g. Marsh Owls)
- Completely natural catchment of the wetland reach

Four categories of sensitivity have been assigned:

- Very High
- High
- Moderately High
- Moderate

It should be noted that all wetlands should be regarded as being sensitive areas / components of the Study Area. The classification of wetland reaches into differing classes of sensitivity has been undertaken in order to indicate those wetlands that should be offered maximum protection, and which should be avoided when aligning linear infrastructure such as power lines, roads and pipelines.

It should be noted that the wetland prioritisation exercise was undertaken for the older (wider) study area – the wetlands in the revised study area have not been re-prioritised and the same classification for the revised study area has been retained.

The sensitivity classes have been assigned based on the following criteria.

Table 7 - Criteria used to assign wetland reach sensitivity classes

Wetland Sensitivity Class	Parameter								
	Functionality		State		NB Biodiversity Features		Wetland HGM Type		Underlying Geology
Very High	High	AND	Natural	AND	Present				
High	High	OR	Natural	OR	Present	OR	Pan or Floodplain	ON	Sedimentary / Dolerite*
Moderately High	High	OR	Natural	AND	Absent		ON		Dolerite
Moderate	All Remaining Reaches								

* - Note when important biodiversity features are present on wetlands underlain by dolerite geology, the reach is placed in the 'high' sensitivity category.

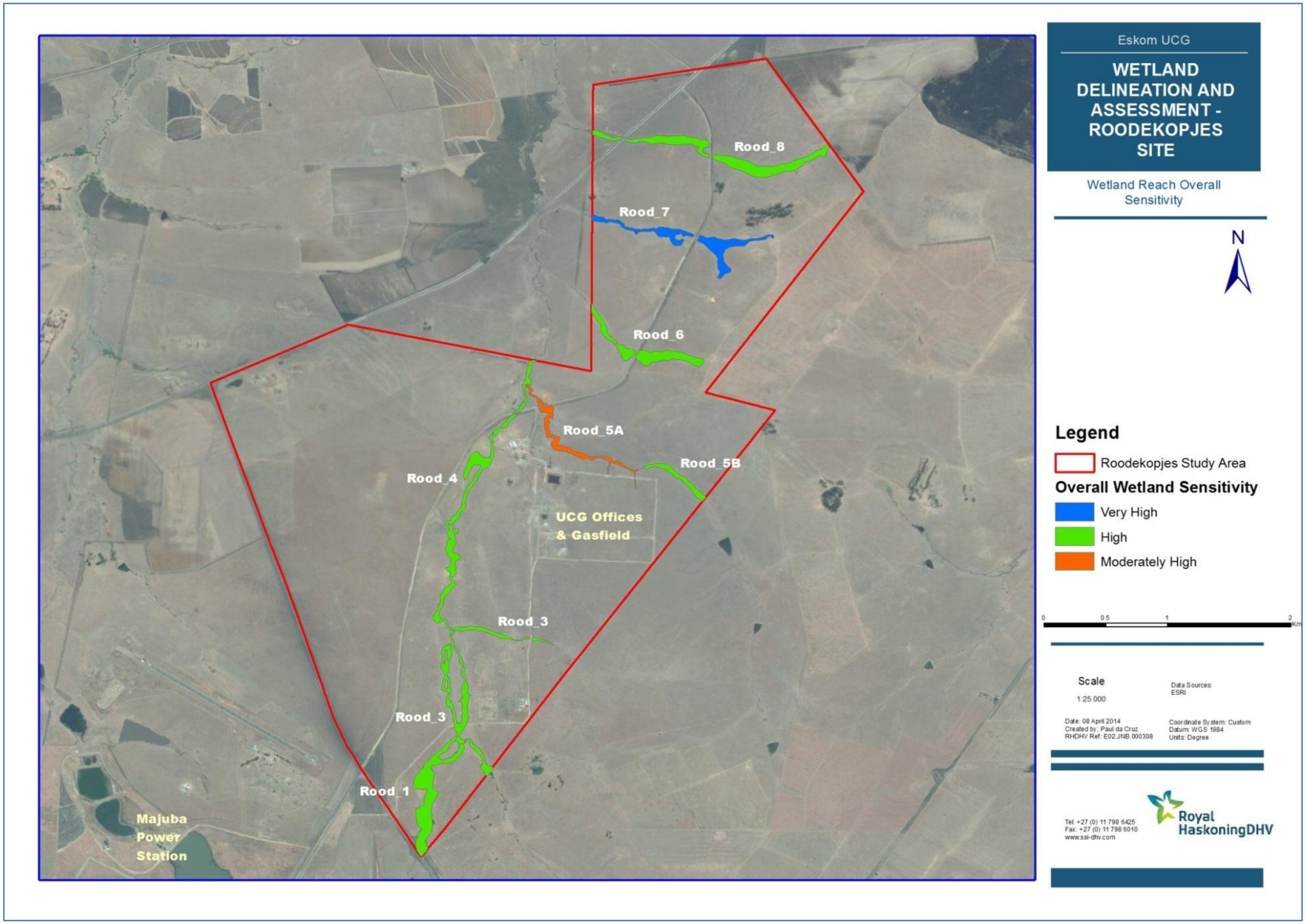


Figure 67 – Sensitivity Assessment for wetlands on the Roodekopjes Site

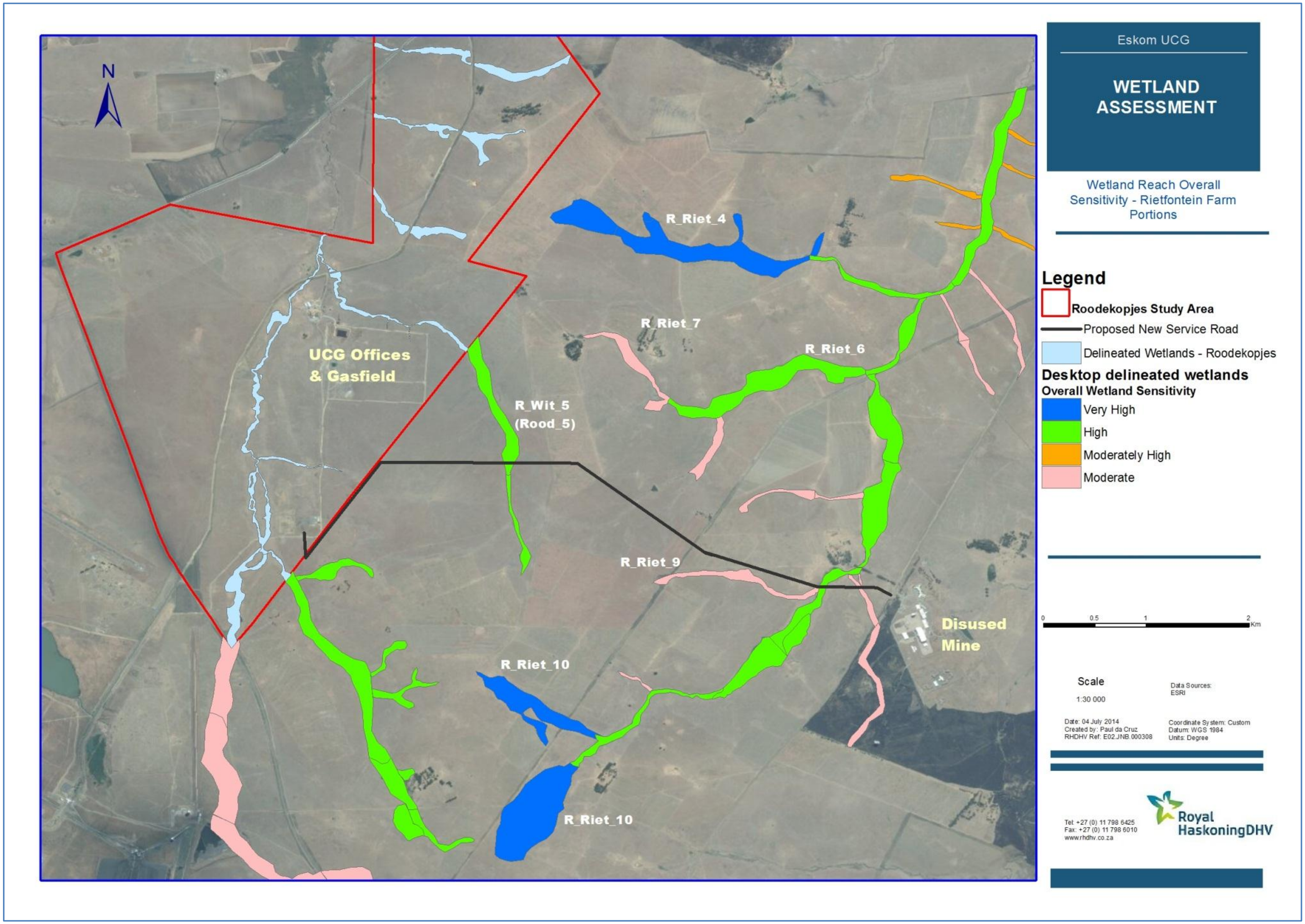


Figure 68 – Sensitivity Assessment for Wetland Reaches on the Rietfontein Farm Portions

The highest class of sensitivity reflects those reaches in the Study Area where the reach displays a high degree of sensitivity, a natural state and displays important biodiversity features. In the next 2 classes down, a high degree of functioning, a natural state or important biodiversity features need to be present; in the 'high' sensitivity class the wetland reach can also be a pan or floodplain and must be located on sedimentary geology (shale or sandstone). In the 'moderately high' sensitivity class reaches displaying one of the highest ratings in the 3 categories of state, functionality and biodiversity features must be located on dolerite.

The highest ratings for wetland functionality, state and presence of important biodiversity features have been used as the three primary categorisation factors as wetlands displaying these characteristics would stand to be most affected if subjected to impacts associated with the proposed development. The two HGM types of floodplains and pan / depression wetlands[4] have been included as a qualifying characteristic for the class of high sensitivity as these are the most uncommon HGM type in the context of the Study Area, and were found to be typically associated with high levels of biodiversity and important ecosystem services. Underlying geology has been used as the characteristic to divide wetland reaches that qualify for either the 'high' or moderately high sensitivity class as wetlands located on sedimentary geology were typically found to have physical characteristics (such as an extensive width and flat terrain) that were associated with a greater degree and number of ecosystem services. Wetlands in the lowest class of sensitivity will not display any high-rating criteria, and are typically the wetlands that have been most affected by pressures, as reflected by their lower classes of wetland state (largely modified or moderately modified).

8.5 Assigning of Buffers

A methodology for assigning buffers based on the evaluated sensitivity of the wetland was formulated as part of the EIA wetland assessment. Following the revaluation of wetlands on the Roodekopjes site, this methodology was applied to the wetlands assessed. The methodology was altered in one respect in terms of the buffer assigned to wetlands falling into the very high sensitivity class; the original methodology stipulated that the entire catchment of the wetland be included as the buffer, however this has been altered to a buffer of 200m. The buffer classes are indicated below.

Table 8 – Wetland Sensitivity Class and Associated buffer widths

Class of Wetland Sensitivity	**Buffer** (i.e. no development, including the alignment of linear infrastructure where possible, irrigation of land with effluent, or undermining of the catchment should be allowed within the buffer zone)
Very High	**A 200m buffer** should be included as part of the buffer
High	**A 100m buffer** beyond the boundaries of the wetland
Moderately High	**A 50m buffer** beyond the boundaries of the wetland
Moderate	

[4] Note that there are no pan / depression wetlands found in the revised study area

The following exclusions must apply to the buffer areas:

- No UCG mining activities should occur within the buffer area – i.e. not undermining should occur in the buffer.
- No associated or linear infrastructure should be placed within the buffer
- No irrigation of land with effluent should occur within the buffer
- The construction footprint should not affect the buffer zone in any way
- No storage areas for hazardous materials (such as fuel), parking areas for vehicles or any temporary toilets should be located within a 50m zone beyond the buffer.

It is understood that in certain areas existing infrastructure would run through the buffer zone. This report has recommended that construction and operational traffic relating to the proposed development use existing roads as far as possible, and as such it is recognised that construction / operational traffic and personnel would access certain buffer areas in this instance. These areas should be carefully monitored by environmental personnel for any signs of impact on the buffer area or the adjacent wetland. Maps of the buffers in different parts of the study area are presented below.

Maps of wetland buffers are indicated in the figure below.

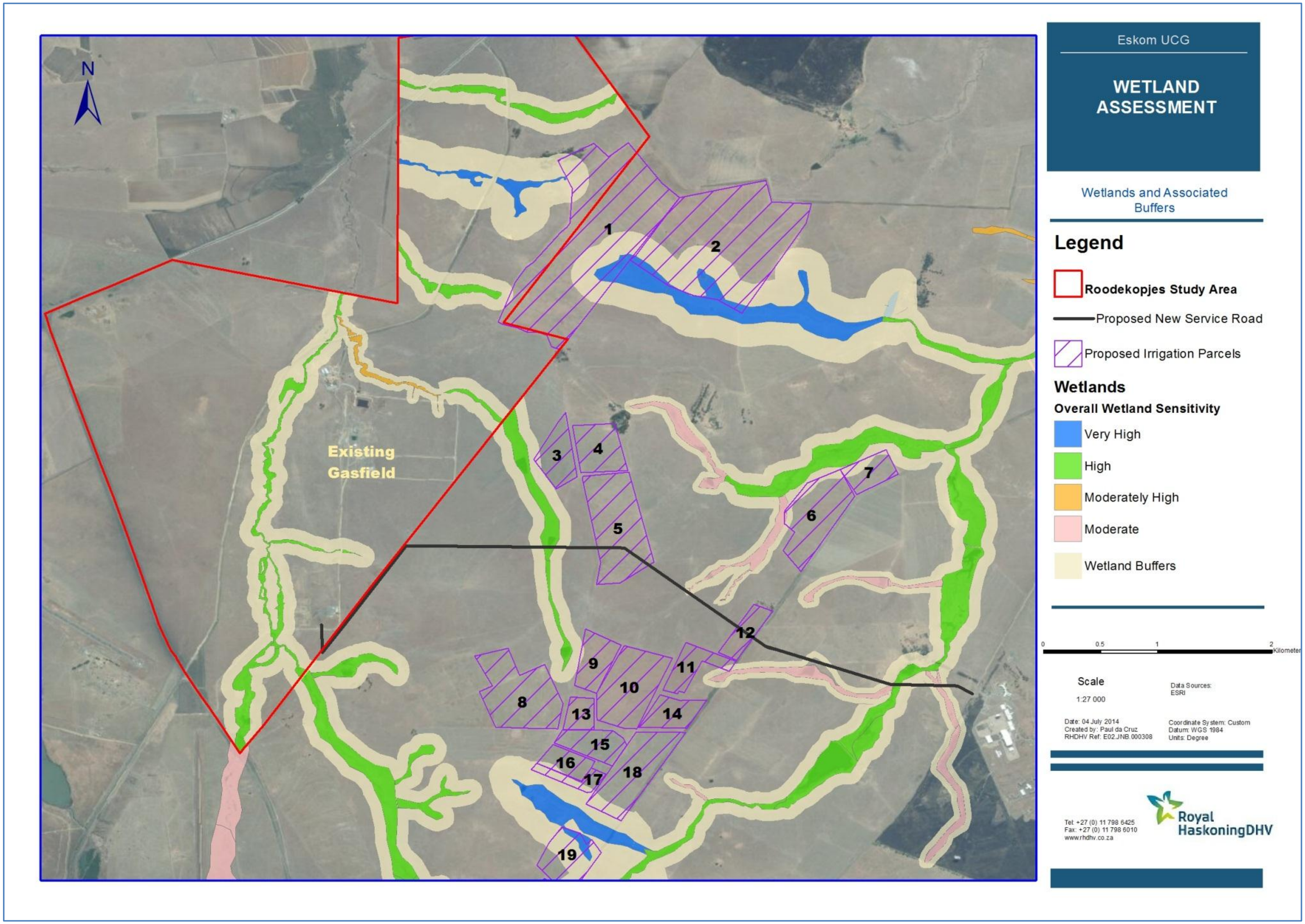


Figure 69 – Wetlands and associated buffers on the development site

9 ASSESSMENT OF THE IMPACT OF THE PROPOSED DEVELOPMENT ON WETLANDS AND ASSOCIATED MITIGATION

9.1 Potential Subsidence due to undermining

One of the most significant impacts potentially associated with the proposed underground coal gasification process is ground subsidence. Subsidence could occur as a result of the gasification of the coal seam that lies deep underground. Subsidence occurs as a result of the gasification of this seam, with the above strata 'collapsing' into the space left by the coal seam.

Subsidence could potentially affect wetlands in a number of ways. Firstly surface water flow inputs could be affected. As described above, once the predominantly vertic soils become saturated, they tend to become highly impermeable, and thus most rainfall falling in an area tends to become surface runoff. Thus in the summer months, the predominant surface water input into most of the wetlands from the area (apart from the flow emanating from the upstream part of the wetland) is likely to be from surface run-off from the immediate catchment. Subsidence could have a critical impact on this dynamic. Information provided by the proponent suggests that up to 0.75m of subsidence could occur. Depending on the spatial extent of the area being undermined in relation to the wetland (i.e. if it underlay the wetland or if wetland areas were excluded from being mined) this could thus potentially result in part of the outer catchment of the wetland subsiding to a level below the ground level of the wetland boundary, or below the ground level of a part of the catchment. This subsidence would presumably form a distinct level difference akin to a micro-escarpment or gulley sidewall. The creation of this level difference would be likely to prevent all above-ground flow from the catchment from flowing into the wetland and any area formerly downslope of the area of subsidence. The level difference could erode back towards the wetland over time if erodible material was exposed (i.e. soils rather than bedrock). This erosion face could erode back into the wetland over time, depending on the composition of the underlying strata that is progressively exposed.

Secondly the subsidence may affect groundwater inputs into wetlands. As described above, groundwater discharge is a critically important feature of the hydrology and associated functionality of many of the wetlands in the study Area, particularly those valleyhead seep wetlands that are situated in dolerite geology. Owing to the nature of dolerite, groundwater discharge to the surface is likely to be as a result of fracturing of dolerite bedrock, with flow paths being likely to occur along these fracture lines. Groundwater discharge may occur where the interface of different strata meets the ground surface. The hydrogeological report for part of the Study Area around the farm Roodekopjes states that groundwater flows are likely to mimic topography (Golder Environmental, 2009), with groundwater piezometric levels becoming shallower and shallower (i.e. the groundwater level getting closer and closer to the surface) as one moves towards the valley bottom. In this context subsidence could disrupt / alter these groundwater flow inputs into the wetlands. Subsidence would presumably affect the entire stratigraphical profile, and could possibly alter / disrupt physical fractures along which groundwater would move. This could result in the re-directing of flow paths so that groundwater discharge no longer occurs into the wetland. If groundwater discharge was to no longer occur in wetlands, this would be likely to have a significant impact on the hydrology of the area and a concomitant impact on wetland ecology and wetland functioning and state. As described above, during low flow periods (i.e. winter) rivers in the area appear to be fed exclusively by base flow (groundwater-fed flow). This baseflow is responsible for the perennial nature of the rivers in the area. The hydro-period of many wetlands in the Study Area would be altered if groundwater inflow was to be removed as a hydrological input into these wetlands. Under this scenario many wetlands would become much drier, resulting in a change in vegetation composition and loss of flora species that depend on the wetland being saturated for relatively long periods. This would have a resultant impact on the fauna in that wetland and may have further knock-on impacts on wetland functioning such as the direct provision of water for domestic use, and in particular on cattle, as critical sources or water and grazing would be lost.

It is very difficult to accurately predict at the level of an individual level how subsidence may affect the input of groundwater into the wetland. The level of impact associated with subsidence on wetlands in the Study Area would depend on a number of factors. In respect of groundwater inputs into a wetland, groundwater flow patterns would need to be modelled to be well-understood. To our knowledge this information is not available at a detailed level for the Study Area, and thus it would be very difficult to accurately predict how the sub-surface hydrology would be affected without this information. More detailed catchment-level modelling of groundwater flows would be required to be undertaken in order to accurately understand how groundwater inputs to wetlands may be retarded at the level of each wetland and its catchment.

The area of ground that is undermined is a significant factor in terms of how both sub-surface and surface flows into the wetland area affected. If the catchment of an entire wetland unit were to be undermined, then the potential impact on surface flows would be likely to be less than if only a portion of the outer catchment were to be undermined (i.e. the outer portion of a catchment beyond the buffer of the wetland as specified above). This would presumably preclude the creation of an artificial level difference where part of the outer catchment would be lower than the reminder of the catchment and wetland itself. The potential impacts on groundwater inputs would be less clear cut, but as groundwater flows are expected to mimic topography, undermining an entire wetland unit catchment would presumably allow this situation to be maintained. Undermining part of a wetland catchment could have potentially significant impacts on hydrological inputs to wetlands as groundwater flow paths could be disrupted and prevented from reaching their current points of discharge.

9.1.1 Implications for development and relevant mitigation / management measures

Overall, undermining could be associated with significant impacts on the integrity of wetlands, especially in terms of their hydrology. There would be a number of likely knock-on impacts, in terms of impacts on the ecological state and functionality of these wetlands. Together these impacts would be greatly likely to diminish the resource quality of wetlands in the Study Area.

In terms of the revised project scope, two options for the undermining of wetlands and their catchments need to be assessed - firstly partially undermining the wetland catchment versus undermining the entire area or local catchment. In terms of technical options, these options would need to be considered against the option that the Eskom project engineers have given of sinking of the wells in such a manner that undermining of surface areas would be unlikely to occur. It is strongly recommended that this technical option be followed, as sinking the wells in such a manner that would avoid any surface / shallow underground subsidence would greatly diminish the impacts on wetlands that would be likely to be associated with the UCG process. Partially undermining wetland catchments would be likely to be associated with the greatest degree of impact to the wetlands, as the surface water and shallow groundwater hydrology of wetlands would be highly likely to be disrupted, due to the wetland and part of its catchment being higher than the outer catchment which would subside. This is least preferred. If subsidence is to be a factor, then the undermining of wetlands and their catchments would be preferred, as this would presumably result in the even subsidence of the ground within the wetland and its catchment, thus precluded parts of the outer catchment of the wetland being lowered. Under this scenario it is uncertain the degree to which groundwater hydrological input to wetlands would be affected. In spite of this option being preferable to the partial undermining, a technical solution that precludes undermining as far as possible is strongly recommended.

If undermining is likely to be a factor, then it is highly recommended that detailed monitoring of shallow groundwater flow paths at the level of individual wetland units be undertaken to improve the assessment of how undermining may or may not affect groundwater discharges to wetlands. This should be undertaken in conjunction with detailed modelling of how subsidence would occur on the ground. Once this information is available, a more detailed local-level assessment of the impact of subsidence on individual wetlands in the area will be able to be undertaken.

9.2 Impacts Associated with Irrigation of Wastewater

In the process of fuel gas extraction associated with the UCG process a large quantity of deep aquifer water and condensate is entrained in the gas stream. Eskom proposes to treat the condensate in an effluent treatment process. Thus the UCG process would generate condensate effluent which contains organic and inorganic impurities and which would need to be disposed of or re-used. Eskom are proposing that the treated condensate stream be considered suitable for irrigation. The water would be used to irrigate land planted predominately with the grass species *Eragrostis curvula* (Golder, 2013). The volume of water produced is expected to peak in 2017 at 126 m^3/day. The produced condensate (liquid) stream is primarily composed of water. The condensate is 97% water and 3% organic (primarily Polycyclic Aromatic Compounds (PMC)) and inorganic impurities. The water will be collected in a centrally located raw water dam. The raw water will be treated using ultra filtration (UF) to remove the bulk of the organic impurities to improve the quality. Eskom's aim is to treat the water in such a way that it could be considered a liquid fertilizer containing ammonium sulphate, potassium and low concentrations of other elements that could be used for irrigation (Golder, 2013).

Eskom's stated preferred method of irrigation is by water tanker fitted with an appropriate spray bar. The Golder Irrigation Feasibility report (Golder, 2013) recommends that irrigation take place on two portions of land (labelled as Agricultural Land 1 and 2) that are located on the farms Roodekopjes and Rietfontein, to the south of the farm portion Weiland 59HS, and to the east of the northerly access road to the UCG current offices and gas field. These two portions of land straddle a higher-lying area (interfluve) between the Witbankspruit catchment to the west and the Skulpspruit catchment to the east, but importantly that incorporate or lie immediately adjacent to a few valleyhead seep and valley bottom wetlands. However site layouts for the proposed irrigation operations indicate a few other parcels of land on which irrigation by effluent is proposed; the implications of irrigation of these parcels of land on wetlands and their buffers is discussed below.

A number of potential impacts of irrigating land with effluent in the context of wetlands exist[5]:

- **Potential hydrology impacts** - The addition of large volumes of irrigated water to the immediate catchments of wetlands and possibly within wetlands themselves could result in increased runoff from the catchment (especially in summer when most of the rainfall in the area falls), thus altering the surface water hydrology of the wetlands and downstream watercourses through increased flows
- **Potential biodiversity – ecological process-related impacts** – The transformation of the catchment of wetland from a natural grassland composition as currently exists, to a sward predominated by *Eragrostis curvula*

There is a concern with the quality of water that could emanate from the irrigated areas and enter surface water or groundwater receptors, thus polluting it. Chetty (2013) has assessed the feasibility of applying treated UCG Condensate effluent for local irrigation from an environmental perspective, including in a water quality context.

[5] One of the potential impacts associated with the proposed irrigating of land would be the pollution of groundwater or surface water if the effluent water is not treated to acceptable standards. However if the water was pre-treated to acceptable water quality levels, this impact would not apply.

The report examined effluent water quality results provided by Eskom and found potential problems in terms of the following parameters (Chetty, 2013):

- In terms of direct discharge of the effluent to a river course in the upper Vaal catchment (in which the study area is located) the levels of sulphate, chloride, total dissolved solids (TDS), electrical conductivity (EC) and phosphate would be unacceptable in terms of the DWA Water Quality Objectives for the Skulpspruit catchment.
- The assessment examined the feasibility of using the effluent for irrigation in a salinisation context and concluded that if the TDS was > 200 mg/l it would preclude the use as irrigation water mainly due to stunted plant growth (whereby more energy is expended by the plant in dealing with the increased salt load in the root system that in the above ground plant growth system) and potential for salinisation as the plant expends pure water through process of evapo-transpiration, more of the dissolved salts are left in the sub-surface.
- Sodification could result if the Sodium (Na) is above 9 mg/l; if the soils contain clay, then in the process of washing and leaching it is possible that only the chloride ion would be eliminated and some of the sodium ions would remain held in an exchangeable form on the clay particles. If the Na ions form more that 15 % of the total exchangeable cation, then clayey soils can become very compacted and impermeable and difficult to irrigate. This would exacerbate an existing problematic quality of the highly impermeable clay on soils on site, as discussed below.
- Lastly in terms of Poly-aromatic hydro carbons (PAH), i.e. compound benzo-a-pyrene effluent containing this contaminant have the potential to contaminate groundwater and surface water. The presence of this compound may prohibit practice of cattle farming or edible crops as the exposure pathway for PAH are through the food chain.

There appears to be a good possibility that this effluent could enter both surface water and groundwater receptors. As detailed in section 7.1.4 above the clayey vertic soils become quickly saturated at the start of the wet season, and due to their high clay content, become effectively impermeable. Thus naturally there is a lot of surface water runoff during rainfall events as opposed to surface water movement within the soil profile. It is thus likely that depending on the quantity and frequency of irrigation, and also depending on the nature of the soils on the sites proposed for irrigation (the Golder Irrigation Feasibility Study (Golder, 2013) recommends detailed soil sampling to accurately determine the nature of soils on the sites), runoff from the catchment areas into the bottomland (valley bottom) wetlands could greatly increase, thus increasing the volumes of water input into wetlands and much of the irrigated effluent could form surface water runoff and thus enter nearby wetlands. Effluent entering the soil profile could also enter groundwater. The soils in the study area are characterised by narrow textured characteristics, thus being within easy reach of the groundwater system (Chetty 2013). The Golder Groundwater monitoring report (Golder, 2009) stated that groundwater recharge by precipitation on the Roodekopjes farm occurs on interfluves, and mimicking topography by moving downslope and discharging into the wetlands in the valley bottoms. The irrigation is planned for such an interfluve, and without the assessment of a more detailed groundwater study, it appears as if there would be a strong possibility that effluent could enter the shallow groundwater system on the site, and thus be discharged into adjacent or downstream wetlands. Effluent containing pollutants as detailed above could thus cause pollution of downstream groundwater and surface water receptors. The potential pollution of downstream surface water resources is very important in both a local and wider catchment context – the Skulpspruit flows into the Amersfoort Dam that supplies the town of Amersfoort with water. In a wider catchment context the study area forms part of the upper Vaal system that is critical in terms of water supply to Gauteng[6].

From a hydrological perspective, the addition of irrigated effluent to the hydrological system could have an impact on the hydrology of local wetlands and rivers / streams. This could create increased flow, which could have

[6] - In both cases the dilution factor may reduce the impact of potential pollutants, but this would need to be assessed as part of a more detailed water quality assessment once final volumes and levels of potential pollutants are finalised.

knock-on impacts in terms of the hydromorphological characteristics or processes of the river / wetland (e.g. increased channelisation) and in terms of the ecological assemblage in the system (e.g. an increase in the composition of obligate hydrophytes) The intensity of such an impact would depend on the volumes and timing of irrigation, as well as factors such as the nature of soils in areas irrigated which would determine how much effluent would be absorbed into the soil profile and how much would run off into adjacent wetlands. The potential for the development of accelerated soil erosion through this increased water input would relate to a number of factors, such as the soil physical characteristics, as well as the degree of vegetation cover.

The Golder Irrigation Feasibility Report (Golder, 2013) has listed the expected effluent amounts created, with $27m^3$/day in the latter parts of 2013 rising to $126m^3$/day in 2014 and 2015. A more detailed hydrological analysis is required to determine the volumes of this water that would be likely to be discharged into nearby surface water drainage, and the volumes that would enter respective catchments on either side of the proposed irrigation areas. When this figure is reduced to consider infiltration and converted to m^3/s (cumecs), split over different catchments and wetland systems this would not appear to be a large amount of water entering the respective drainage systems on the site (half of $126m^3$/day would equate to $0.00073m^3$/s, a negligible overall volume) and thus it would seem that this would be unlikely to have a significant hydrological impact, however this would need to be confirmed by a more detailed hydrological study.

Lastly the transformation of parts of the catchments of wetlands and even parts of certain wetlands on the sites proposed for irrigation through the replacement of the current natural sward that is likely to be dominated by *Themeda triandra* and other grass species such as *Tristachya leucothrix* as well as a variety of forb and bulbous species by a sward dominated by *Eragrostis curvula*. This would represent a significant localised loss of biodiversity that would adversely affect the ecotone and ecological linkages between the wetland and its catchment, potentially having an impact on fauna inhabiting the area. This biodiversity-related impact would presumably be assessed in greater detail in the EIA ecological specialist assessment.

9.2.1 Implications for development and relevant mitigation / management measures

The parcels of land for the proposed irrigation as indicated in the Golder (2013) report are located very close to a number of valleyhead seep wetlands that are located near the boundary of the Skulpspruit and Witbankspruit catchments respectively. All of these are valleyhead seeps, although they all become valley bottom wetlands lower down in the reach. Importantly three of the four wetland systems that rise in close proximity to the proposed site of the irrigation were identified as being of high sensitivity (two – the valleyhead seepage wetlands in the Witbankspruit catchment on the Roodekopjes site – Rood_6 &8) or very high sensitivity (three - R_Riet_4 & R_Riet_10 in the Skulpspruit catchment and Rood_7 on the Roodekopjes Site). As detailed above, this sensitivity has been assigned based on a number of factors, including the wetland state, functionality and biodiversity features. For the two wetlands in the Witbankspruit catchment the high level of sensitivity was based on a natural state of the wetlands and a high degree of functionality. In the case of the all of the very high sensitivity wetlands, the wetlands were assigned a very high sensitivity due to a combination of a natural / unmodified state, a high degree of functionality, and biodiversity reasons including habitat suitable for Red Data-listed species and ecological linkages between wetland and associated natural catchment. In the case of all three of wetlands, the upper part of the wetland reach in the uppermost part of the catchment is highly natural. The two seepage wetlands in the Skulpspruit catchment to the east of the Roodekopjes Site are unusual in the context of the study area in that they take the form of un-channelled, wide seepage wetlands within the geomorphological context of a flat ‘bowl’ in sandstone geology, unlike most of the other valley bottoms in the area that are more incised and more channelised. The vegetation in these wetlands is moribund and diffuse flow occurs in the wetlands. Importantly the wetlands’ respective catchments re highly natural and from the field observation contained a high floristic diversity. The underlying geology of sandstone would suggest that a greater risk of surface-groundwater interaction within these wetlands as opposed to the wetlands on dolerite would exist. In the case of the Rood_7 wetland unit similar extensive areas of seepage habitat exist, as well as the presence of habitat suitable for the grassland owl species.

The presence of these high, and in particular the very high sensitivity wetlands and their associated buffers has important implications for the proposed irrigation of the area with effluent. The buffer recommendation for high sensitivity wetlands is 100m beyond the boundary of the wetland, and for very high sensitivity wetlands 200m beyond the boundary of the reach. This would mean that no irrigation should be allowed to occur in the buffers around the wetlands.,. This has important implications for the area available to be irrigated as shown in the map below. A consideration of moving the area to be irrigated into the catchments of less sensitive wetlands would thus need to be considered in this context.

The Eskom layout for the site indicates a number of other parcels of land on which irrigation could occur or is planned. These parcels are indicated in the map below. The table below lists all of these parcels and how they affect wetlands and the wetland buffers.

Table 9 – Proposed Irrigation Parcels in relation to wetlands and their buffers

Parcel of land	Land Parcel located over a wetland?	Land Parcel Located over a wetland buffer?	Comments
1	Yes	Yes	Wetland is a very high sensitivity & the parcel falls within the wetland and its buffer zone
2	Yes	Yes	Wetland is a very high sensitivity & the parcel falls within the wetland and its buffer zone
3	No	Yes	Only a small part of the parcel falls within the wetland buffer zone
4	No	No	
5	No	No	
6	Yes	Yes	Only a small part of the parcel falls within the wetland and buffer zone
7	No	Yes	
8	No	No	
9	No	Yes	Only a small part of the parcel falls within the wetland buffer zone
10	No	No	
11	No	Yes	Only a small part of the parcel falls within the wetland buffer zone
12	No	No	
13	No	No	
14	No	No	
15	No	No	
16	No	Yes	Wetland is a very high sensitivity & part of the parcel falls within the buffer zone of this wetland
17	No	Yes	Wetland is a very high sensitivity & part of the parcel falls within the buffer zone of this wetland
18	No	Yes	Wetland is a very high sensitivity & part of the

Parcel of land	Land Parcel located over a wetland?	Land Parcel Located over a wetland buffer?	Comments
			parcel falls within the buffer zone of this wetland
19	Yes	Yes	Most of the parcel is located within a wetland or its buffer – wetland is a very high sensitivity wetland
20	No	Yes	Most of the parcel is located within a wetland or its buffer – wetland is a very high sensitivity wetland

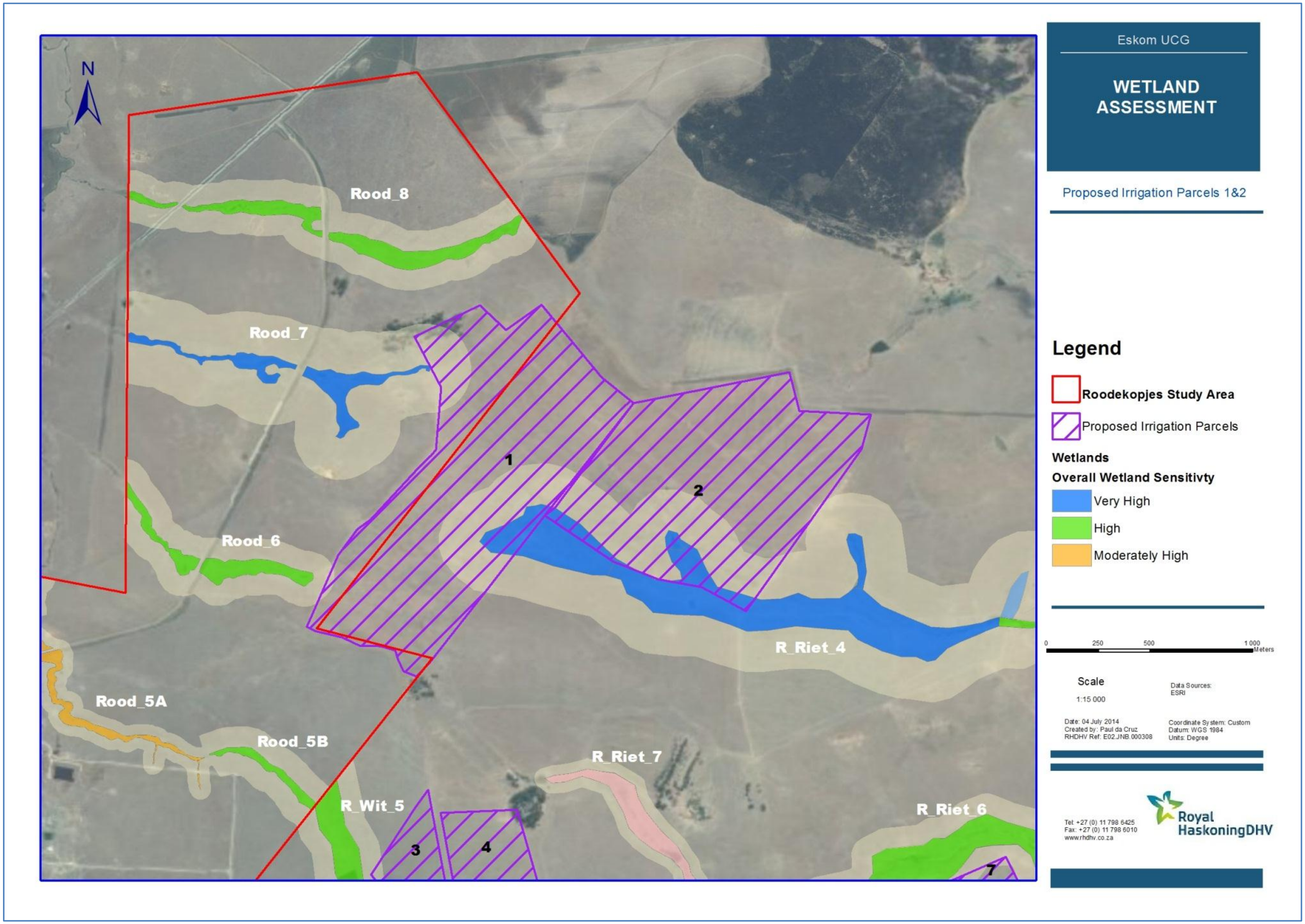


Figure 70 – Location of parcels 1&2 in relation to the adjacent wetlands and their buffers

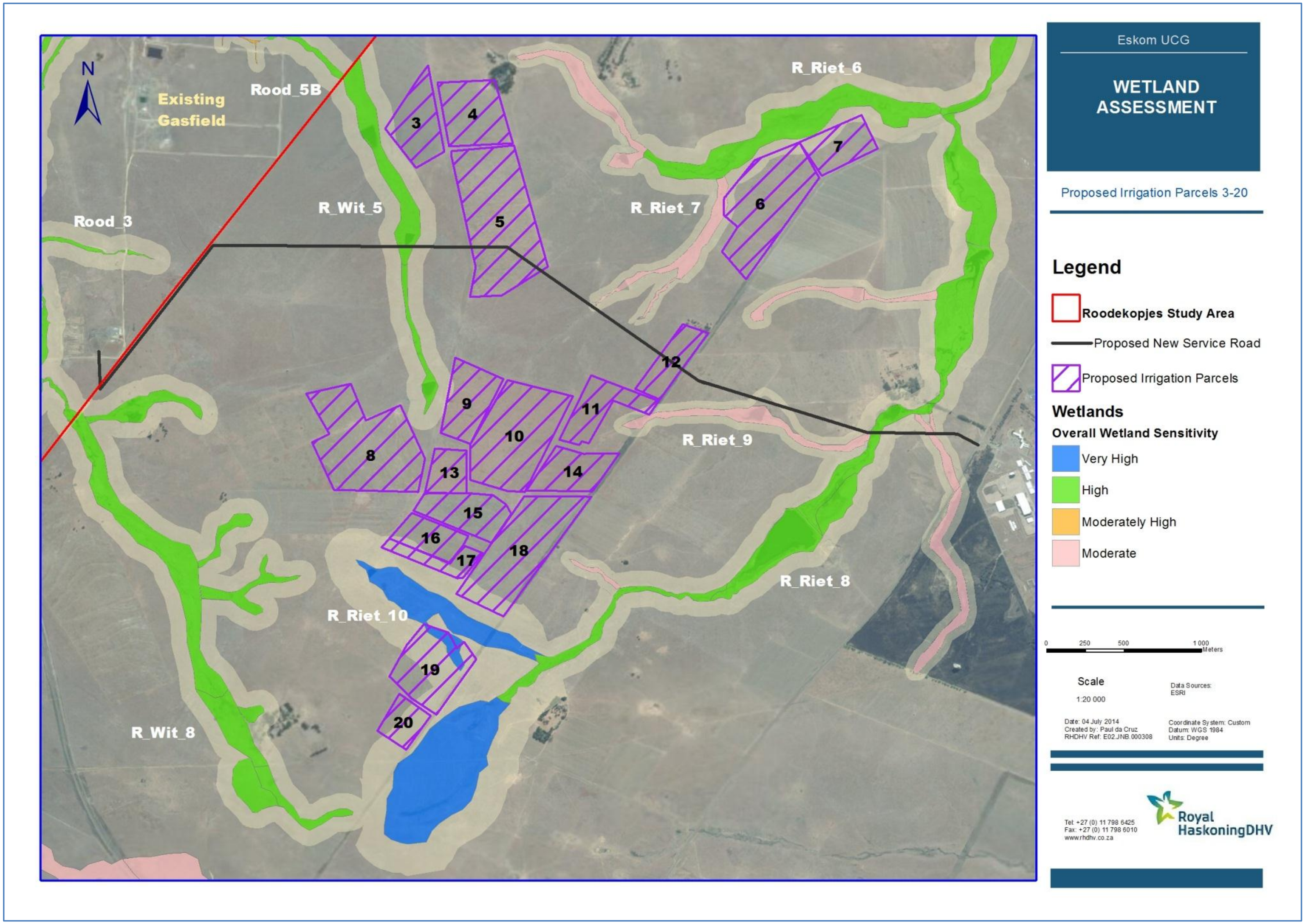


Figure 71 - Location of parcels 3 – 20 in relation to the adjacent wetlands and their buffers

In terms of the above table a number of the parcels are located within wetland buffer areas or more importantly, within the wetland itself. Most importantly a number of the parcels – i.e. 1,2,16,17,18,19 and 20 are located within the buffer of a high sensitivity wetland, or within the high sensitivity wetland (1,2,19). The location of these parcels and the potential for irrigation of effluent within the wetland poses a high degree of environmental risk, and impact on the wetland and downstream watercourses (although these high functionality wetlands would be likely to ameliorate certain of the water quality pollution-related impacts). It is thus strongly recommended that these parcels not be utilised at all for any form of irrigation of wastewater. For the other parcels that marginally fall within the wetland buffer, it is recommended that their areas be revised slightly to fall outside of the buffer area.

In a context of water quality, water quality impacts would be mitigated by releasing effluent devoid of pollutants, and thus treated to an acceptable standard. The assessment undertaken by Chetty (2013) explores a number of measures to reduce the load of certain pollutants, including TDS and management of PAH's. It is beyond the remit of this study to recommend measures for treating the effluent, however it is highly recommended that if the effluent is to be used for irrigation of land within the catchment and immediately adjacent to the buffers of the wetlands on the site, then the effluent should be treated to acceptable levels that would not result in pollution if the effluent were to enter groundwater or surface water receptors.

9.3 Impacts associated with linear infrastructure

Part of the associated infrastructure consists of linear infrastructure, including power lines, roads and pipelines. All of these types of linear infrastructure could potentially be associated with impacts on wetlands. It is understood that the exact alignments of certain linear infrastructure have not yet been determined, and that the Eskom technical team would route this infrastructure based on environmental sensitivities that emerge from the EIA. The generic impacts associated with each type of linear infrastructure are explored, and a comment on the most optimal routing for linear infrastructure is made. In cases where the alignment of linear infrastructure has been provided, this has been assessed.

9.3.1 Impacts relating to pipelines

9.3.1.1 Existing Pipeline on the Roodekopjes Site

It should be noted that an existing gas pipeline runs from the UCG gasfield on the Roodekopjes site south-west towards the Majuba Power Station. Certain activities were conducted on the Roodekopjes without authorisation, including this pipeline crossing of wetlands / rivers. As such the wetland crossings of the pipeline were constructed without any prior environmental input or authorisation. This accordingly resulted in certain impacts on the wetlands crossed – i.e. localised loss of wetland habitat and hydrological impacts on the wetlands crossed due to the presence of an access road along the pipeline, as well as the creation of a physical barrier across the wetlands crossed.

As part of a Section 24G licensing process and a water use licencing process for certain elements of the UCG development on the Roodekopjes Site, the author was appointed to compile a wetland rehabilitation and management plan (da Cruz, 2013) for the wetlands impacted by the existing gas pipeline and associated access road, as well as to address impacts relating to other access roads that crossed wetlands within the Roodekopjes gasfield. The report recommends management and mitigation (rehabilitation) measures to address impacts relating to the unauthorised activities for each wetland affected. The findings of this report have been included as **Appendix 2** of this report.

The existing pipeline crosses two wetlands – the valleyhead seepage wetland Rood_3 (Crossing 6) and the Witbankspruit Rood_2 (Crossing 7). The following impacts were caused by the pipeline and associated access road:

Crossing 6 (Rood_3):

- Ingress of artificial material into the wetland downstream of the crossing.
- Ingress of silt into the wetland due to poor stormwater controls on the road in the immediate catchment of the wetland.
- Concentration of diffuse flows in the portion of the wetland upstream of the crossing through too few culverts being installed.

Crossing 7 (Rood_2):

- The road crossing of the river adjacent to the pipeline only contains one pipe to allow through flow, resulting in the impounding of sediment immediately upstream of the crossing, and effectively impounding flow upstream of the road structure.
- Large boulders placed on the downstream side of the road crossing have slumped into the channel, presumably having been dislodged by spate flows that have overtopped the road structure. This collapsed rock has blocked the pipe outlet on the downstream side, further enhancing the impounding effect of the road
- The eastern bank immediately downstream of the road crossing is being undercut (eroded), and is eroding back towards the nearest pillars holding up the pipeline. This undercutting is part of the natural channel erosion but may be accelerated by the presence of the road crossing that is starving the downstream reach of sediment.
- Sediment and rock from the road substrate and the western bank immediately downstream of the reach has been washed into the immediate downstream reach of the river, and has been deposited on the western bank

Mitigation:

The rehabilitation and management plan report has set out a number of generic and site-specific measures that need to be implemented to ameliorate or correct the impacts detailed above, as well as a set of post rehabilitation management actions. **Please refer to Appendix 2.**

These mitigation measures must be implemented in order to ensure that the wetlands crossed by the existing pipeline are rehabilitated to an acceptable state, and prevented from being further impacted in the future.

Figure 72 – Existing pipeline crossing the Witbankspruit near the demonstration plant

9.3.1.2 New pipelines

It is understood that all new pipelines are likely to be above-ground structures. This entails that the pipeline would be founded on support structures such as pilings / pillars which would have their foundations in the ground. The pipeline would have a permanent footprint where it crosses wetlands, but this footprint would be limited to the area around the support structures. The pipeline would thus have a physical impact on wetlands, but the footprint would be limited.

Pipeline-related impacts could result in both the construction and operational phases. In the construction phase, wetlands would likely need to be accessed by construction crews and machinery to lay foundations for the support structures, and to further construct the pipeline through the wetland. Due to the need to access the wetland with heavy machinery, the most important potential impact of the proposed pipelines on wetlands relates to the disturbance of wetland soils and vegetation. Heavy machinery could compact soils (especially if wet and thus more 'plastic') and destroy vegetation through uprooting. This is a particular risk in the more inundated wetlands where soils are likely to be more vulnerable to compaction and where more sensitive wetland vegetation is located.

Water is an erosive force, and the exposed soils could be eroded, especially in the permanently wet parts of the wetlands where above ground or underground flow / seepage of water through the wetland would naturally occur. If the flow of water and seepage out of the wetland soils was not controlled, this could initiate a 'knick point' which may lead to development of gulley (donga) erosion into the upstream part of the wetland. Any eroded material would be deposited in the downstream portion, potentially causing sedimentation in that part of the wetland which may smother the existing vegetation, and leading to further impacts on this part of the wetland.

Biota in the wetland may be disturbed, but this is likely to be a disturbance that is limited to the length of time of construction through the wetland. Biota is likely to return to the wetland, provided that the habitat integrity remains in a similar state to the pre-construction state.

Other potential construction period-related impacts potentially associated with the construction of pipelines through wetlands are:

- The pollution of water within the wetland, through construction activities
- The incorrect re-instatement of wetland vegetation that may result in the exposing and erosion of wetland soils

In an operational context, the limited physical footprint of the pipeline through the wetland should minimise the impacts associated with the pipeline. The spacing of support structures should allow the surface hydrology of the wetland to be maintained. This factor would also allow the free movement of biota along the wetland.

Impacts may arise if construction-related impacts are not properly mitigated; i.e. if vegetation that is disturbed is poorly rehabilitated, this may result in exposing of soils and may lead to the development of headcut erosion.

Although the alignments of pipeline infrastructure have not been determined, pipeline crossings would be likely to have a greater impact on wetlands that have longer periods of inundation (thus containing a greater proportion of the wetland as the permanent zone) and on wetlands that are wider in width, resulting in a greater footprint in the wetland due to the higher number of support structures that would need to be constructed within the wetland.

It should be remembered that most of the impacts related to the existing pipeline at the wetland crossings on the Roodekopjes Site have been directly created by the adjacent access road (track), rather than by the pipeline itself. In this context all mitigation measures relating to access roads (see section 9.3.4 below) must be applied to any access roads / tracks constructed alongside new pipelines.

9.3.2 Pipeline-related mitigation and management measures

Note: Please refer to the Wetland Rehabilitation and Management Plan Report (Appendix 2) for rehabilitation and management actions relating to the existing pipeline wetland / river crossings on the Roodekopjes Site.

The following mitigation measures should be enforced in the construction and operation of ***new*** pipelines through wetlands in the Study Area:

- Pipeline-related construction must occur in the drier winter months. At this time the predominantly vertic soils will be drier in many parts of the wetland, and less likely to be compacted by machinery. Vegetation is also dormant and less likely to be damaged.

- A form of running track should be constructed through wetlands adjacent to the pipeline alignment, especially if heavy tracked machinery is going to access the wetland to undertake construction. The running track would protect underlying soils and vegetation, especially in wetter parts of the wetland, and would facilitate the access of heavy machinery in these areas
- Pipeline design should take into account the potential for flooding and spate flows in wetlands, especially within valley bottom wetlands and along riverine corridors. Due to the nature of runoff in the Study Area, high flow peaks are likely to occur in most of the valley bottom wetlands in the Study Area. It is recommended that design be undertaken to withstand a 1:100 year flood.
- Alignment of pipelines should aim to cross wetlands perpendicularly to the direction of flow in the wetland, as this is usually the shortest route across the wetland.
- Alignment of pipelines should aim to cross wetlands at their narrowest point, where possible, as wetlands are often channelised at these points, making a single span that does not physically affect the wetlands possible.
- As discussed below, all highly sensitive wetlands should avoid being crossed by pipelines
- Access roads / tracks constructed alongside new pipelines must be subject to the mitigation measures specified for access roads, detailed below.

9.3.3 Impacts related to roads

Roads and their associated impacts are similar in many ways to pipelines. The design of the road crossing across a wetland / river will have a bearing on the degree to which a wetland is affected, with the degree to which the wetland is physically affected or spanned being important.

Roads will be used and required to access different parts of the site during both construction and operation. There is a reasonable network of different types of roads and tracks that cross the Study Area, but it is likely that new roads will need to be constructed to access parts of the site.

Roads may have a much greater physical footprint in a wetland area as substrate may need to be laid and imported into the wetland area. It is unlikely that it would be cost effective for all wetlands to be spanned with a bridge. The two most important types of impacts that would relate to new roads constructed into wetlands relates to the destruction of wetland habitat and vegetation and the alteration of the hydrological regime.

Roads constructed into a wetland would typically involve the placing of imported substrate into the wetland. This would cause a certain area of wetland vegetation to be lost. The presence of the raised road and its substrate typically acts as hydrological barrier to flow in the wetland. This would typically alter the hydrology of the wetland by damming water on the upstream side of the road (making this wetter than a natural situation) and by allowing less water to bypass the road to the downstream section of the wetland, thus drying out the downstream portion. Culverts are typically constructed under a road, through which flow in the wetland / river can bypass it. The number and size of the culverts is an important factor in determining the degree and nature of the hydrological impact on the wetland's hydrological regime. Too few culverts can exacerbate the impounding function of the road. Too few culverts placed under a road tend to concentrate flow under the road, and can result in channelisation of a wetland. This is very important in the context of a wetland where diffuse flow would naturally occur; the reduction in diffuse flow and channelisation of the downstream part of the wetland can have an important impact on the resource quality in the wetland and could negatively affect its level of functionality. In this context the alteration of the hydrology of a wetland can alter the vegetative composition of a wetland, by allowing pioneer non-wetland plant species to establish themselves in an area where the wetland has been channelised and the water table has been lowered.

Roads can also form hard barriers which can hamper the movement of terrestrial biota along the wetland corridor, and even other flying invertebrates such as butterflies. It is thus strongly recommend that culvert design allow for the movement of terrestrial biota through the culvert, and allow enough space for flying invertebrates to easily pass through the culvert.

Roads can also be associated with stormwater inputs into wetlands, especially if the road has an impermeable surface. Stormwater input into a wetland can artificially increase the flow within the wetland, resulting in potential knock-on effects such as scour and erosion. Stormwater may also pick up pollutants that are spilt onto the road surface, especially fuel, oil and other hydrocarbons that could pollute the downstream wetland. Stormwater may also feed silt from the catchment or road surface itself into a wetland.

As the alignment of roads has not been specified at this point in time, other than that of the proposed service road (discussed below), it is not possible to individually assess the impact of roads on wetlands / rivers in the Study Area. A set of generic mitigation measures is provided below for roads.

9.3.3.1 Proposed Service Road

Since the revision of the project scope the alignment of a proposed service road has been specified and included in the project scope. The road would link the Bergvliet district road (that runs past the old mine) with the gasfield and core of the UCG site located to the west. The road would traverse part of the Skulpspruit catchment, and would then run into the Witbankspruit catchment and in so doing would cross four wetlands along its entire length, as well as running immediately upstream of two further wetlands. The wetland crossings are detailed in section 7.4 above.

The western part of the road is aligned across high ground close to the interfluve between the Witbankspruit catchment to the west and the Skulpspruit catchment to the east and thus does not cross any wetlands in the Witbankspruit catchment except for the upper extension of the Rood_5 valley bottom wetland. To the east the road traverses similarly high ground at the top of the Skulpspruit catchment thus not affecting two wetlands on the farm Rietfontein. Close to the mine three valley bottom wetlands near the Bergvliet Road are crossed., it.

The nature of the geology in this part of the study area (underlain by dolerite) entails that valleyhead seeps and the upper parts of valley bottom wetlands are relatively narrow. This accounts for the relatively short length of most of the crossings, which is beneficial as less wetland habitat is typically transformed than if the road were to cross wider wetlands downstream. This is a mitigating factor, along with the road not being proposed to cross any wetlands of very high sensitivity. The aspect of sensitivity typically associated with valleyhead seepage wetlands is the discharge of groundwater into the drainage system. The relatively small footprint of the proposed road across these valleyhead seepage wetlands is likely to entail that any groundwater discharge is not prevented from reaching the downstream part of the wetland provided that culverts / bridge of sufficient volume are incorporated in the design to allow any seepage flow to underpass the road.

9.3.3.2 Mitigation measures for the Service Road

Note: These mitigation measures should be implemented in addition to the generic road-related mitigation measures below.

- It is recommended that structures that span the wetlands (across their entire width) be considered as part of the road design rather than constructing the road substrate into the wetland with the se of piping or culverts. This measure would also allow the potentially high volume spate flows from the surrounding vertic soil-dominated catchments to be accommodated.
- In addition to the generic road-related mitigation measures detailed below, it is recommended that stormwater design along the roads ensure that stormwater is not discharged directly into any wetland crossed, rather being discharged diffusely into areas adjacent to the wetland, with the recommended inclusion of 'soft engineering' features such as grassy swales through which stormwater is passed prior to entering a wetland in order to retard stormwater and trap pollutants being carried by the stormwater.
- For Crossing 6 in the Witbankspruit catchment where the road would cross the wetland at the upper reaches of a dam, in order not to create a significant impact on the wetland – as excavation of saturated wetland soils and the presence of standing water is highly conducive to the creation of silt that can pollute downstream reaches of the wetland – and in order to ensure the stability of the road, it is recommended that consideration be given to breaching the downstream dam and restoring the natural hydrological regime of the wetland immediately downstream of the crossing point.

9.3.4 Generic Road-related mitigation and management measures

The following mitigation measures should be enforced in the construction and operation of roads through wetlands in the Study Area:

- Existing access roads and tracks across wetlands must be used as far as possible, as these are typically associated with an existing impact on a wetland / stream. It is preferable for existing drifts / causeways to be upgraded rather than new road structures built into an un-impacted section of the wetland.
- Where wetlands cannot be spanned by bridges, road design must incorporate a sufficient number and volume of culverts to allow flow within the wetland to pass under the road in as natural a manner as possible; i.e. flow within wetlands should be kept as diffuse as possible where diffuse flow occurs.
- Measures to minimise stormwater ingress into wetlands off roads should be included in the design of the road. Stormwater from a road in the catchment of the wetland should be directed into a deposition / swale area where it can infiltrate the ground and flow slowly into the wetland, and not directly into it.
- Road construction through wetlands must occur in the drier winter months. At this time the predominantly vertic soils will be drier in many parts of the wetland, and less likely to be compacted by machinery. Vegetation is also dormant and less likely to be damaged. There is likely to be less surface flow that could potentially carry silt and pollutants into the wetland, and which could act as an erosive force
- A form of running track should be constructed through wetlands adjacent to the road alignment, especially if heavy tracked machinery is going to access the wetland to undertake construction. The running track would protect underlying soils and vegetation, especially in wetter parts of the wetland, and would facilitate the access of heavy machinery in these areas
- Road design should take into account the potential for flooding and spate flows in wetlands, especially within valley bottom wetlands and along riverine corridors. Due to the nature of runoff in the Study Area, high flow peaks are likely to occur in most of the valley bottom wetlands in the Study Area. It is recommended that design be undertaken to withstand a 1:100 year flood.
- As such temporary rights of way across wetland / riverine areas are strongly discouraged (unless these are associated with construction of a road or pipeline across a wetland) as these could be easily washed away, causing pollution / siltation in the downstream wetland
- Alignment of roads should aim to cross wetlands perpendicularly to the direction of flow in the wetland, as this is usually the shortest route across the wetland.

- Alignment of roads should aim to cross wetlands at their narrowest point, where possible, as wetlands are often channelised at these points. A smaller area of wetland would thus potentially be affected.
- As discussed below, all highly sensitive wetlands should avoid being crossed by roads.
- Formal stormwater management measures must be implemented for all roads constructed on the site, to ensure that roads do not erode and thus feed silt into wetland / drainage systems on the site.
- No stormwater must be directly discharged off a road surface into the channel of a wetland / watercourse on the site; rather stormwater must be discharged into an area adjacent to the road before being discharged into the watercourse. Ideally grassy swales or detention areas adjacent to the discharge point must incorporated into the stormwater design to slow down and trap stormwater prior to entering any surface water feature. The use of soft engineering features in this context is preferred.

9.3.5 Impacts related to power lines

Power lines are not typically associated with impacts on most wetlands and rivers, as the power lines do not have a physical footprint over the length of the power line other than the footprint of each tower position. As the lines are strung above the ground and as the towers are spread approximately 200m apart (although it may vary between 250m and 375m depending on the ground profile and terrain), most wetlands are able to be 'spanned' by the power lines and thus avoided from being physically affected. Power lines can however be associated with impacts on surface water resources if the towers are placed within a river or wetland. The process of constructing the power line can also cause impacts on wetlands, especially if certain mitigation measures and procedures are not followed. These potential impacts are explored in greater detail below.

Towers / electricity pylons are large structures and are require foundations in order for the structures to remain standing. The process of excavating the foundations would disturb the substrate and entail the removal of soil and vegetation from parts of the footprint, as well as the potential damage to vegetation due to the movement of construction machinery in the vicinity. If towers are constructed within a wetland, this activity could potentially adversely affect the wetland soil and vegetation through the compaction of wetland soils, the trampling / smothering of wetland vegetation and the resultant exposure of wetland soils that could result in their desiccation and subsequent erosion.

9.3.6 Power line-related mitigation measures

- Every effort should be made to avoid placing towers in wetlands; however should for any reason a tower be needed to be placed in a wetland a detailed set of mitigation measures to reduce impacts of the tower construction on the wetland should be identified.
- In this instance towers should be placed within the 'drier' temporary zone of the wetland rather than in the more permanently inundated (and thus more sensitive) sections of the wetland. In this event a permit for the placing of the tower in the wetland under Section 21 of the National Water Act would need to be sought from the Department of Water Affairs.
- All relevant Eskom Distribution environmental procedures to mitigate impacts related to wetlands and other surface water resources, especially those impacts related to construction activities and servitude management should be followed. Should these procedures be followed as stipulated in all Eskom power line construction projects, the majority of these impacts will be avoided or reduced to an acceptable level.

9.3.7 Implications of Wetland Sensitivity for alignment of linear infrastructure

The results of the wetland reach sensitivity assessment indicate a few 'nodes' of very high sensitivity wetlands. These wetland reaches and their sub-catchments should be entirely avoided by any new linear infrastructure. It is strongly recommended that no mining activities or irrigation occur within the catchments of these wetland reaches either.

The sensitivity assessment indicates that the valley bottom systems (riverine corridors) along most of the rivers in the wider area have a high sensitivity[7]. This is true for most of the length of the Witbankspruit that runs north-south across the Roodekopjes property and .has implications for the crossing of this river and associated wetland habitat by pipelines and roads in particular. This riverine and wetland corridor should be avoided from being crossed and thus physically affected. It is highly recommended that new roads be built off existing roads, and that no new crossings across the Witbankspruit valley bottom system be built. Pipelines, power lines and roads should be routed along interfluves between valley bottom systems to avoid having to cross any wetlands. The interfluves are generally aligned in a north-south direction in line with the river systems, and thus routing pipelines and roads along these (off the existing road infrastructure) will allow most parts of the Roodekopjes site to be accessed.

9.4 Other Project-related Impacts

9.4.1 Other construction-related impacts

The erection and then operation of mining infrastructure and the construction of other associated infrastructure such as water treatment plants could be associated with other generic construction-related impacts on wetlands / rivers that are detailed below. The most important of these potential impacts relate to:

- A lack of / poor stormwater controls being put in place on the construction site. This may result in the creation of runoff containing pollutants such as cement and oils being transported by stormwater runoff into nearby drainage systems.
- The dumping of construction material, including fill or excavated material into, or close to surface water features that may then be washed into these features.
- Spills of hazardous materials, especially oils and other hydrocarbons that may be washed into, or infiltrate nearby surface water features.
- The conducting of certain construction-related activities (such as cement batching) too close to surface water features or without the implementation of certain controls that may lead to the direct or indirect pollution of the surface water feature.
- The lack of provision of ablutions that may lead to the conducting of 'informal ablutions' within or close to a surface water feature that may lead to its pollution by faecal contaminants.
- The interaction of untrained construction workers with wetlands and water resources, which could result in the washing if equipment in rivers, for example

Most of these and other potential construction-related impacts can be minimised or adequately mitigated by controlling construction activities on the basis of an appropriately designed Environmental Management

[7] This sensitivity designation is supported by the designation of the Witbankspruit channel in the study area as a CBA (Critical Biodiversity Area) River under the recently completed Mpumalanga Biodiversity Sector Plan (2013).

Programme (EMPr). As mentioned above, the relative proximity of the construction activities to surface water features is an important factor in the degree of risk of these construction-related impacts occurring.

These construction-related impacts apply to all of the associated infrastructure discussed above.

9.4.2 Impacts of the UCG process on shallow groundwater

In addition to the impacts discussed above the UCG mining process could potentially be associated with a number of indirect impacts on the water cycle, and thus on wetlands and drainage lines. Should groundwater become polluted through the process, this could result in polluted water being discharged via seepage areas wetlands and downstream rivers. No information has been presented as to whether the process will be likely to cause pollution of groundwater, or whether any polluted groundwater will be likely to interact with surface water receptors. It should be noted that the preliminary hydrogeological report undertaken by Golder Environmental (2009) has not shown that the current UCG operations in the Roodekopjes area are associated with shallow any groundwater quality impacts.

9.4.3 Impacts related to the removal of cattle

It is understood that due to health and safety concerns, all people and livestock would be removed from the areas in which UCG mining would be taking place for the operational life time of the respective mining area. This would entail that the livestock rearing would stop for this period of time. The removal of all livestock from the wetlands and catchments of the wetlands for this period of time is likely to constitute a positive impact on the wetlands on the site. As described in section 4.2 above, cattle are directly and indirectly responsible for most of the wetland degradation in the wetlands of the Study Area. The removal of this factor for an extended period of time will give the wetlands that have been subject to cattle-related impacts a chance to naturally recover, and no further degradation would be likely to occur. This factor would be even more beneficial if during this time certain of the problem areas in the wetlands on the site (especially erosion-related impacts) were able to be rehabilitated. Should environmental offsets for impacts related to the proposed development be required, the rehabilitation of erosion-related problems in wetlands would be an excellent way to achieve this objective. Rehabilitation efforts would be likely to be much more successful in this period without the presence of cattle compared to if cattle were still present.

9.5 Impact Rating Matrix

Each specialist is required to fill in an impact rating table for their respective discipline. The table for wetlands appears below.

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	• Irresponsible construction practices could lead to the pollution of wetlands and rivers (e.g. faecal contamination, or pollution of surface water through hydrocarbons) • Poor stormwater management could lead to the siltation (pollution) of surface waters • Temporary accesses across wetlands / rivers could cause hydrological and morphological impacts and degrade the resource quality	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Construction to be guided by Eskom guidelines for construction • Construction to be monitored by an ECO according to the stipulations of the EMPr • No batching or chemical / fuel storage areas to be located within any surface water feature or associated buffer • A construction stormwater management plan to be devised to prevent silt ingress into surface water features • No temporary construction accesses to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a construction activity	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	**Operational Activities (Gasification)** • Gasification activities could lead to the subsidence of parts of the wetland catchment that are undermined, causing parts of the outer catchment to be lower than the inner catchment, significantly impacting surface and sub-surface (including groundwater) flows into the wetland • Spills of any pollutants such as hydrocarbons due to leakage of infrastructure may cause pollution of nearby surface water features	**Extent:** Local (-2) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Probable (-3) **Significance: High (-12)**	• Gasification (sinking of wells) should be designed in such a way that subsidence is greatly limited or does not occur • If the above is not possible, consideration of undermining of entire wetland unit catchments to ensure even subsidence across the catchment and not disrupt surface flows & sub-surface flows from the catchment into the wetland • Leakage detection system to be implemented to ensure that leakage of hydrocarbons do not enter wetlands • Leakage rehabilitation and clean up procedures to be put in place	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**
	Irrigation of parcels of land with effluent • Irrigation of areas of wetland catchments and some wetlands themselves could cause pollution of the wetland and downstream water bodies if the effluent contains pollutants, thus affecting the resource quality • Transformation of wetland catchments with the introduction of a single cultivated species would affect the ecological integrity of the ecotone	**Extent:** Local (-2) **Duration:** Long Term (-3) **Intensity:** Moderate (-3) **Probability:** Probable (-3) **Significance: Medium (-11)**	• Ensure that effluent does not contain any pollutants / acceptable levels of pollutants • No irrigation must occur within the wetland or within the buffer of the wetland	**Extent:** Site (-1) **Duration:** Long Term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	between the wetland and its catchment			
	Linear Infrastructure • Roads constructed across wetlands could adversely affect the hydrology and morphology of wetlands, primarily by creating channelisation • Access of machinery for pipeline and power line maintenance could damage wetlands • Pipeline leaks / failures within wetlands or their catchments could pollute the wetland with hydrocarbons	**Extent:** Local (-2) **Duration:** Long Term (-3) **Intensity:** Moderate (-3) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Avoid routing all linear infrastructure through wetlands, rather running it along interfluves • Strict control of machinery access into wetlands for maintenance purposes • Access roads crossing wetlands should cross at their narrowest points, and importantly perpendicular to the flow and not obliquely through the wetland • Leakage detection system to be implemented to ensure that leakage of hydrocarbons do not enter wetlands • Leakage rehabilitation and clean up procedures to be put in place	**Extent:** Site (-1) **Duration:** Long Term (-3) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Medium (-7)**
Decommission-ing	• Removal of pipelines from wetland (crossings) could result in spillage of pipeline contents (hydrocarbons) into wetlands, thus pollution of the wetland would result • Entrance of machinery into wetlands could damage wetlands, affecting the resource quality • Irresponsible and uncontrolled decommissioning (construction) practices could cause pollution of the wetland	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Decommissioning to be guided by Eskom guidelines for construction / decommissioning • Decommissioning to be monitored by an ECO according to the stipulations of the EMPr • No temporary accesses to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a decommissioning activity	
Cumulative	• Impacts on individual wetland (units) across the site could result in an important cumulative impact on respective catchments (e.g. the Skulpspruit and Witbankspruit catchments) • Pollutants released into numerous wetlands through activities could result in downstream impacts • Subsidence in a number of catchments across the study area could result in cumulative levels of wetland		• Refer to activity / phase specific mitigation measures above	

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	(hydrological) transformation across the catchment and could result in downstream hydrological impacts			

10 CONCLUSIONS

Wetlands are found extensively across the Study Area. These can be divided up into a number of different hydrogeomorphic forms, the most common of which is the channelled valley bottom wetland and the valleyhead seep. There are a number of drivers of wetland physical characteristics, the most important of which are geology and soils. Landuse has been responsible for the relatively low anthropogenic impact on wetlands, and most wetlands have been assessed to be in a largely natural or natural state. Wetlands provide different types of, and levels of ecosystem services; these can be collectively assessed to assign an overall level of functionality to each wetland reach. The most important aspects of wetland functionality are the provision of water and grazing for cattle, erosion control and streamflow regulation. Many wetland reaches in the Study Area provide suitable habitat for rare / endangered (Red Data-listed) fauna. Based on a comparative assessment of a wetland reach's state, functionality and presence of important biodiversity features, the wetland reaches have been able to be categorised into four classes of sensitivity from very high to moderate sensitivity.

The proposed UCG mining process could potentially be associated with a number of impacts on wetlands in the Study Area. The most important impact is potential subsidence of ground in the wetland's catchment due to underground mining activities. This could have critically important impacts on the hydrological inputs into wetlands (both surface and groundwater) that could have significant knock-on impacts in terms of the biological make-up of wetlands, their state and associated ecosystem services provided. As no detailed modelling of the likely subsidence, or associated impacts of subsidence on groundwater inputs into wetlands at a wetland reach level, it is not possible to assess how subsidence could affect individual wetland units; this modelling is required to be undertaken. It is strongly recommended that the UCG mining methodology be undertaken in a way that no / minimal subsidence would occur.

A proposal to use wastewater (effluent) from the gasification process to irrigate parcels of land within certain parts of the study area could exert significant impacts on certain of the wetlands in the study area as these land parcels on which irrigation is proposed occur immediately adjacent to, or in some cases even within the wetland. The irrigation of this land with effluent could introduce pollutants into the wetlands, and the conversion of wetland catchments to singular grass species would have an impact on the ecological integrity of the ecotone between the wetland and its catchment. Importantly the preferred site for irrigation occurs within the catchment of, and immediately adjacent to a very high sensitivity wetland, and thus the potential impacts would be even more potentially significant. In order to avoid such impacts, no irrigation of land within the buffer areas of wetlands must be undertaken.

Other potential impacts relating to the UCG process relate to potential construction impacts, impacts associated with the creation of linear infrastructure (i.e. roads, pipelines and power lines) and impacts associated with the removal of livestock from the area during the mining operational period. Recommendations in terms of the alignment of linear infrastructure have been made, with the key recommendations being:

- existing roads be used as much as possible to access different parts of the area
- very sensitive wetlands and their catchments must be avoided
- linear infrastructure should be aligned along interfluves to access different parts of the Study Area

Another key mitigation measure relates to the creation of buffer zones beyond the wetland boundaries. Different buffer zones have been assigned based on the wetland sensitivity assessment:

Class of Wetland Sensitivity	Buffer
Very High	**A 200m buffer** beyond the boundaries of the wetland
High	**A 100m buffer** beyond the boundaries of the wetland
Moderately High	**A 50m buffer** beyond the boundaries of the wetland
Moderate	

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APPENDIX 1:

Wetland Delineation Methodology for the UCG Site

11.1 Introduction

Vertic soils are predominant in the study area. Vertic soils present a number of problems for wetland delineation, especially where uniform vertic clay soils with no differentiation in terms of the lower horizons between the in-wetland and non-wetland areas exist. This is further complicated by the absence of any visible redoximorphic features in the vertic soils. Vertic soils, even those that appear in wetlands, do not typically display redoximorphic features in the form of yellow or red/orange mottles. This is due to their high (alkaline) ph. status ≥8. Thus the usual soil wetness indicators do not apply to most of the wetlands in the study area, including the larger valley bottoms in which clear wetland vegetation and habitat exists. Two soil forms that are characterised by the upper-most (A) horizon being vertic occur in the South African soil classification system. The first, the Arcadia soil form, is defined as a vertic A horizon over unspecified material and the second, the Rensburg soil form, is characterised by a vertic A horizon underlain by a G horizon. The Rensburg Soil Form is listed as a wetland soil form by the DWA wetland delineation guidelines, while the Arcadia form is not. The Rensburg soil form is most likely defined as a wetland soil form due to the presence of a G horizon, which is a typical wetland horizon. Although the G horizon can occur at depths much lower than 50cm, the presence of the G horizon in the soil form qualifies it as being a wetland. Problematically however in a wetland delineation context, Rensburg Soil Forms occur widely across the area and are not only restricted to parts of the landscape in which wetlands commonly (i.e. they are not only restricted to valley bottoms or seepage areas) (Johan van der Waals, pers. comm.). Thus it is difficult for soil form to be used in this setting as the basis on which to delineate wetlands.

The absence of an upper soil horizon showing signs of wetness (i.e. the absence of redoximorphic features in these soils) coupled with the uniformity of soils from valley bottom to crest and the wide occurrence of the Rensburg soil form on the site make wetland delineation based on soil wetness and soil form characteristics alone in parts of the Study Area underlain by vertic soils highly problematic. Soil wetness and soil form characteristics cannot be used to practically delineate wetland areas as the entire landscape could be either delineated as a wetland, or non-wetland. Accordingly other wetland indicators – i.e. vegetation, terrain and hydrology – need to form the basis for a wetland delineation methodology for the Roodekopjes site.

Vertic soils on the site are typically underlain by, and are derived from dolerite. Due to the presence of areas underlain by both dolerite and shale in the study area, vertic soils are unlikely to occur exclusively on the site, and thus areas in which the standard DWA wetland delineation methodology can be applied do occur on the site. Accordingly the wetland delineation methodology for the site has been split between areas on which vertic soils occur, and on which non-vertic wetland soils occur. The presence of vertic soils will need to be determined in the field (as soil form occurrence can be highly variable), however as a rule of thumb, the underlying geology – as detailed on the Council for Geoscience 1:250,000 scale geological maps of the area – can be used as a guideline to determine where vertic soils are likely to occur. Where areas of dolerite bedrock occur vertic soils will likely predominate, while on areas of shale or sandstone geology, non vertic soils will be likely to occur. The map below indicates areas of differing geology on the site

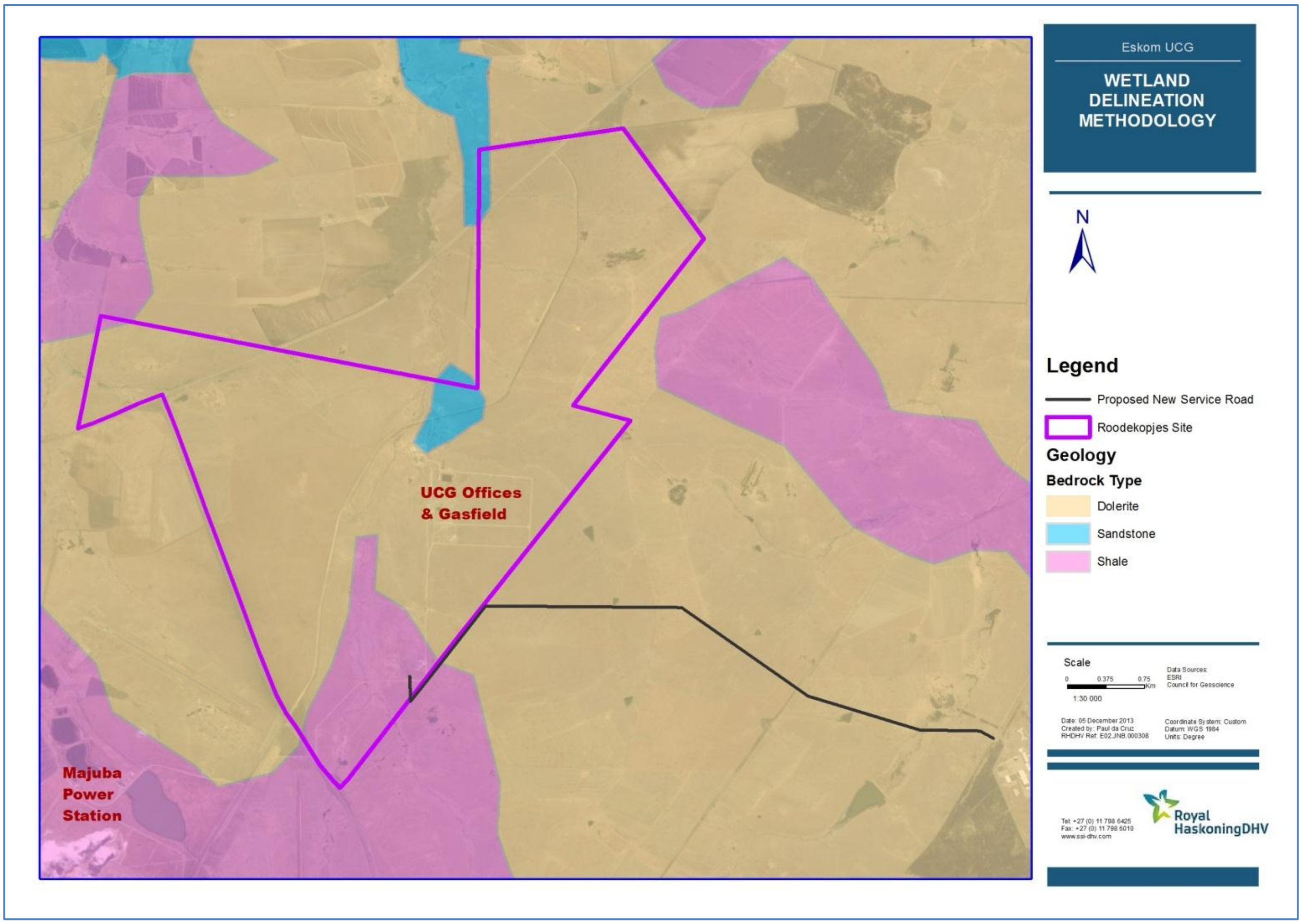

Figure 73 – Geology on the Roodekopjes Site

11.2 Delineation Methodology for Vertic Soils

The delineation methodology for parts of the UCG site in which vertic soils occur is based on analysis of three indicators:

- Vegetation
- Terrain unit
- Hydrology

11.2.1 Vegetation Indicator

The vegetation methodology is based upon the vegetation assessment methodology presented in Kotze and Marneweck (1999). This methodology uses the relative dominance of facultative and obligate wetland plant species at the sample location to determine whether an area is likely to be a wetland or not. A number of wetland hydrophytes (species) are listed, which are divided into two groupings:

- **Obligate wetland (ow) species**: almost always grow in wetlands (>99% of occurrences).
- **Facultative wetland (fw) species**: usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas.

The Kotze and Marneweck (1999) methodology presents a list of plant species (grass, rush and sedge species) occurring in the upland areas of the eastern Seaboard and in the Highveld which indicate wetland conditions. This list has been slightly modified to reflect species composition in the study area, as assessed during the EIA wetland specialist study for the UCG project. The vegetation methodology requires that vegetation zonation be clearly visible between wetland and non-wetland areas. This is largely evident in the study area; the catchments in these areas of vertic soils are relatively natural and untransformed by landuse factors such as cultivation, and thus a natural vegetation gradient still exists. Many wetlands display a vegetative transition between the *Themeda triandra*-dominated catchment and the margin of the wetland where hydrophytic species occur, with typical hydrophytes dominating the central or wettest parts of the wetland. The Kotze and Marneweck vegetation methodology can thus be applied with confidence in this context.

The methodology for vegetation assessment and the list of wetland hydrophytes are presented below.

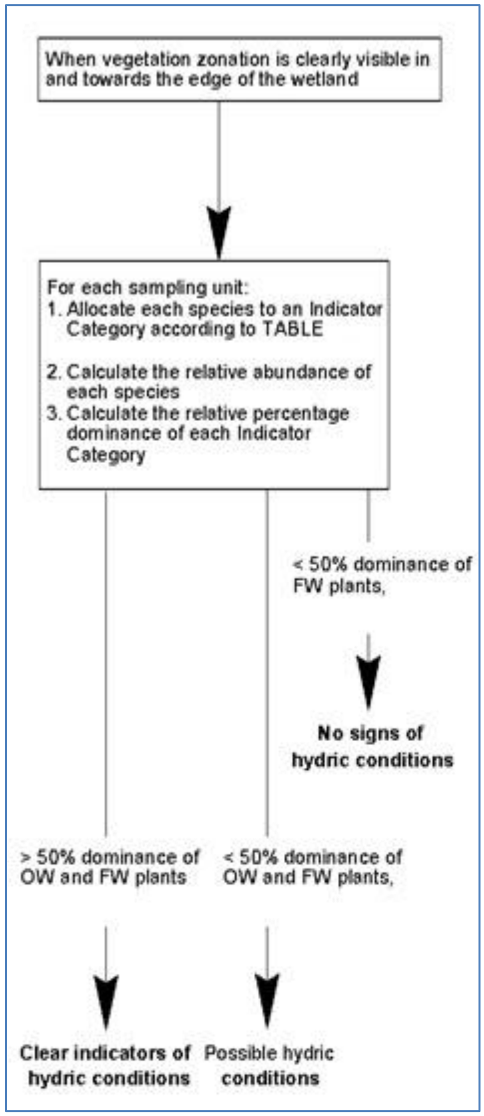

Figure 74 – Vegetation Indicator wetland delineation methodology (Kotze and Marneweck, 1999)

Table 10 - Grass, rush and sedge species which indicate wetland conditions (modified from Kotze and Marneweck, 1999)

POACEAE (GRASSES)	
Agrostis eriantha fw	CYPERACEAE (SEDGES)
Agrostis lachnantha ow	*Ascolepis capensis* ow
Andropogon appendiculatus fw	*Bulbostylis schoenoides* ow
Andropogon eucomis fw	*Carex acutiformis* ow
Arundinella nepelensis fw	*Carex austro-africana* ow
Brachiaria eruciformis fw	*Carex cognata* ow
Diplachne fusca ow	*Carex glomerabilis* ow
Echinochloa crus-galli fw	*Cyperus denudatus* ow
Echinochloa jubata fw	*Cyperus difformis* ow
Eragrostis lappula fw	*Cyperus fastigiatus* ow
Eragrostis plana fw(dry climate); f (wet climate)	*Cyperus latifolius* ow
Eragrostis planiculmis ow	*Cyperus longus* fw?
Festuca caprina fw	*Cyperus marginatus* fw
Fingerhuthia sesleriiformis ow	*Cyperus sexangularis* fw
Helictotrichon turgidulum fw	*Cyperus sphaerospermus* ow
Hemarthria altissima fw	*Eleocharis acutangular* ow
Imperata cylindrica w(dry climate); f(wet climate)	*Eleocharis dregeana* ow
Ischaemum fasciculatum ow	*Eleocharis limosa* ow
Koeleria capensis fw	*imbristylis complanata* fw
Leersia hexandra ow	*Fuirena pubescens* ow
Miscanthus capensis fw	*Isolepis costata* ow
Miscanthus junceus ow	*Isolepis fluitans* ow
Panicum coloratum fw	*Kyllinga erecta* fw
Panicum hymeniochilum ow	*Kyllinga melanosperma* ow
Panicum repens ow	*Kyllinga pauciflora* ow
Panicum schinzii fw	*Mariscus congestus* fw
Paspalum dilatatum fw	*Mariscus solidus* ow
Paspalum distichum ow	*Pycreus cooperi* ow
Paspalum scrobiculatum fw	*Pycreus macranthus* ow
Paspalum urvillei fw	*Pycreus mundii* ow
Pennisetum macrourum ow	*Pycreus nitidus* ow
Pennisetum natelense ow	*Pycreus unioloides* ow
Pennisetum sphacelatum ow	*Rynchospora brownii* ow
Pennisetum thunbergii ow	*Schoenoplectus brachyceras* ow

Pennisetum unisetum fw	*Schoenoplectus decipiens* ow
Phalaris arundinacea ow	*Schoenoplectus paludicola* ow
Phragmites australis ow	*Scirpus burkei* fw
Setaria sphacelata fw	*Scirpus ficinioides* fw
Stiburus alopecuroides fw	*Scleria dietelenii* ow
	Scleria dregeana ow
	Scleria welwitschii ow
JUNCACEAE (RUSHES)	*Scleria woodii* ow
Juncus dregeanus w	
Juncus effusus w	TYPHACEAE (BULRUSHES)
Juncus exsertus/oxycarpus w	*Typha capensis* w
Juncus krausii w	
Juncus lomatophyllus w	
Juncus punctorius w	
Juncus tenuis w	

11.2.2 Terrain unit indicator

Terrain unit is typically a good indicator of wetland occurrence as wetlands occur in parts of the landscape where water would typically collect – i.e. in depression areas in valley bottoms. Most wetlands occur as valley bottom units. However depressions can occur on other terrain units in the landscape, including crests and footslopes. Lastly wetlands are not necessarily limited to depressions, and can occur as seepage areas on slopes.

However micro-terrain is equally as important, and should be examined as part of the terrain unit indicator. Previous assessment experience on the site shows that micro-terrain in vertic soil settings in the study area is an important indicator of wetland habitat occurrence, with valley bottom wetlands being narrow features, and being typically defined by a clear macro-channel within which wetland habitat typically occurs. In many cases wetland habitat appears to be confined to this relatively narrow macro-channel, with hydrophytic vegetation being confined to the channel bed and to the banks of the macro channel (in terms of the banks, seepage was noted in many cases emanating from area between the top of the macro channel bank and the channel bed). This vegetative-morphological template appears to extend up into the head of wetland units in valley heads. Thus in the context of narrow valley bottom and valleyhead seepage wetlands in the study area, micro-terrain is a useful indicator of the extent of wetland occurrence.

It should be noted that the terrain unit indicator is a confirmatory indicator, and the vegetation indicator takes preference. Thus wetlands should not be determined to be limited to valley bottom depressions (macro channels), and the vegetation indicator should take preference. In practice, in the case of narrow valley bottom and valley head seepage wetlands, the terrain unit indicator (especially micro terrain) should be used to preliminarily identify wetland extents, to be confirmed by assessment of the vegetation indicator. In any cases where vegetation cannot reliably be used (e.g. if vegetation has been burnt or transformed), the terrain unit indicator along with the hydrological indicator should be used to determine the extent of the wetland.

11.2.3 Hydrology Indicator

The hydrology indicator is not used as a primary indicator in the DWAF wetland delineation guidelines, but in the absence of soil-related indicators can be used as a confirmatory indicator in the context of the UCG site, especially as the vast majority of wetland / drainage features in the study area are channelled.

The hydrology indicator makes an association between wetland occurrence and hydrological activation (degree of soil saturation related to the presence / absence of the water table). The assumption made is that in channel reaches with a perennial flow (C sections) , or in those channels with a fluctuating water table (B sections), wetland habitat is likely to be present due to the hydroperiod that would be sufficient to alter the characteristics of soils to make them hydric. Conversely channel reaches where baseflow never occurs (A sections) are unlikely to be wetlands. Groundwater seepage occurring at the head of wetland systems is an important factor in providing baseflow within the downstream wetland system. The presence of baseflow within a channelled wetland reach is an important indicator of the likelihood of wetland habitat within that system. Caution must be applied in terms of the seasonality of flow – in summer flows within wetland channels may reflect surface water inputs following rainfall events (due to the high degree of runoff associated with vertic soil catchments). Conversely in winter lower water tables may deprive certain reaches in which soils are subject to baseflows of flow, thus professional discretion needs to be used.

The presence of active seepage, especially in hillslope seepage compartments, or in valley heads, is also a reliable indicator of wetland habitat, as hydrophytic vegetation is typically found in these areas.

Like with the terrain unit indicator, the hydrology indicator is confirmatory, with the vegetation indicator being the primary indicator.

11.3 Delineation Methodology for non-vertic soils

The standard DWA wetland delineation methodology must be used for non-vertic soils – i.e. the primary indicator must be the soil wetness (presence / absence of redoximorphic features) and the soil form indicator. Vegetation and terrain unit can be used to confirm the results of the soil assessment, and as with the vertic soils methodology, the hydrology indicator can also be used in a confirmatory capacity.

11.4 Applying the wetland delineation methodology in practice

The following steps are recommended in delineating wetlands on the UCG site:

Desktop delineation:

Step 1 – high resolution aerial imagery should be analysed (in conjunction with the delineated wetland boundaries as created by the EIA wetland specialist study), in order to identify all potential areas of wetland occurrence in the study area. The desktop delineation assessment should aim to identify all areas of natural vegetation associated with valley bottoms and valley heads, as well as other locations which show a change in colour / texture from the surrounding grassland vegetation that could be reflective of wetland occurrence. The primary deliverable of this step should be a wetland delineation shapefile to be ground-truthed in the field

Field Assessment

Step 2 – Field assessment should be started at the downstream end of each wetland reach. Transects laterally across the wetland system should be conducted at an interval of at least 200m, ensuring that all transects be geographically referenced (use of a GPS). Prior to starting the transect, the likely nature of soils in the wetland reach being assessed must be determined (i.e. vertic or non-vertic). The geological map of the study area can be used to determine the underlying bedrock and resultant likely soil properties. This can be confirmed through examination of exposed soil profiles (e.g. channel banks, etc.) or soil augering. Based on the nature of soils, the delineation procedure for vertic soils or non-vertic soils must be applied to the transect.

(Note: the steps below reflect delineation methodology for vertic soils)

Step 3 – Each transect should be started at the centre of the wetland (i.e. the wettest point) or in the wetland channel bed, and the assessor must move outwards, sampling at regular points where the vegetation, or topography is noted to change. In addition to vegetation, hydrology and terrain unit must be examined at each sample point. With vegetation being the primary indicator, the vegetation at the sample point must be identified and described in detail; the relative percentage dominance of each Indicator Category must be calculated. Hydrology and Terrain unit must be assessed to confirm the findings of the vegetation indicator assessment. The boundary of the wetland (as determined by vegetation – i.e. where the relative dominance of hydrophytes indicates that the soils are not likely to be hydric, and confirmed by hydrology and terrain unit) must be noted.

Step 4 – The same process must be conducted on the far side of the wetland in order to determine the far-side boundary of the wetland.

Step 5 - The assessor must walk along the contour along which the wetland boundary was assessed to occur, noting changes in vegetation or other factors such as the presence of seepage that would indicate a change in the wetland boundary. Sampling must be undertaken if a significant change from the conditions is not, otherwise the transect must be repeated 200m upstream.

Post-field assessment

Step 6 – Once the wetland boundaries have been recorded in the field, the GPS boundaries must be plotted in GIS and the wetland boundary shapefile refined to reflect the wetland boundary as delineated in the field.

APPENDIX 2:

Findings and Recommendations of the Wetland Rehabilitation and Management Plan Report for the unauthorised wetland crossings on the Roodekopjes Site (da Cruz, 2013)

12 WETLAND REHABILITATION PLAN

12.1 Overall Objective of Rehabilitation of Wetlands affected by Crossings

It is important to establish the overall objective of rehabilitation, as this will guide the actions needed to be taken as part of the rehabilitation and management of the six existing (currently unauthorised) crossings on the site.

The six crossings are all road crossings on the site of the existing UCG operations on the Roodekopjes farm. These roads were constructed approximately five years ago when the UCG operations commenced. Four of the crossings (crossings 8, 9, 11 & 12) are crossed by internal roads access roads on the gasfield, while crossings 6 and 7 are located along the access road that runs along the above-ground gas pipeline. It is understood that all of these roads are important for the continued operations of the UCG on the site (to access the pipeline and in order to access the gasfield), and thus it is important to note that these roads are not able to be decommissioned and the affected wetlands fully rehabilitated.

Accordingly the overall objective of the rehabilitation of these six road crossings is to restore the wetlands / rivers crossed to a state as close to natural as possible, while retaining the presence of the roads. In this context the aim of the rehabilitation actions is to remediate impacts of the road on the hydrology, morphology, and vegetative structure of each wetland crossed as fully as possible.

Luckily in four of the six cases the spatial extent of the crossing across the wetland is spatially very limited, and these four crossings occur in the context of being located near the head of two very narrow valleyhead seepage wetlands which are characterised by a relatively high degree of bedrock outcropping within the wetland, the presence of vertic soils and which are characterised by a hydroperiod of limited saturation and limited deposition (rather the wetlands are conduits for the drainage of overland flow from the surrounding small catchment areas). These factors, in particular the presence of extensive bedrock outcropping and the presence of vertic soils entail that these wetlands are more resilient to impacts associated with road crossings than other wetland types, and it could be argued that these four crossings are less sensitive than crossings 6 and 7. The most important impact of the road in these settings relates to alteration of the hydrology of the wetland in preventing the free flow of drainage down the system due to the impounding effect of the road that has resulted from the provision of insufficient volume within the drainage pipes under the road. Accordingly for these four crossings the primary rehabilitation objective is to restore the hydrology to a regime as natural as possible, i.e. allowing flow in the system to easily underpass the road crossing. Limited alteration of wetland vegetative cover and composition was noted and limited effects on morphology were noted; nonetheless these aspects are addressed as part of the rehabilitation measures for each crossing.

Crossing 6 and 7 are more sensitive for varying reasons; crossing 6 occurs in the context of a valleyhead seepage wetland with active seepage that is characterised by dense grassy vegetation in a more steeply sloping context. Crossing 7 crosses the primary wetland unit on the site – the valley bottom floodplain of the Witbankspruit. The presence of floodplain components to this wetland unit engenders it with a high sensitivity value. The Witbankspruit is a perennial river and although baseflows in the dry winter months are much reduced, it can be prone to spate flows of significant volumes during rainfall events due to a high runoff component from the surrounding catchment. The wetlands at crossings 6 and 7 both contain areas of active bank / gulley erosion, and remediation of this erosion has needed to be considered. The primary rehabilitation objective for these two crossings is likewise to restore as natural a hydrological regime as possible, but with stronger emphasis on restoring the pre-impacted morphological state of the affected river channel in the case of crossing 7 in particular.

12.2 Generic Actions

A number of generic actions and rehabilitation principles apply to all of the six crossings. These are listed below.

12.2.1 Works recommended to occur during the dry season

Due to the strong seasonality of rainfall, significantly lower volumes of surface water drainage occur within the wetland and river systems in the study area during the dry winter months. From both an environmental and technical perspective, it is optimal to construct in-river or in-wetland works when flows are minimal, as this makes for an easier and safer working environment. Most importantly however from an environmental perspective a drier hydrological setting is associated with a lower risk of siltation and erosion of in-river and in-wetland works through fluvial action and it is much easier to manage flows in the drainage systems, allowing these to be bypassed past the works.

In this context it is recommended that if practical, works be undertaken during the drier low rainfall period from May to October.

12.2.2 Limiting of heavy machinery within wetlands

While it is acknowledged that heavy machinery such as excavators need to be used to complete certain aspects of the rehabilitation works, the large size of this and other types of heavy tracked vehicles can cause significant damage to wetland soils and vegetation, including many of the bulbous geophytes that typically occur within wetlands in such a grassland setting. It is thus important that the access of such machinery be limited to the parts of the wetlands where works are taking place. This is particularly an issue in the more sensitive wetlands at crossings 6 and 7, where machinery could damage saturated soils and river banks.

Accordingly measures to limit the areas in which heavy machinery is able to move must be put in place, and where relevant, a running track through the wetland must be constructed to allow machinery to access works areas without causing significant damage to soils and vegetation.

12.2.3 Stormwater Control

Poor stormwater management associated with roads was observed across most of the UCG site and it is noted that a number of road stretches on the site have had to be reconstructed to repair significant damage (surface wash ways) caused by stormwater. This absence of stormwater control is having an impact on certain of the wetlands in terms of silt deposition into the wetland (especially at crossing 6). Stormwater is believed to be affecting the hydrology of certain wetlands by creating channelised flow into the wetlands, especially as in some cases ditches have been excavated adjacent to the site roads that capture and channel overland flow from the catchment into the wetland.

Rehabilitation measures stipulated for each wetland crossing have included stormwater control measures in the catchment, but stormwater control must be viewed and addressed more holistically by Eskom and its contractors on the site. It is recommended that the use of ‘soft’ stormwater control measures be implemented to ensure that channelised stormwater is not directly discharged in the wetland. Such measures include the use of grassy swales into which stormwater can be discharged, allowing it to seep into the wetland.

12.2.4 Removal of Livestock from Rehabilitated Areas

Once works are complete, it is vital that the rehabilitated and reinstated areas are fenced off to prevent the entry of livestock, in particular cattle, into them. Cattle are attracted to areas where surface water is present and areas of new vegetation growth, and thus they have the potential to severely damage rehabilitated sites where vegetation is being re-established.

12.3 Site-specific Rehabilitation Measures

12.3.1 Rehabilitation Method Statement for Crossing 6

12.3.1.1 Summary of Overall Works:

- The existing road substrate is to be removed from the wetland and the single pipe is to be replaced with culverts. Culverts must be of sufficient size (height and width) to allow flow across the width of the wetland during a spate flow event to be maintained.

- The actively eroding gulley head and southern sidewall must be stabilised with rock gabions to prevent further extension of the headcut up towards the pipeline and road

- Proper stormwater control off the road in the in the immediate catchment of the wetland must be implemented to prevent silt ingress and channelised flow to enter the wetland

12.3.1.2 Preparatory Works

- ➢ Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as a no-go area.
- ➢ Lay Geotextile material over the areas where topsoil and subsoil will be stored. Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for a concrete batching area if one is required at this site.
- ➢ A temporary soil berm (placed over the existing vegetation) approx. 0.5m wide, comprising preferably of impermeable clay soil must be placed immediately upstream of the works area across the wetland in order to prevent overland flow from entering the works area thus mobilising silt. Any ponded water must be pumped / flumed to a point downstream of the works and discharged into the channel of the wetland. If there is overland flow across the wetland, this flow must be temporarily channelled / flumed through the works area and discharged in a diffuse manner into the channel of the downstream wetland.
- ➢ For machinery to access the downstream side of the works area, machinery will be likely to need to move alongside the western side of the pipeline (opposite to the road). Heavy machinery must move immediately alongside the pipeline, and a construction right of way must be delineated to avoid heavy machinery ingress into adjacent natural grassland
- ➢ At silt fence must be placed across the width of the downstream wetland (channel).
- ➢ The wetland immediately upstream of the existing road crossing is sensitive as it contains dense grassy wetland vegetation. Due to the impounding action of the road crossing soils in this part of the wetland may be saturated. Machinery will be likely to need to access this part of the wetland to complete the works. In order to protect the topsoil and vegetation it is recommended that a running track be created alongside the road. The running track can comprise of bound wooden beams (bogmats) or imported crushed stone, at least 0.5m deep.

12.3.1.3 Removal of Existing Road Substrate, & excavation and storage of soil

- Existing rocky / soil substrate must be removed from the wetland and stored for re-use, if required. Road substrate material must be removed to natural ground level
- All artificial fill (concrete) material must be separated from the natural rock road substrate and removed to an appropriate landfill site and not dumped within the wetland
- Natural soil material underlying the existing road that may need to be excavated to enable the correct placement of culvert structures. Such removed topsoil must be removed and be stored separately
- All removed topsoil and any removed subsoil must be stored separately. Removed topsoil and subsoil must not be stockpiled within the wetland or on the steep immediate slopes of the catchment of the wetland, but on the flatter ground on the edge of the valley head.

12.3.1.4 Reconstruction of Road Crossing

- Culverts must be placed in the wetland to replace the existing pipe and rocky substrate of the road. Culverts must be constructed so that the bottom of the culvert is a ground level to allow movement of biota through the road crossing
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes
- It is recommended that 'stepped' rock basket gabions properly keyed into the soil be included in the design of the crossing downslope of the culverts to accommodate the drop in levels between the natural ground level on the upstream side of the crossing and the ground level at the top of the headcut downstream of the road crossing and pipeline.
- Smaller gabions or packed rock must be used to protect the area between the foot of the gabions and the gabions placed within the headcut
- Newly created embankments surrounding the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^{o} be incorporated into the design
- Newly created embankments surrounding the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base). After reinstatement, all exposed, newly created embankments are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind

12.3.1.5 Stabilisation of Gulley sidewalls (headcut) below the road crossing

- The headcut (head of the gulley) and eroding sidewalls of the gulley (especially those on the southern side) must be stabilised and prevented from eroding further by the placement of rock gabions at the head and in the eroding sidewalls of the gulley.
- Gabions must be properly keyed into the sides and foot of the gulley (channel floor) to ensure that flow in the wetland does not erode soils on the sides of the gabions
- Gabions must extend along the sidewalls to cover all actively eroding faces of the gulley sidewalls

12.3.1.6 Reinstatement

- Any soils removed from the works area must be properly reinstated to natural ground levels

- If topsoil is imported into any of the newly created slopes / embankments, it must be seeded with a natural grass mix comprising of grass species typically found in the surrounding area.
- The temporary berm must be fully removed from the wetland
- The running track on the upstream side of the wetland must be carefully removed so as not to uproot any existing vegetation. If crushed stone is used machinery can be used to remove the upper parts, but remaining stone closer to the natural ground level must be removed by hand
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road), and in areas where the running track has been placed

12.3.1.7 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment as stormwater inflow from the road is feeding silt into the wetland.
- Stormwater controls must be implemented that ensure that no silt from the road surface enters the wetland
- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.1.8 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.
- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.
- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

12.3.2 Rehabilitation Method Statement for Crossing 7

12.3.2.1 Summary of Overall Works:

- The existing road substrate is to be removed from the river crossing and is to be replaced with a series of box culverts. The culverts must be of sufficient size (height and width) to allow flow across the width of the river channel during a spate flow event to be maintained.
- The actively eroding eastern channel bank immediately downstream of the existing crossing must be stabilised with rock gabions to prevent further extension of the bank towards the adjacent pipeline support structure
- Proper stormwater control off the road in the in the immediate catchment of the wetland / floodplain must be implemented to prevent silt ingress and channelised flow to enter the wetland
- **Note:** It is strongly recommended that the works in the river be undertaken during low flow periods – in winter or in early summer before the onset of the rains. This is to reduce the risk of a rainfall event(s) causing temporary structures and material to be washed downstream, and to ensure as little water as possible to need to be bypassed past the works.

12.3.2.2 Preparatory Works

- ➢ Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as no-go.
- ➢ Lay Geotextile material over the areas where topsoil and subsoil will be stored. These must be stored outside of wetland Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for the concrete batching area, if one is required for this area. This area covered with Geotextile material shall be a minimum of 3 meters from the pipe in all directions.
- ➢ Spill prevention measures must be put in place both up and down stream of the area where works are to be installed prior to any activities taking place. Other spill response equipment must also be onsite during activities.
- ➢ Prior to the onset of works, it is recommended that the flow in the river be impounded behind the works in order that the works can be completed in a 'dry' environment. It is recommended that a temporary impoundment consisting of clay and sand bags be constructed across the channel, *if works are undertaken during a low flow period.* Water must be pumped past the works and discharged downstream. A similar impoundment must be constructed at the downstream end of the works to prevent backflow into the works area from the downstream reach. The works area should be pumped dry once the impoundments have been completed, and any aquatic fauna stranded in the works area must be safely relocated to the downstream river channel.
- ➢ If works have to be undertaken during high flow periods with a stronger baseflow in the river, it is recommended that river flow be allowed to bypass the works on one side of the channel with temporary structures placed (e.g. sand bags etc.) to keep the works dry. Once work is completed on the one side, the river flow should be diverted through the newly completed culverts and work can be completed on the opposite side.
- ➢ In order to access the downstream side of the works, machinery will need to access the river bed via the bank on the downstream side of the pipe. If necessary this bank may need to be re-profiled to have a slope less than 40^{o} in slope and an access created to allow machinery to safely access the river bed and the downstream side of the works. Machinery must only access the works on the downstream side of the works from the western bank, and must not access the downstream side of the works from the eastern side (i.e.by crossing the floodplain).

- No servicing areas, laydown areas, or machinery turning areas must be allowed in the floodplain part of the wetland area on the eastern side of the channel. The construction right of way must be limited to the access track alongside the pipeline and the surrounding floodplain must be marked as a no-go area.
- 2 silt traps must be installed in the downstream part of the channel to trap any silt mobilised as part of the works. The integrity of these traps must be checked for the duration of the works.

12.3.2.3 In-river Works

- Once preparatory works in the river have been completed (as per above for low flow or high flow conditions), work can commence on the removal of the existing substrate and construction of box culverts in the channel.
- The large boulders that have slumped into the downstream side of the channel must be removed, and if to be used as part of the new structure must be stored out of the wetland, or taken for use elsewhere if not to be re-used at this crossing site.
- The existing rocky / soil substrate that comprise the current road access must be removed from the channel. All of this foreign material must be removed from the river bed to the natural level of the river bed. If it is to be re-used for the new road structure it must be temporarily stored outside of the wetland (i.e. on top of the river macro channel bank on the western side). If it is not to be re-used, it must be disposed of at a suitable site away from the river / wetland and must not be dumped within the channel or within the floodplain.
- The naturally-occurring substrate in the channel bed underlying the existing road may need to be excavated to enable the correct placement of culvert structures. Such removed substrate must not be dumped into the downstream channel; it must either be stored separately (temporarily) if it is to be re-used as part of the new structure, or suitably disposed of if not to be used at another site.
- Culverts must be placed in the channel in such a way that low flows within the channel *are not impounded behind the new bridge structure, and that water and aquatic biota are allowed to freely bypass the structure*. Culverts must be large enough to let flows of a volume that occupies most of the channel to underpass the road, thus culverts at least 3m in height must be used.
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes. Design of new embankments must take into account potential flood / spate flows within the system that would inundate the new structure and thus the embankments must be suitably secured to prevent erosion
- Newly created embankments surrounding the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^o be incorporated into the design
- Newly created embankments surrounding the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base). After reinstatement, all exposed, newly created slopes are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind.
- Silt / sediment that has backed up behind the existing structure must not be removed. This is naturally occurring material in the channel bed that will be likely to be re-mobilised by spate flows once the new structure is completed and the hydrology of the channel is restored to the baseline hydrology without any impounding structure.
- Rocky material that has slumped into the channel bed down the western bank must be removed towards the end of the works (this material may provide a suitable substrate to avoid the movement of machinery into the channel while works are underway). All rocky material must be removed to the natural ground level.

12.3.2.4 Stabilisation of channel sidewalls on the eastern bank downstream of the road crossing

- The eroding channel bank / sidewall on the eastern side of the river channel downstream of the existing road structure must be stabilised and prevented from eroding back to the pipeline supports by the placement of rock gabions.
- Gabions must be properly keyed into the sides of the bank and into the channel bed to ensure that flow in the wetland does not bypass the gabions and erode the bank or bed behind the gabions. Gabions must also be properly secured to the adjacent culvert structure to avoid undercutting.

12.3.2.5 Reinstatement

- Once works are complete, all temporary impounding structures in the channel must be fully removed down to the natural level of the channel bed.
- The western bank on the downstream side of the river crossing that may have been re-profiled to allow safe access of machinery must be restored to a natural profile as far as possible.
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road)
- The silt traps downstream of the works must be carefully removed to ensure that silt trapped behind them is note re-mobilised into the downstream river. Manual removal of silt trapped behind these silt traps must be undertaken if necessary.

12.3.2.6 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment as stormwater inflow from the road has the potential to feed silt into the wetland and to create channelised overland flows into the catchment. Stormwater controls must be implemented on the sloping ground to the east of the floodplain, and on the sloping ground to the west of (nearer) the channel.
- Stormwater controls must be implemented that ensure that no silt from the road surface enters the wetland
- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.2.7 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.
- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.
- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

12.3.3 Rehabilitation Method Statement for Crossing 8

12.3.3.1 Summary of Overall Works:

- The existing road substrate is to be removed from the wetland and the single pipe is to be replaced with a suitably sized box culvert.
- The physical footprint of the works is to be kept as spatially limited as possible
- Stormwater controls off the adjacent road area must be upgraded
- Sideslopes are to be properly vegetated and rehabilitated

12.3.3.2 Preparatory Works

- Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as no-go.
- Lay Geotextile material over the areas where topsoil, subsoil, or rock will be stored. Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for the concrete batching area, if a batching area is required.
- Regular flow within the wetland is unlikely, however if works are being undertaken in the wet summer months, a temporary soil berm (placed over the existing vegetation) approx. 0.5m wide, comprising preferably of impermeable clay soil must be placed immediately upstream of the works area across the wetland in order to prevent overland flow from entering the works area and mobilising silt. Any ponded water must be pumped / flumed to a point downstream of the works and discharged into the channel of the wetland. If there is overland flow across the wetland, this flow must be temporarily channelled / flumed through the works area and discharged in a diffuse manner into the channel of the downstream wetland.
- 1 silt fence must be placed across the width of the wetland within the downstream wetland (channel).

12.3.3.3 Removal of Existing Road Substrate, & excavation and storage of soil

- Existing rocky / soil substrate forming the road must be removed from the wetland and stored for re-use as required. Road substrate material must be removed to natural ground level.
- However kikuyu was noted on the embankments on the downstream side of the crossing. Due to the invasive properties of this grass it is recommended that soil containing kikuyu roots not be re-used but rather disposed of at a suitable landfill site.
- All artificial fill (concrete) material must be separated from the natural rock road substrate and removed to an appropriate landfill site and not dumped within the wetland
- Natural soil material underlying the existing road that may need to be excavated to enable the correct placement of culvert structures. Such removed topsoil must be removed and be stored separately
- All removed topsoil and any removed subsoil must be stored separately. Removed topsoil and subsoil must not be stockpiled within the wetland.
- Access of machinery must be limited to the parts of the wetland immediately upstream / downstream of the crossing point, and machinery must not access any part of the wetland or the adjacent catchment more than 20m either upstream or downstream of the crossing.

12.3.3.4 Reconstruction of Road Crossing

- A box culvert of at least 1.5m in height and width must be placed in the wetland to replace the existing pipe and rocky substrate of the road. The culvert must be constructed so that the bottom of the culvert is at the natural ground level to allow movement of biota through the road crossing, and so as not to obstruct water flow in any way.
- Although bedrock outcropping is present in the in the wetland channel bed immediately downstream of the existing crossing that will prevent erosion, it is recommended that rip rap or similar large packed rocks be placed at the mouth of the culvert to retard flows exiting the culvert.
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes
- Newly created embankments adjacent to the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^{o} be incorporated into the design.
- Existing boulders can be used to stabilise or to form part of newly-created embankments on the upstream and downstream sides of the crossing
- Newly created embankments adjacent to the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base, but not topsoil from the existing embankments where kikuyu was growing). After reinstatement, all exposed, newly created slopes are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind

12.3.3.5 Reinstatement

- Any soils removed from the works area must be properly reinstated to natural ground levels
- If topsoil is imported, it must be seeded with a natural grass mix comprising of grass species typically found in the surrounding area.
- If a bund is placed across the wetland upstream of the crossing, this must be removed
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road.

12.3.3.6 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment that ensure that no silt from the road surface enters the wetland
- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.3.7 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.
- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.

- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

12.3.4 Rehabilitation Method Statement for Crossing 9

12.3.4.1 Summary of Overall Works:

- The existing road substrate is to be removed from the wetland and the single pipe is to be replaced with a suitably sized box culvert.
- The physical footprint of the works is to be kept as spatially limited as possible
- Sideslopes / embankments are to be properly vegetated and rehabilitated

12.3.4.2 Preparatory Works

- ➢ Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as no-go.
- ➢ Lay Geotextile material over the areas where topsoil, subsoil, or rock will be stored. Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for the concrete batching area, if a batching area is required.
- ➢ Regular flow within the wetland is unlikely, however if works are being undertaken in the wet summer months, a temporary soil berm (placed over the existing vegetation) approx. 0.5m wide, comprising preferably of impermeable clay soil must be placed immediately upstream of the works area across the wetland in order to prevent overland flow from entering the works area and mobilising silt. Any ponded water must be pumped / flumed to a point downstream of the works and discharged into the channel of the wetland. If there is overland flow across the wetland, this flow must be temporarily channelled / flumed through the works area and discharged in a diffuse manner into the channel of the downstream wetland.
- ➢ 1 silt fence must be placed across the wetland within the downstream wetland (channel).

12.3.4.3 Removal of Existing Road Substrate, & excavation and storage of soil

- ➢ Existing rocky / soil substrate must be removed from the wetland and stored for re-use as required. Road substrate material must be removed to natural ground level. Soil from the existing embankments can be used for the newly-created embankments.
- ➢ All artificial fill (concrete) material must be separated from the natural rock road substrate and removed to an appropriate dumping site and not dumped within the wetland
- ➢ Natural soil material underlying the existing road that may need to be excavated to enable the correct placement of culvert structures. Such removed topsoil must be removed and be stored separately to be used to line embankments
- ➢ All removed topsoil and any removed subsoil must be stored separately. Removed topsoil and subsoil must not be stockpiled within the wetland.
- ➢ Access of machinery must be limited to the parts of the wetland immediately upstream / downstream of the crossing point, and machinery must not access any part of the wetland or the adjacent catchment more than 20m either upstream or downstream of the crossing.

12.3.4.4 Reconstruction of Road Crossing

- ➢ A box culvert of at least 1.5m in height and width must be placed in the wetland to replace the existing pipe and rocky substrate of the road. The culvert must be constructed so that the bottom of the culvert is at the natural ground level to allow movement of biota through the road crossing, and so as not to obstruct water flow in any way.

- Although bedrock outcropping is present in the in the wetland channel bed immediately downstream of the existing crossing that will prevent erosion, it is recommended that rip rap or similar large packed rocks be placed at the mouth of the culvert to retard flows exiting the culvert.
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes
- Newly created embankments adjacent to the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^{o} be incorporated into the design.
- Existing boulders can be used to stabilise or to form part of newly-created embankments on the upstream and downstream sides of the crossing
- Newly created embankments adjacent to the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base). After reinstatement, all exposed, newly created slopes are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind

12.3.4.5 Reinstatement

- Any soils removed from the works area must be properly reinstated to natural ground levels
- If topsoil is imported, it must be seeded with a natural grass mix comprising of grass species typically found in the surrounding area.
- If a bund is placed across the wetland upstream of the crossing, this must be removed
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road).

12.3.4.6 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment that ensure that no silt from the road surface enters the wetland
- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.4.7 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.
- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.
- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

12.3.5 Rehabilitation Method Statement for Crossing 11

12.3.5.1 Summary of Overall Works:

- The existing road substrate is to be removed from the wetland and the single pipe is to be replaced with a suitably sized box culvert.
- The physical footprint of the works is to be kept as spatially limited as possible
- Sideslopes / embankments are to be properly vegetated and rehabilitated
- The two excavated depressions and associated bunds downstream of the crossing must be rehabilitated

12.3.5.2 Preparatory Works

- ➢ Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as no-go.
- ➢ Lay Geotextile material over the areas where topsoil, subsoil, or rock will be stored. Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for the concrete batching area, if a batching area is required.
- ➢ Regular flow within the wetland is unlikely, however if works are being undertaken in the wet summer months, a temporary soil berm (placed over the existing vegetation) approx. 0.5m wide, comprising preferably of impermeable clay soil must be placed immediately upstream of the works area across the wetland in order to prevent overland flow from entering the works area and mobilising silt. Any ponded water must be pumped / flumed to a point downstream of the works and discharged into the channel of the wetland. If there is overland flow across the wetland, this flow must be temporarily channelled / flumed through the works area and discharged in a diffuse manner into the channel of the downstream wetland.
- ➢ 1 silt fence must be placed across the wetland immediately downstream of the crossing and a second must be placed across the wetland immediately downstream of the lower excavated depression to be re-filled.

12.3.5.3 Removal of Existing Road Substrate, & excavation and storage of soil

- ➢ Existing rocky / soil substrate must be removed from the wetland and stored for re-use as required. Road substrate material must be removed to natural ground level. Soil from the existing embankments can be used for the newly-created embankments.
- ➢ All artificial fill (concrete) material must be separated from the natural rock road substrate and removed to an appropriate landfill site and not dumped within the wetland
- ➢ Natural soil material underlying the existing road may need to be excavated to enable the correct placement of culvert structures. Such removed topsoil must be removed and be stored separately to be used to line embankments
- ➢ All removed topsoil and any removed subsoil must be stored separately. Removed topsoil and subsoil must not be stockpiled within the wetland.
- ➢ Access of machinery must be limited to the parts of the wetland immediately upstream / downstream of the crossing point and the excavated depressions downstream of the crossing, and machinery must not access any part of the wetland or the adjacent catchment more than 20m either upstream or downstream of the works area.

12.3.5.4 Reconstruction of Road Crossing

- A box culvert of at least 1.5m in height and width must be placed in the wetland to replace the existing pipe and rocky substrate of the road. The culvert must be constructed so that the bottom of the culvert is at the natural (pre-road construction) ground level to allow movement of biota through the road crossing, and so as not to obstruct water flow in any way.
- An attempt must be made to re-fill the excavated area immediately upstream of the exiting crossing (from which soil was excavated) to restore the natural ground level as far as possible. Material from the existing road embankments can be used for this purpose but must be consolidated / protected to prevent erosion and wash-away of the material
- Rip-rap or similar large packed rocks must be placed at the mouth of the culvert to retard flows exiting the culvert.
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes
- Newly created embankments adjacent to the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^{o} be incorporated into the design.
- Existing boulders can be used to stabilise or to form part of newly-created embankments on the upstream and downstream sides of the crossing
- Newly created embankments adjacent to the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base). After reinstatement, all exposed, newly created slopes are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind

12.3.5.5 Reinstatement

- Any soils removed from the works area must be properly reinstated to natural ground levels
- If topsoil is imported, it must be seeded with a natural grass mix comprising of grass species typically found in the surrounding area.
- If a bund is placed across the wetland upstream of the crossing, this must be removed
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road).

12.3.5.6 Rehabilitation of excavated depressions

- Two elongated depressions were created downstream of the crossing point through an excavator digging out the topsoil within 2 areas of the downstream wetland. The excavated material was used to create a bund to impound water in the excavated depressions. The excavated soil must be reinstated to the excavated depression and lightly compacted, with the level slightly higher than ground level to allow for natural settling of material. Any excess material must be removed from this part of the wetland.
- If necessary the reinstated material placed back into the excavated depressions can be covered with geotextile material to protect it from erosion.

12.3.5.7 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment that ensure that no silt from the road surface enters the wetland

- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.5.8 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.
- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.
- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

12.3.6 Rehabilitation Method Statement for Crossing 12

12.3.6.1 Summary of Overall Works:

- The existing road substrate is to be removed from the wetland and the single pipe is to be replaced with a suitably sized box culvert.
- The physical footprint of the works is to be kept as spatially limited as possible
- Sideslopes / embankments are to be properly vegetated and rehabilitated
- Stormwater from the road in the immediate (sloping) catchment must be properly managed.

12.3.6.2 Preparatory Works

- ➢ Delineate the boundary of the wetland (away from the working areas immediately adjacent to the road crossing) with stakes and danger tape (or similar measures), and mark as no-go.
- ➢ Lay Geotextile material over the areas where topsoil, subsoil, or rock will be stored. Geotextile material with a plastic membrane underneath it shall be placed on top of the top soil for the concrete batching area, if a batching area is required.
- ➢ Regular flow within the wetland is unlikely, however if works are being undertaken in the wet summer months, a temporary soil berm (placed over the existing vegetation) approx. 0.5m wide, comprising preferably of impermeable clay soil must be placed immediately upstream of the works area across the wetland in order to prevent overland flow from entering the works area and mobilising silt. Any ponded water must be pumped / flumed to a point downstream of the works and discharged into the channel of the wetland. If there is overland flow across the wetland, this flow must be temporarily channelled / flumed through the works area and discharged in a diffuse manner into the channel of the downstream wetland.
- ➢ 1 silt fence must be placed across the wetland immediately downstream of the crossing and a second must be placed across the wetland immediately downstream of the lower excavated depression to be re-filled.

12.3.6.3 Removal of Existing Road Substrate, & excavation and storage of soil

- ➢ Existing rocky / soil substrate must be removed from the wetland and stored for re-use as required. Road substrate material must be removed to natural ground level. Soil from the existing embankments can be used for the newly-created embankments.
- ➢ All artificial fill (concrete) material must be separated from the natural rock road substrate and removed to an appropriate landfill site and not dumped within the wetland
- ➢ Natural soil material underlying the existing road may need to be excavated to enable the correct placement of culvert structures. Such removed topsoil must be removed and be stored separately to be used to line embankments
- ➢ All removed topsoil and any removed subsoil must be stored separately. Removed topsoil and subsoil must not be stockpiled within the wetland.
- ➢ Access of machinery must be limited to the parts of the wetland immediately upstream / downstream of the crossing point and the excavated depressions downstream of the crossing, and machinery must not access any part of the wetland or the adjacent catchment more than 20m either upstream or downstream of the works area.

12.3.6.4 Reconstruction of Road Crossing

- A box culvert of at least 1.5m in height and width must be placed in the wetland to replace the existing pipe and rocky substrate of the road. The culvert must be constructed so that the bottom of the culvert is at the natural (pre-road construction) ground level to allow movement of biota through the road crossing, and so as not to obstruct water flow in any way.
- An attempt must be made to re-fill the excavated area immediately upstream of the exiting crossing (from which soil was excavated) to restore the natural ground level as far as possible. Material from the existing road embankments can be used for this purpose but must be consolidated / protected to prevent erosion and wash-away of the material
- Although bedrock outcropping occurs in the channel bed downstream of the crossing rip-rap or similar large packed rocks must be placed at the mouth of the culvert to retard flows exiting the culvert.
- Available bedrock from the old road crossing can be used to stabilise reinstated ground around the new crossing. A compacted mix of stone and smaller rocks can be used to stabilise reinstated slopes
- Newly created embankments adjacent to the newly constructed road crossing must not be designed to be too steep as these will easily erode. It is recommended that no slopes steeper than 40^o be incorporated into the design.
- Existing boulders can be used to stabilise or to form part of newly-created embankments on the upstream and downstream sides of the crossing
- Newly created embankments adjacent to the newly constructed road crossing must be reinstated with a layer of topsoil (ideally sourced from topsoil removed as part of the works in the wetland crossing or immediate catchment, as this soil will contain a natural seed base). After reinstatement, all exposed, newly created slopes are to be covered with geotextile or similar hessian sack material pegged into the surface to protect the soil from erosion by water and wind

12.3.6.5 Reinstatement

- Any soils removed from the works area must be properly reinstated to natural ground levels
- If topsoil is imported, it must be seeded with a natural grass mix comprising of grass species typically found in the surrounding area.
- If a bund is placed across the wetland upstream of the crossing, this must be removed
- Any areas of compacted wetland soils must be lightly ripped / scarified, with care to be taken to not unduly damage (uproot) vegetation. This should be applied particularly to areas where excavators and similar heavy machinery have worked (alongside the road).

12.3.6.6 Stormwater

- Stormwater controls must be implemented on the road on both sides of the wetland in its immediate catchment that ensure that no silt from the road surface enters the wetland, especially as the immediate catchment is sloping and may input silt into the wetland.
- No channelised stormwater from the catchment / road surface must be discharged directly into the wetland. Flow retarding devices such as packed stone or rip-rap must be used to slow the velocity of stormwater down. It is recommended that stormwater from the road be discharged into grassy swales located outside of the wetland on its periphery in order to promote the slow infiltration of runoff into the wetland.

12.3.6.7 Service Areas and machinery

- No refuelling, servicing or chemical storage must occur within 50 m of the wetland boundary.

- A service area is to be established on the outside of the buffer zone of the wetland on each side of the pipeline consisting of at least a temporary refuelling area, maintenance area, waste collection and hazardous chemical storage points, all lined, impervious, demarcated and equipped with a spill kit.
- Any water pumps operating in the works area must be placed inside / on top of a drip tray to prevent any spillage and contamination to the wetland. The drip tray will be lined with absorbent pads and checked daily for spills
- No toilets are to be allowed within 50m of the water bodies – these are to remain outside the wetland.
- All equipment working in the wetland must be checked daily to ensure there are no oil / diesel leaks prior to entry into the wetland area

13 POST REHABILITATION MANAGEMENT ACTIONS

It is important that the rehabilitation works be followed up with management and monitoring actions to ensure the integrity of newly constructed structures, and to counteract any erosion and other factors that could negatively impact the integrity of the rehabilitation effort. Such management actions are detailed below.

13.1 Exclusion of Livestock from Rehabilitation Sites

As detailed in the EIA wetland specialist report, livestock movement in the study area is a critical factor in the creation of erosion through the trampling of soils which results in the destruction of vegetation and the exposure and desiccation of these soils. Livestock tend to congregate around wetlands and rivers in order to drink water and in order to graze vegetation which is more nutritious than vegetation in surrounding grassland, especially in the non-growing season (winter).

Due to the physical reconstruction of the crossing sites which entails the re-profiling and re-vegetation of parts of the newly-constructed crossing, these areas will be vulnerable to erosion and physical disturbance, especially while newly reinstated areas are allowed to re-vegetate. If livestock (cattle) are allowed to access the sites immediately after reconstruction, trampling and the movement of livestock down banks / embankments could disturb re-vegetated topsoil. This risk applies to re-profiled slopes surrounding the culverts, as well as the wetland channel bed. All sites are vulnerable to cattle movement and disturbance, but the Witbankspruit (crossing 7) is particularly vulnerable due to cattle movement due to the perennial flow in the river.

As a result the following management actions are recommended:

- ➢ Immediately after rehabilitation works are completed, the rehabilitated area must be completed fenced off with a stock-proof fence to ensure that no livestock are able to access the new crossing and the area immediately upstream and downstream of the crossing.
- ➢ The rehabilitated sites are to remain fenced off for at least 6 months or until a full growing season has passed in order to allow reinstated surfaces to be fully vegetated.
- ➢ Prior to removal of fencing after this period has lapsed, the sites must be checked to ensure that re-vegetation has been complete and that topsoil is sufficiently protected. If not, sites must remained fenced off from livestock
- ➢ Once fencing is removed, part of the longer term monitoring of these sites must include monitoring of sites for signs of livestock-related / livestock-initiated erosion and trampling.

13.2 Fire and Burning:

In the same way as livestock movement and trampling can expose newly-reinstated soils and rehabilitating vegetation, fire can destroy or at least temporarily remove vegetation cover, leaving soils exposed to wind and water erosion. Thus:

- ➢ (Controlled) Veld burning actions / programmes in the area surrounding the rehabilitated sites must be prevented from causing vegetation at the rehabilitated sites from being damaged / burnt. If necessary a firebreak surrounding the rehabilitated sites must be created to ensure that vegetation at the sites is not damaged by fire.

13.3 Monitoring of Rehabilitated Sites

It is critical that the success of rehabilitation efforts be monitored once the works have been completed to check the stability and integrity of rehabilitated structures and areas and to make note of any developing problems that require follow up actions.

Following the completion of works, the following monitoring regime is recommended:

- For a period of 2 months after the completion of works, weekly monitoring of all sites is recommended. This monitoring must be undertaken by a suitably qualified environmental practitioner, preferably with wetland assessment and rehabilitation experience.
- Beyond 2 months of the completion of the works, bi-monthly monitoring must occur for the ensuing 4 months if in the dry season, or weekly monitoring must continue for the ensuing 4 months if these fall in the wet season (November to April).
- After 6 months of the completion of works, monthly monitoring of all sites must be undertaken for a period of up to 1 year from the completion of the works
- After a 1 year period has lapsed, monitoring must occur once every 3 months for the next year.

Monitoring must check for / report on:

- The integrity of reinstated soils and embankments at the rehabilitation sites
- The degree of vegetation-regrowth
- The presence of any emergent erosion in the form of rill erosion, headcut development, slumping or undercutting
- The emergence of weeds and alien invasive plant species
- The hydrological state of the wetland / river through the crossing – i.e. is water being ponded / impounded behind the new structure(s) or is it free-flowing
- The integrity of gabion structures, especially those installed along the banks of the Witbankspruit should be regularly checked.
- The integrity of stormwater controls from the road in the immediate catchment, taking note of the presence of any siltation related to stormwater ingress.

The following action must be taken if issues regarding the above are noted:

- Remedial actions must be undertaken preferably by manual means, rather than with machinery. If machinery needs to be used light machinery such as a bobcat excavator should be used.
- All erosion must be immediately rectified to prevent its further spread. The source of the erosion must be rectified if applicable. Eroded areas must be re-topsoiled and re-vegetated if necessary.
- Re-seeding of poorly re-vegetated areas can be considered if the initial seeding has not been successful. This can be considered especially if initial seeding was not undertaken in the growing season, and follow up seeding should ideally be undertaken just prior to the start of the growing season

In addition:

- A regular weed-clearing programme needs to be implemented at all crossings, and all declared invader plant species need to be removed at regular intervals (in line with the monitoring schedule above)