REHABILITATION OF THE MAIN ROAD P50-1 NEAR NGOJE, UMLALAZI LOCAL MUNICIPALITY, KWAZULU-NATAL

Freshwater Habitat Impact Assessment Report

Version 1.0

Date: 13 June 2017

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Report No: EP280-01

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SPECIALIST ASSESSMENT REPORT DETAILS AND DECLARATION OF INDEPENDENCE

This is to certify that the following report has been prepared as per the requirements of Section 32 (3) of the NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (Act No. 107 OF 1998) ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS 2014 as per Government Notice No. 38282 GOVERNMENT GAZETTE, 4 DECEMBER 2014.

Document Title:	Rehabilitation of The Main Road P50-1 near Ngoje, Umlalazi Local Municipality, KZN: Freshwater Habitat Impact Assessment Report
Report No.	EP280-01
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Date:	13 June 2017
Report prepared by:	Ryan Edwards and Andrew Briggs
Field of study/Expertise:	Wetland and River Ecology
Internally Reviewed by:	Ryan Edwards **Pr. Sci. Nat**
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Sign-off:	
Client:	Royal HaskoningDHV (Pty) Ltd on behalf of the KwaZulu-Natal Department of Transport (KZN DoT)

I, **Ryan Edwards**, hereby declare that this report has been prepared independently of any influence or prejudice as may be specified by the Department of Environmental Affairs.

Signed: ______________________ Date: 13 June 2017

Details of Specialist Team

The relevant experience of specialist team members involved in the compilation of this report are briefly summarized below. *Curriculum Vitae's* of the specialist team are available on request.

Specialist	Role	Details
Ryan Edwards *Pr. Sci. Nat.* Senior Scientist	Project manager, lead author and internal report reviewer	Ryan Edwards is a wetland specialist with eight years' experience in wetland associated environmental management work. Core field of focus and specialization is wetland ecology and regularly conducts wetland assessments for private, commercial and industrial clients as well as for provincial and national government departments and municipalities. Competent in data collection, analysis and report writing related to wetland assessments. Also has experience in wetland offset mitigation, wetland rehabilitation and management and basic riparian zone/aquatic/riverine assessments. Ryan has an MSc in Environment Science (Wetland Hydro-geomorphology) and is a registered Professional Natural Scientist in the field of Environmental Science. He oversaw successful implementation of the project.
Andrew Briggs *Cand. Nat. Sci.* Junior Environmental Scientist	Undertaking fieldwork and co-author	Andrew is a Junior Scientist at Eco-Pulse with an MSc. Degree in Conservation Ecology. His thesis focused primarily on invertebrate and plant diversity in KZN watercourses. Andrew is currently involved in wetland delineation, riparian delineation, background research and undertaking wetland assessment using widely used WET-Management Series tools developed through the Water Research Commission.

EXECUTIVE SUMMARY

The KwaZulu-Natal Department of Transport (KZN DoT) is proposing to rehabilitate the main Road P50-1 from KM 18.00 to KM 26.00. P50-1 Road is a provincial road that links the town of Eshowe with Nkandla, within the Umlalazi local Municipality, KwaZulu-Natal. The road will follow the existing alignment and will be widened to a maximum of 1.5m – 2m on either side along the entire alignment except for one horizontal curve. One horizontal curve has been realigned (between km 23.00 and km 23.250). The bend has been widened to about 10m to the left to increase the chainage direction. Rehabilitation (upgrading) will be in accordance with the Departmental "Type 2C" standard, raising the road surface by 150mm and extending ancillary infrastructure. Temporary shoulders of ±2m width will also be required outside of the expanded footprint.

The study area occurs within two DWA quaternary catchments; W11A (east) and W12B (west). The majority of the road upgrade will occur within the quaternary catchment W12B. Quaternary catchments W11A and W12B both form part of the Usutu to Mhlatuze Water Management Area (WMA). Watercourses within the study area occurring within W12B are within the uMhlatuze River catchment. The uMhlatuze River is the main collecting river of the catchment and is located approximately 8km downstream More locally, the 1: 50000 2831CD topo-cadastral map indicates that the road under investigation currently crosses two tributaries of the Bomvana River. The Bomvana River is a right-bank tributary of the uMvazane River that is a right-bank tributary of the uMhlatuze River. The western tributary is called the Kwanonkolombelana Stream and the eastern tributary is unnamed. Watercourses within the study area occurring within W11A are within the Matigulu River catchment. The Matigulu River is the main collecting river of the catchment and is located approximately 11.5 km south of the study site.

In terms of the NFEPA project, the study area occurs within two sub-quaternary catchments. The northern sub-quaternary catchment is not classified as a River FEPA, however, the southern sub-quaternary catchment is classified as an Upstream Management Area. Upstream Management Areas are sub-quaternary catchments which have been identified as part of the NFEPA project where human activities need to be managed in order to prevent degradation of key downstream river FEPAs and Fish Support Areas (Driver et al. 2011). No wetland FEPAs are present in close proximity to the study area. In terms of the KZN Freshwater Systematic Conservation Plan (SCP), the planning units No. 2080, 2175 and 2179 which accounts for the majority of the area within the study site is classified as 'Available'. This means the catchment has been identified as being available for conservation purposes. Areas on the extreme western and eastern extents of the study site, namely: planning units No. 2074 and 2086, have been 'Earmarked' for conservation. This means the catchment has been identified as having a potential to conserve aquatic biodiversity.

A number of watercourses were mapped as occurring within 500m of the proposed development. Two (2) streams and five (5) wetlands were screened at a desktop level as the units most likely to be measurably negatively impacted by the proposed development and these units were taken forward for detailed assessment. Those units occurring within 500m of the proposed development but which are unlikely to be measurably negatively impacted were not assessed further.

The wetlands delineated and assessed within the project area were primarily valley bottom wetlands, namely three (3) Un-channelled Valley Bottom (UCVB) units (W03, W04 and W05) and two (2) Channelled Valley Bottom (CVB) units (W01 and W02). Two stream units assessed and included an ephemeral mountain headwater stream (Unit S01) and a seasonal mountain headwater stream.

In terms of Present Ecological State (PES), wetland units W01, W04 and W05 were assessed as being in a good condition and Largely Natural ("B" PES Category) and wetland units W02 and W03 were assessed as being Moderately Modified ("C" PES Category). Both stream units S01 and S02 were assessed as being in a Moderately Modified condition (reflected by a "C" PES Category). The key impacts observed and interpreted included infilling for the establishment of the existing road, the indirect impacts of flow canalisation and impoundments associated with the existing P50-1 road crossings, namely increased rates of erosion, and indirect habitat impacts in the form of habitat degradation and the increased presence of ruderal, pioneer, opportunistic and alien invasive species within the assemblages of the wetland and riparian vegetation communities.

In terms of the present Ecological Importance and Sensitivity (EIS) assessment, Unit W01 was assessed as being of moderately-high EIS due to the moderately-high importance of the biodiversity maintenance services provided. The rest of the units were assessed as being of moderate EIS due to the provision of one or more moderately important regulating and supporting services as well as providing moderately important biodiversity maintenance services in the case of Units W04 and W05. Units W01, W03 and W05 were assessed as being of moderate socio-cultural importance due to providing moderately important provisioning services, particularly harvestable resources. Unit S01 was assessed as being of very low EIS and Unit S02 of moderately-low EIS. Both units are characterised by a fairly low diversity of instream biotopes, highly intermittent flow regimes, and instream and riparian habitat was assessed as not being rare.

The potential impacts that are likely to occur during the construction and operational phases of the proposed road upgrade were grouped into the following impact categories:

1. Direct habitat loss and modification impacts (C1 & O1).
2. Flow, erosion and sedimentation impacts (C2 & O2).
3. Water quality impacts (C3 & O3).

Although the wetlands to be impacted are considered important and sensitive systems, the impact assessment revealed that potential impacts are not that significant with most construction phase impacts assessed as being of moderately-low significance and operational phase impacts being of low significance under a realistic poor mitigation scenario. This is largely due to the road already being present and the proposed upgrade being small in extent and involving low levels of encroachments into the wetland and stream habitats. The impact assessment also revealed that the construction impacts are the most significant impacts, particularly the impacts of freshwater habitat infilling, clearing and disturbance and the associated indirect impacts of working within the watercourses and altering flow patterns. This emphasises the importance of ensuring that the miti8agtion measures recommended for the construction phase are strictly adhered to and monitored for compliance.

Similarly, risks were generally assessed as low, with the exception of the proposed infilling impacts that were assessed as being of moderate risk. However, the moderate risk score is within 25 points of the low risk category and thus is considered a borderline case. Considering this and the fact that impact on the overall functioning of the affected units is predicted to be moderately-low, it is the author's opinion that the risks of all the impacts can be reduced to low significance assuming that all mitigation measures provided are implemented. It is also important to note that the proposed development presents an opportunity to improve the hydrological functioning of the affected wetlands through installing more culverts and spreading out flow as recommended in Section 5. However, the project engineers have not yet confirmed their acceptance of the culvert recommendations in this report. If the culvert design recommendations are adhered to, the proposed activities will actually have a positive impact on wetland functioning. Nevertheless, it is up to the DWS to provide formal correspondence on whether the proposed activities can be authorised under a GA or not.

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1. INTRODUCTION

1.1 Project Background & Locality

The KwaZulu-Natal Department of Transport (KZN DoT) is proposing to rehabilitate the main Road P50-1 from KM 18.00 to KM 26.00. P50-1 Road is a provincial road that links the town of Eshowe with Nkandla, within the Umlalazi local Municipality, KwaZulu-Natal. As shown in Figure 1 the proposed road upgrade site is located approximately 13 km northwest of the town of Eshowe.

The proposed road upgrade constitutes a listed activity in Listing Notice 1 of the National Environmental Management Act (NEMA) Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) that requires Environmental Authorisation (EA) subject to a Basic Assessment (BA) process. Eco-Pulse Environmental Consulting Services ('Eco-Pulse') have been appointed by Royal HaskoningDHV (RHDHV) to undertake a freshwater habitat impact assessment to inform the Basic Assessment and possibly the Water Use License Application (WULA).

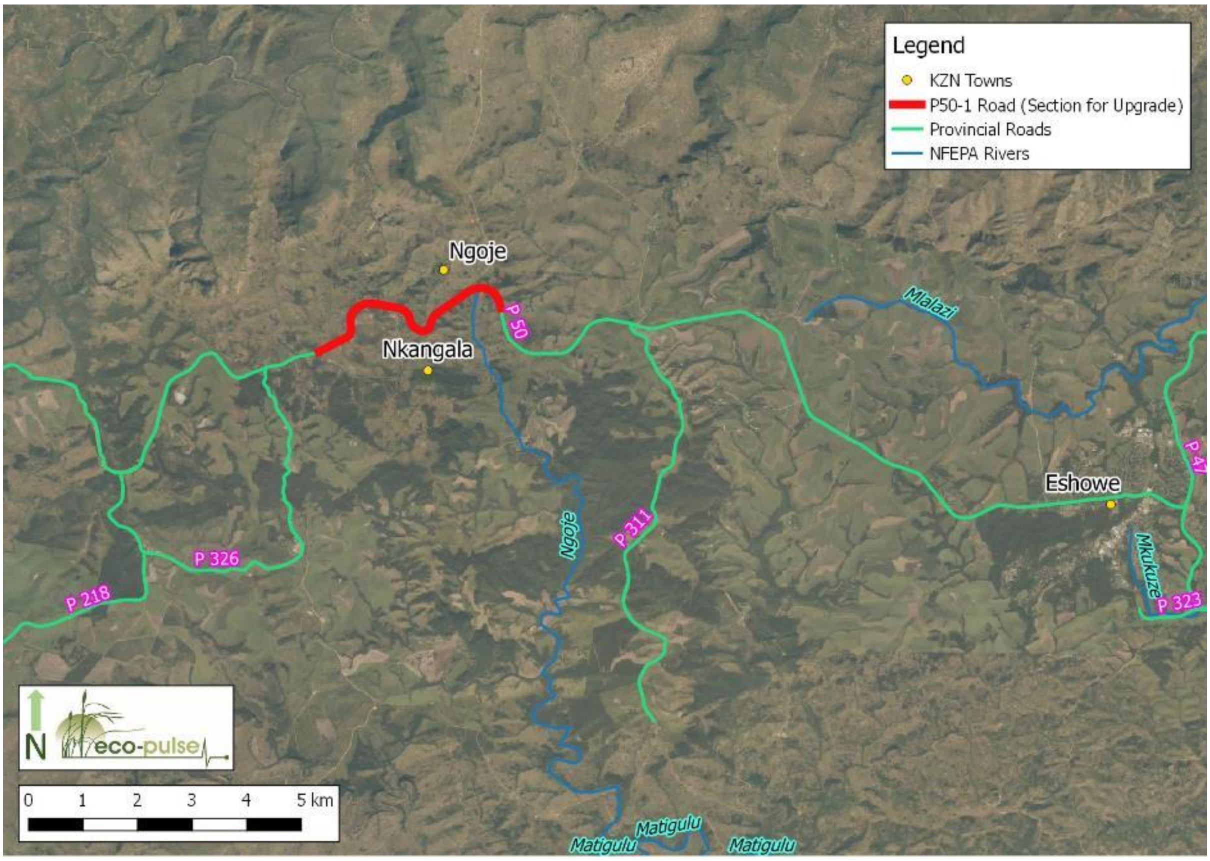


Figure 1 Locality map showing the linear project area in relation to the town of Eshowe.

1.2 Project Description

The proposal is to rehabilitate an 8km section of the P50-1 Road from KM 18.00 to KM 26.00. As it stands the road surface width varies from 10m wide (KM 18.00 to 22.00) to 7m wide (KM 22.00 to 26.00).

The road will stick to the existing alignment and will be **widened to a maximum of 1.5m – 2m on either side** along the entire alignment **except for one horizontal curve**. One horizontal curve has been realigned (between km 23.00 and km 23.250). The bend has been widened to about **10m to the left** to increase the chainage direction. Rehabilitation (upgrading) will be in accordance with the Departmental "Type 2C" standard, raising the road surface by 150mm and extending ancillary infrastructure. Temporary shoulders of ±2m width will also be required outside of the expanded footprint.

The gravel material for the C3 sub base layer (G4 stabilised to C3 strength) is to be obtained from commercial sources. The gravel materials for the subgrade, selected subgrade and shoulder fill are to be obtained from an existing borrow pit located on the western side of the intersection of P50-2 with P316 which is situate approximate 595m after the end of P50-1 (GPS co-ordinates 28° 53' 1,56" S; 31° 16' 34,16" E).

The existing prefabricated culverts will be extended to conform to the widened roadway profile and the inlet and outlet structures re-constructed. Where necessary, open stormwater drainage systems will be improved.

Continuous maintenance of the existing road by the Contractor will be required throughout the contract period in other to keep the road in a safe and serviceable condition for road users."

In terms of the extent of the works, the following details were provided by RHDHV:
"*The works to be carried out include the following main activities:*

- a. *The Contractor's establishment on site and the provision of facilities for the Engineer, including a materials testing laboratory facility.*
- b. *Provision of traffic accommodation facilities, including the use of half-width construction methods, the erection of temporary advance warning / information road signs, the installation of traffic signal control points, the use of STOP/GO traffic control methods, and the provision of other traffic control devices. Temporary shoulder widening of 2,0. m will also be constructed for the accommodation of traffic to provide sufficient working space where required.*
- c. *Clearing and grubbing.*
- d. *Provision of survey control, and setting out of Works*
- e. *Continuous maintenance of the existing road during the construction period, including patching and edge break repairs.*
- f. *Construction of subsoil drainage.*
- g. *Extension of the prefabricated pipe culvert cross-drainage together with the reconstruction of the affected inlet and outlet structures.*

h. *Widening of the existing fills to accommodate the new roadway formation width, using gravel material imported from the existing borrow pit*
i. *Construction of a 300mm thick selected subgrade layer (G7) to the top of the fill widening using gravel material imported from the existing borrow pit.*
j. *Import 100mm G4 gravel material on top of the exiting bituminous surface.*
k. *In situ cement stabilised the existing base together with the 100mm imported G4 gravel material.*
l. *Construction of a new 80 mm bituminous base layer.*
m. *Construction of shoulder fill (G7) using gravel material imported from the existing borrow pit and from commercial source to achieve 10,0 m wide surfaced road.*
n. *Priming to protect the base layer.*
o. *Construction of 40 mm continuously graded medium grade wearing course.*
p. *Construction of road prism drainage, including open concrete lined drains where necessary.*
q. *Application of road markings and installation of roadstuds.*
r. *Grass sodding and hydroseeding to protect the cut and fill slopes where required, and to reinstate the vegetation at spoil, stockpile and borrow areas.*
s. *Improvements to existing minor access points.*
t. *Erection of new guardrails and fencing.*
u. *Installation of road signs and road marking.*
v. *Finishing and cleaning up of the road and road reserve.*
w. *Continuous quality control over material and workmanship, and compliance with the Particular Specification with regard to environmental management and occupational health, during all the above construction activities.*
x. *Removal of all site establishment facilities and constructional plant on completion of the Works.*
y. *Making good of any defects during the Defects Liability Period.*"

1.3 Scope of Work

The following scope of work was completed as part of this assessment:

- Contextualisation of the study area in terms of freshwater ecosystem setting and conservation planning.
- Desktop mapping and impact potential screening of all watercourses within a 500m radius of the proposed road upgrade project.
- Delineation of the outer boundary of wetland and riparian areas within the study area according to the approach, methods and techniques contained in '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005).
- Classification of delineated wetlands and riparian areas using the latest *National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis *et al.*, 2013).
- Description of key biophysical and habitat characteristics of the delineated watercourses.

- Assessment of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the delineated watercourses. This also included a functional assessment of the watercourses to inform EIS.
- Determination of Recommended Ecological Category (REC) for each of delineated watercourses.
- Identification, description and assessment of the construction and operational phase impacts to wetlands/rivers/streams and associated riparian habitat. Impact assessment will involve both a qualitative significance assessment and a qualitative risk assessment using the DWS Risk Matrix.
- Provision of planning, design, construction and operational phase mitigation measures to avoid, minimise and remediate potential impacts.
- Application of the DWS "Risk Assessment Matrix" for each watercourse likely to be impacted by the road upgrade project, as detailed in the General Authorisation in terms of Section 39 of the National Water Act No. 36 of 1998 for Water Uses as defined in Section 21 (c) or Section 21 (i), as contained in Government Gazette No. 40229, 26 August 2016 and contained within the DWS document titled '*Section 21(c) and (i) Risk-based assessment and authorization, October 2014, Edition 2*'.
- Provision of opinion on the legislative implications of the proposed development related to impacts to watercourses, with particular focus on NEMA and NWA requirements.

1.4 Introduction to Wetlands and Rivers

1.4.1 Key Definitions and Concepts

Under Section 1(1)(xxiv) of the National Water Act (Act No. 36 of 1998) (NWA), a 'watercourse' is defined as:

a) a **river** or **spring**;
b) a **natural channel** in which water flows regularly or intermittently;
c) a **wetland, lake or dam** into which, or from which, water flows; and
d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

This assessment focuses on the assessment of all natural watercourses and their associated habitats / ecosystems likely to be measurably affected by the proposed road upgrade, focussing specifically on wetlands, streams and rivers. For the purposes of this assessment, wetlands, streams and rivers are defined as follows:

- **Wetlands** are areas that have water on the surface or within the root zone for extended periods throughout the year such that anaerobic soil conditions develop which favour the growth and regeneration of hydrophytic vegetation (plants which are adapted to saturated and anaerobic soil conditions). In terms of Section 1 of the NWA, wetlands are legally defined as: (1) "…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."

- **Rivers and streams** are natural channels that are permanent, seasonal or temporary conduits of freshwater. In terms of ecological habitats, rivers and streams comprise in-stream aquatic habitat and riparian habitat. Generally, riparian zones mark the outer edge of stream and river systems. Streams and rivers are differentiated in terms of channel dimensions and generally fall within the broad category of rivers / riverine ecosystems in this report.
- **Instream habitat** is the aquatic habitat (or alluvial in the case of intermittent / ephemeral watercourses) within the active channel that includes the water column, river bed and the inundated active channel margins, and associated vegetation. In terms of Section 1 of the NWA, instream habitat is legally defined as habitat that includes "…the physical structure of a watercourse and the associated vegetation in relation to the bed of the watercourse."
- A **riparian zone** is a habitat, comprising bare soil, rock and/or vegetation that is: (i) associated with a watercourse; (ii) commonly characterised by alluvial soils; and (iii) inundated or flooded to an extent and with a frequency sufficient to support vegetation species with a composition and physical structure distinct from those of adjacent land areas (DWAF, 2005). In terms of Section 1 of the NWA, riparian habitat is legally defined as: 'habitat that "…includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

1.4.2 Importance of Freshwater Ecosystems

Freshwater ecosystems are a subset of the Earth's aquatic ecosystems and include all inland freshwater rivers, streams, wetlands, lakes, ponds and springs. South Africa's freshwater ecosystems are diverse, ranging from subtropical in the north-eastern part of the country, to semi-arid and arid in the interior, to the cool and temperate rivers of the Western Cape. Rivers and wetlands are vital for supplying freshwater, South Africa's most scare natural resource and foundation for social-economic growth, as well as a range of other important ecosystem services and resources like biodiversity maintenance and habitat provision, provisioning services (e.g. harvestable natural resources) and cultural services (e.g. tourism and recreation). Freshwater ecosystems are likely to be particularly hard hit by the rising temperatures and shifting rainfall patterns associated with climate change while at the same time being vital for maintaining resilience to climate change and mitigating its impact on human wellbeing by helping to maintain a consistent supply of water and for reducing flood risk.

Freshwater ecosystems, including rivers and wetlands, are also particularly vulnerable to anthropogenic or human activities, which can often lead to irreversible damage or longer term, gradual/cumulative changes to freshwater resources and associated aquatic ecosystems. Since channelled systems such as rivers and streams are generally located at the lowest point in the landscape; they are often the "receivers" of wastes, sediment and pollutants transported via surface water runoff as well as subsurface water movement (Driver *et al.*, 2011). This combined with the strong connectivity of freshwater ecosystems, means that they are highly susceptible to upstream, downstream and upland impacts, including changes to water quality and quantity as well as changes to aquatic habitat & biota (Driver *et al*., 2011).

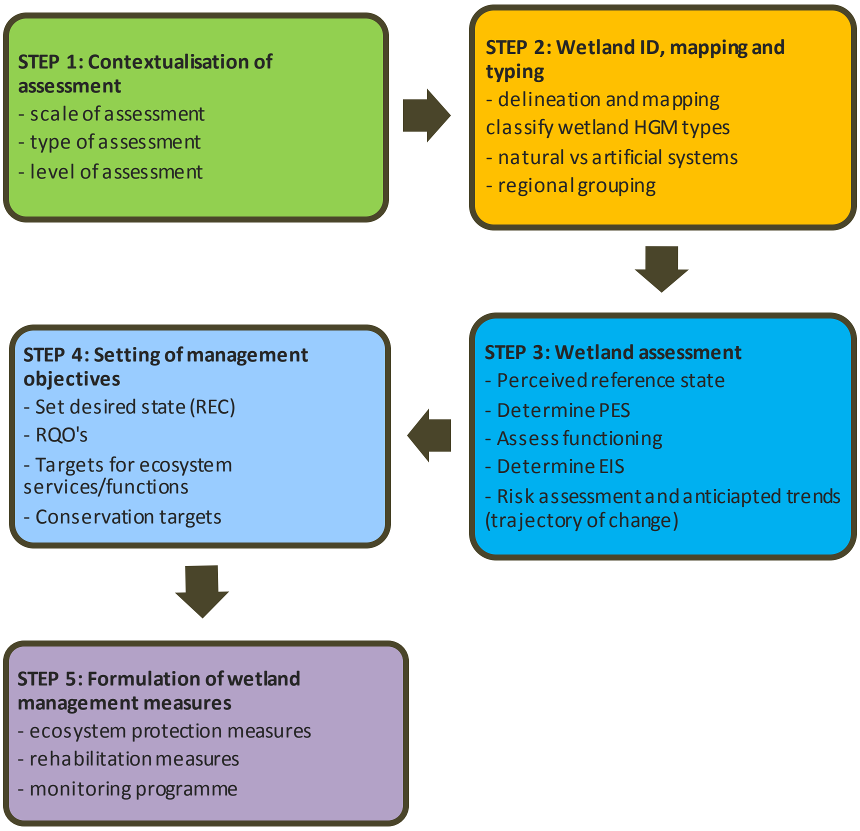
South Africa's freshwater ecosystems have been mapped and classified into National Freshwater Ecosystem Priority Areas (NFEPAs). This work shows that 60% of our river ecosystems are threatened and 23% are critically endangered. The situation for wetlands is even worse: 65% of our wetland types are threatened, and 48% are critically endangered (Driver *et al*., 2011). Recent studies reveal that less than one third of South Africa's main rivers are considered to be in an ecologically 'natural' state, with the principal threat to freshwater systems being human activities, including river regulation, followed by catchment transformation (Rivers-Moore & Goodman, 2009). South Africa's freshwater fauna also display high levels of threat: at least one third of freshwater fish indigenous to South Africa are reported as threatened, and a recent southern African study on the conservation status of major freshwater-dependent taxonomic groups (fish, molluscs, dragonflies, crabs and vascular plants) reported far higher levels of threat in South Africa than in the rest of the region (Darwall *et al*., 2009). Clearly, urgent attention is required to ensure that representative natural examples of the different ecosystems that make up the natural heritage of this country for current and future generations to come. The degradation of South African rivers and wetlands s is a concern now recognized by Government as requiring urgent action and the protection of freshwater resources, including rivers and wetlands, is considered fundamental to the sustainable management of South Africa's water resources in the context of the development of the country.

2. METHODS

2.1 Approach

The general approach to the freshwater (wetland and aquatic) habitat assessment was based on the proposed framework for wetland assessment proposed in the Water Research Commission's (WRC) report titled: '*Development of a decision-support framework for wetland assessment in South Africa and a Decision-Support Protocol for the rapid assessment of wetland ecological condition*' (Ollis *et al.*, 2014). This is shown graphically on the next page.

Proposed decision-support framework for wetland assessment in SA (after Ollis *et al.,* 2014):



2.2 Desktop Review of Freshwater Ecosystem Context

As freshwater ecosystems are linear features connected over regional scales, it is important to first contextualise the onsite freshwater ecosystems in terms of local and regional setting, and conservation planning. An understanding of the biophysical and conservation context of the site will assist in the assessment of the importance and sensitivity of the onsite freshwater ecosystems, the setting of management objectives and the assessment of the significance of anticipated impacts. The following data sources and GIS spatial information listed in Table 1 was consulted to inform the specialist assessment. The data type, relevance to the project and source of the information is provided.

Table 1. Data sources and GIS information consulted to inform the aquatic habitat assessment.

	Data/Coverage Type	Relevance	Source
Biophysical Context	**Quaternary catchment MAP, MAT, MAR and PET**	*Determination of climatic factors that drive freshwater hydrology.*	Schulze, 1998
	KZN Rivers (National GIS Coverage)	*Highlight potential onsite and local rivers and map local drainage network*	Surveyor General (2006)
	KZN Geology (GIS Coverage)	*Understand regional geology and factors controlling wetland formation and subsurface hydrological processes*	Surveyor General (2006)
	10m Elevation Contours (GIS Coverage)	*Desktop mapping of drainage network and freshwater habitats*	Surveyor General (2006)
	National Geomorphic Provinces	*Understand regional geomorphology influencing watercourse characteristics*	Partridge *et al.*, 2010
	DWA Eco-regions (GIS Coverage)	*Understand the regional biophysical context*	DWA (2005)
	South African Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference vegetation*	Mucina & Rutherford (2006)
	KwaZulu-Natal Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference vegetation*	Scott-Shaw and Escott (2011)
	NFEPA Wetland Vegetation Groups	*Classify wetland vegetation types*	CSIR (2011)
Conservation Context	**National Freshwater Ecosystem Priority Areas (NFEPA)** (GIS Coverage)	*Shows location of national aquatic ecosystems conservation priorities*	CSIR (2011)
	National Biodiversity Assessment - Threatened Ecosystems (GIS Coverage)	*Freshwater ecosystem / vegetation type threat status*	SANBI (2011)
	KwaZulu-Natal Provincial Pre-Transformation Vegetation Type Map (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation and its provincial threat status*	Scott-Shaw and Escott (2011)
	KZN Terrestrial Conservation Plan (GIS Coverage)	*Provincial conservation planning importance.*	EKZNW (2011)
	KZN Aquatic Systematic Conservation Plan (GIS Coverage)	*Provincial conservation planning importance.*	EKZNW (2007)

2.3 Desktop Mapping and 'Likelihood of Impact' Screening

A desktop 'likelihood of impact' screening assessment for all watercourses within 500m of the proposed road upgrade was undertaken to confirm the watercourses most likely to be negatively affected by the proposed road upgrade (at risk) and the extent of the watercourses to be taken forward for detailed assessment. This assessment involved the desktop mapping of all watercourse units within 500m of the proposed road upgrade and assigning a likelihood of impact rating to each of these watercourse units. Those units rated as being as having a moderate to high likelihood of impact were taken forward in the detailed assessment.

2.3.1 Desktop Mapping

The desktop delineation of all watercourses (rivers / riparian zones and wetlands) within 500m of the proposed road upgrade was undertaken by analysing available 20m contour lines and colour aerial photography supplemented by Google Earth™ imagery where more up to date imagery was needed. Digitization and mapping was undertaken using QGIS 2.10 GIS software. All of the mapped watercourses were then broadly subdivided into distinct resource units (i.e. classified as either riverine or wetland systems / habitat). This was undertaken based on aerial photographic analysis and professional experience in working in the region. Please note that the desktop map was updated as part of the finalisation of the assessment to include the detailed delineation of the units occurring within the study area.

2.3.2 'Likelihood of Impact' Screening Assessment

Following the desktop identification and mapping exercise, watercourses were assigned preliminary 'likelihood of impact' ratings based on the likelihood that activities associated with the proposed road upgrade will result in measurable direct or indirect changes to the mapped watercourse units within 500m of the proposed road upgrade. The 'likelihood of impact' ratings were refined following the completion of the field work. Each watercourse unit was ascribed a qualitative rating according to the ratings and descriptions provided in Table 2 below.

Table 2. Qualitative 'likelihood of impact' ratings and descriptions.

Impact Potential	Description and Rating Guidelines
Definite / Probable	These resources will require an assessment of aquatic impacts and a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are located **within the footprint of the proposed development** and will be directly impacted; and/or ➢ resources are located **within 15m upstream or upslope** of the development and trigger requirements for Environmental Authorisation according to the latest NEMA: EIA regulations; and/or ➢ resources are located **downstream or downslope** of the development and trigger requirements for Environmental Authorisation according to the latest NEMA: EIA regulations under the following development scenarios: o within **15m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o within **50m downstream/downslope of a moderate risk development** (e.g. housing estates) o within **100m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. large dams and water abstraction projects, mining, large industrial sites, WWTW, etc.)
Likely	These resources are likely to require an assessment of aquatic impacts and a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are located **within 32m but greater than 15m from** the proposed development activity/activities, with a high likelihood of incurring direct impacts as a result; and/or ➢ resources are **located within a range at which they are likely to incur indirect impacts** (e.g. water pollution, erosion and sedimentation) associated with development activities and usually downstream of the development within the following guiding thresholds:

	o within **32m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o within **100m downstream/downslope of a moderate risk development** (e.g. housing estates) o within **500m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. dams, water abstraction, mining, large industrial sites, WWTW, etc.)
Unlikely	These resources are <u>unlikely to require an assessment of aquatic impacts or a Water Use License</u> in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are **located a moderate distance upstream or upslope (>32m)** of the proposed development and are unlikely to be directly impacted by the development activities; and/or ➢ the location of resources and nature of the development activity is **not considered a 'Listed Activity'** according to the latest NEMA: EIA regulations [1] ; and/or ➢ resources are **located downstream but well beyond the range at which they are likely to incur indirect impacts** (e.g. water pollution, erosion and sedimentation) associated with the development and usually downstream of the development within the following guiding thresholds: o **>32m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o **>100m downstream/downslope of a moderate risk development** (e.g. housing estates) o **>500m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. dams, water abstraction, mining, large industrial sites, WWTW, etc.)
None	These resources <u>will not require impact assessment or a Water Use License</u> in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) as resources are: (i) situated **a large distance (>100m) upstream of the impact causing activity**, or (ii) **located within another adjacent sub-catchment**, such that the drivers and characteristics of the watercourse will not be modified or impacted in any way, shape or form.

2.4 Watercourse Delineation and Classification

2.4.1 Delineation of Wetland Areas

Formal delineation of the present extent of the watercourses within the study area was undertaken according to the national wetland and riparian zone delineation guidelines (DWAF, 2005). Sampling was undertaken systematically across valley lines and concave slopes where wetlands are predicted to occur. Three specific wetland indicators were used in the delineation of wetlands, namely:

- **Terrain unit indicator**

The location of the areas sampled in the landscape was recorded i.e. valley bottom, foot slope etc. As watercourses are generally associated with valley lines, sampling was focussed within the valley bottom and foot slope areas.

[1] Note that the latest EIA Regulations and Listed Activities should be referred to on a case-by-case basis when considering the need for impact assessment in terms of NEMA.

- **Soil wetness indicator**

Soil wetness indicators are clear and distinct redoximorphic features occurring within the rooting zone (top 50cm of the soil profile) that characterise hydric / hydromorphic soils from dryland soils. In South Africa soil wetness indicators are the primary indicators of the outer boundary of a wetland with all other indicators generally playing a secondary and confirmatory role. This is because redoximorphic features remain in the soil for long periods of time after hydrological disturbance whereas vegetation shifts relatively rapidly once wetland soils are dried out / desiccated.

At each sample point, soil was sampled between 0-50cm depths using a clay auger. The sampled soil was described in the field in terms of texture, colour and presence/absence of redoximoprhic features. Texture was recorded based on feel and professional experience, soil matrix colour was recorded in terms of hue, value and chroma using a Munsell Soil Colour Chart and the degree of mottling was recorded in terms of colour, size and abundance. Soil sampling points were recorded using a GPS (Global Positioning System) and captured using Geographical Information Systems (GIS) for further processing. The soils sampled were classified in terms of wetness zones as per the illustration in Figure 2 and details in Table 3 below.

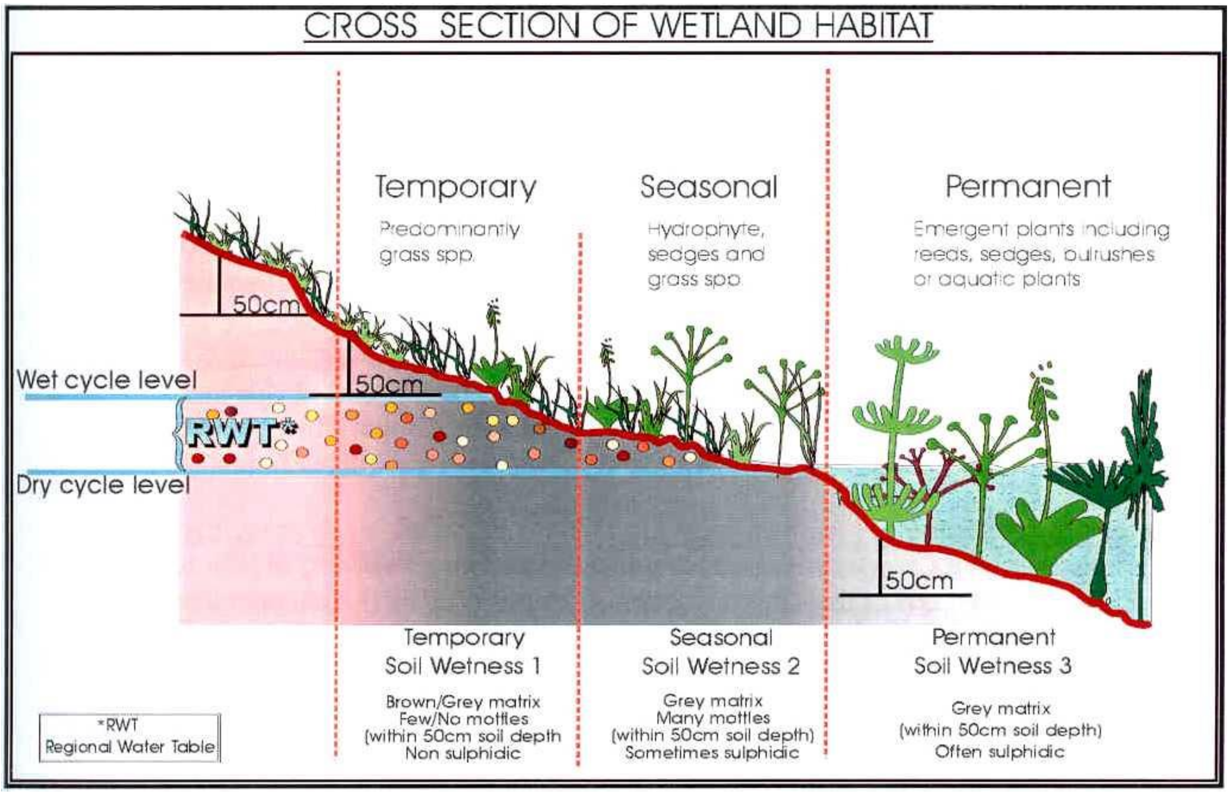


Figure 2 Diagram representing the different zones of wetness found within a wetland (DWAF, 2005).

Table 3. Soil criteria used to inform wetland delineation using soil wetness as an indicator (after DWAF, 2005).

Soil depth	Temporary wetness zone	Seasonal wetness zone	Permanent wetness zone
0 – 10cm	**Matrix chroma**: 1- 3 (Grey matrix <10%) **Mottles**: Few/None high chroma mottles **Organic Matter**: Low **Sulphidic**: No	**Matrix chroma**: 0- 2 (Grey matrix >10%) **Mottles:** Many low chroma mottles **Organic Matter**: Medium **Sulphidic**: Seldom	**Matrix chroma**: 0- 1 (Prominent grey matrix) **Mottles**: Few/None high chroma mottles **Organic Matter**: High **Sulphidic**: Often
30 – 50cm	**Matrix chroma**: 0 – 2 **Mottles**: Few/Many	As Above	As Above

- **Wetland vegetation indicator**

Vegetation in an untransformed state is a useful guide in finding the boundary of a wetland as wetland plant are generally distinct from dryland plants and are specifically adapted to wetland conditions (anaerobic soil conditions), making their presence a strong indicator of saturated soils conditions, Furthermore, distinct and observable zonations in plant communities are often present as one proceeds along the soil wetness gradient from the wet to dry areas.

All identifiable plant species within a 5m radius of each sample point was recorded and the cover abundance qualitatively rated on a three point scale (low, moderate and high).) An example of criteria used to classify wetland vegetation and inform the delineation of wetland zones is provided in Table 4.

Table 4. Criteria used to inform the delineation of wetland habitat based on wetland vegetation (adapted from Macfarlane *et al.*, 2008 and DWAF, 2005).

Vegetation	Temporary wetness zone	Seasonal wetness zone	Permanent wetness zone
Herbaceous	Mixture of non-wetland species and hydrophilic plant species restricted to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Emergent plants including reeds and bulrushes; floating or submerged aquatic plants
Woody	Mixture of non-wetland and hydrophilic species restricted to wetland areas	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species restricted to wetland areas with morphological adaptations to prolonged wetness (e.g.: prop roots)
SYMBOL	**HYDRIC STATUS**	**DESCRIPTION/OCCURRENCE**	
ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
fw	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas	
f	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas	
fd	Facultative dry-land species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)	
d	Dryland species	Almost always grow in drylands	

It is also important to note the soil formation indicator was not sampled / investigated as part of this study.

2.4.2 Delineation of Riparian Areas

The outer edge of riparian areas (also known as the riparian zones) were delineated according to the methods in the Department of Water Affairs wetland delineation manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005a). Like wetlands, riparian areas have their own unique set of indicators that enable delineation these features.

Sampling was undertaken systematically across valley lines where river and stream channels are predicted to occur. Three specific riparian zone indicators were used in the field delineation, namely:

- **Topography associated with the watercourse**: The outer edges of distinct fluvial geomorphic / morphological features were recorded e.g. macro channel bank.
- **Vegetation**: This is the primary indicator of a riparian area, whereby the edge of the riparian zone is defined as the zone where a distinctive change in species composition and physical structure occurs between those of surrounding/adjacent terrestrial areas. In this case a combination of aerial photography analysis and on-site field information (pertaining to the vegetation health, compactness, crowding, size, structure and numbers of individual plants) was used to differentiate between riparian and terrestrial vegetation.
- **Alluvial soils and deposited material**: This includes relatively recently deposited sand, mud, etc. deposited by flowing water that can be used to confirm the topographical and vegetation indicators.

2.4.3 Classification

The delineated watercourses were classified in terms of Level 4 of the national wetland and aquatic ecosystems classification system (Ollis et al., 2013), which is classification at the hydro-geomorphic unit scale / level. This classification was based on observations of topographical setting, position within the landscape and flow regime.

2.5 Baseline Habitat Assessment Methods / Tools

Published tools were employed for the baseline PES, EIS and functional assessments. Table 5 summarises the tools that were used to assess the watercourse units to be affected by the proposed road upgrade. The reader is referred to **ANNEXURE A** for descriptions of each of the baseline assessment methods used.

Table 5. Summary of methods used in the assessment of delineated water resource units.

Method/Technique	Reference for Methods/Tools Used	Annexure
Wetland Present Ecological State (PES)	*Level 1 WET-Health tool (Macfarlane et al., 2008).*	**A1**
River Condition/Present Ecological State (PES)	*Qualitative Index of Habitat Integrity tool (Kleynhans, 1996)*	**A1**
Wetland & River Ecological Importance & Sensitivity (EIS)	*EIS tool developed by Eco-Pulse adapted from the DWAF River EIS tool (Kleynhans, 1999) and Wetland EIS tool (Duthie, 1999).*	**A2**
Wetland & River Functional / Ecosystem Services Assessment	*Level 2 WET-EcoServices assessment tool (Kotze et al., 2007).*	**A3**

2.6 Impact Assessment

Freshwater ecosystem / aquatic ecosystem impacts can typically be grouped into the following three categories based on distinct activities and associated impact pathways:

- **Destruction and modification of freshwater / aquatic habitat**: This refers to the physical and direct modification, transformation and destruction of aquatic habitat and associated ecosystem goods and services.
- **Hydrological modification and erosion / sedimentation**: This refers to the alteration of hydrological and geomorphological processes and drivers, and associated impacts to aquatic habitat and ecosystem goods and services.
- **Alteration of water quality**: This refers to the alteration or deterioration in the physical, chemical and biological characteristics of water within streams, rivers and wetlands, and associated impacts to aquatic habitat and ecosystem goods and services.

Each of the above impact groups were described in terms of the impacts to key ecosystem processes and components and qualitatively assessed in terms of impacts to PES and the supply of ecosystem services based on professional opinion. Thereafter, the significance of each impact was assessed in terms of the ultimate consequences (impacts to resources of known societal value) in line with the National Wetland Offset Guidelines (SANBI & DWS, 2014), namely:

(i) **<u>Water resource provision and management</u>**: This addresses impacts to the **quantity** and **quality** of water provided by water resources. Such impacts may be the result of more direct impacts like abstraction, regulation and/or return discharges, and/or the result of freshwater ecosystem degradation that affects the ability of watercourses to provide supporting regulating and supporting services.

(ii) **<u>Ecosystem conservation:</u>** This deals specifically with impacts to quality and condition of **habitat** and the ability to meet conservation targets for freshwater ecosystems. This therefore accounts for the loss or change in freshwater habitat, which is particularly important for highly threatened ecosystem types.

(iii) **Species conservation**: This addresses impacts on freshwater **biota**, with a particular emphasis on species or populations of conservation concern and the ability to meet species conservation targets; and

(iv) Impacts to **local communities** reliant on freshwater ecosystem goods and services: This deals with impacts to provisioning (e.g. water supply & cultivated foods) and cultural services (e.g. cultural significance or recreational values) of direct value to local users and consequences for human health, safety and livelihood support.

The approach to impact conceptualisation is depicted by the diagram in Figure 3, below.

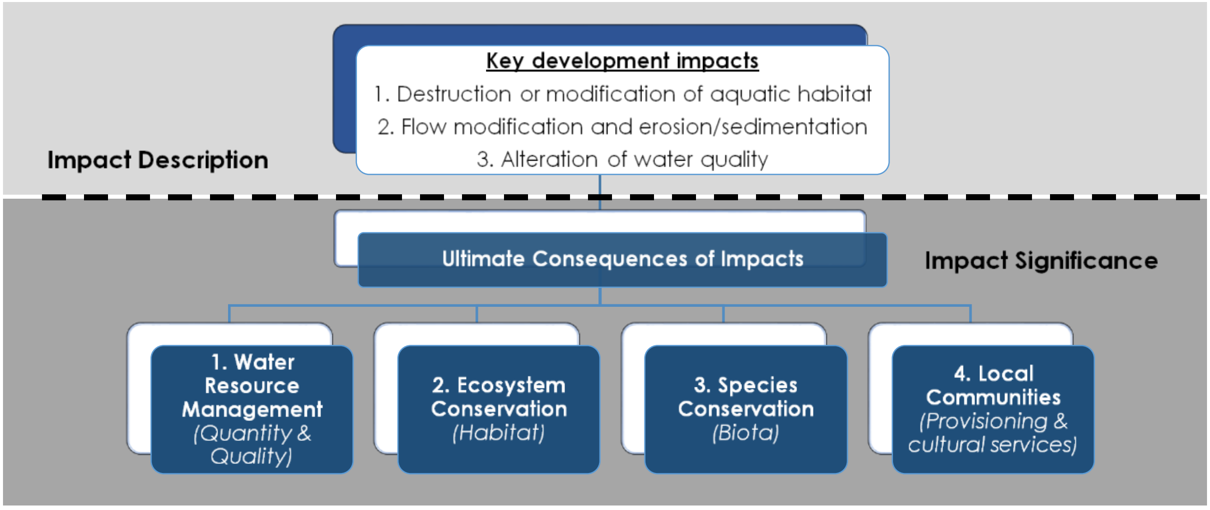


Figure 3 Diagram illustrating how the impact assessment framework is conceptualized.

Using this approach, the following tasks were undertaken as part of the impact assessment:

- Review of project information to understand project activities and key impacts / risks to aquatic ecosystems.
- Description and assessment of potential freshwater / aquatic ecosystem impacts under the following development / mitigation scenarios:
    - **Realistic Poor / Bare Minimum Mitigation Scenario**: This scenario involves the implementation of the development plan and designs that are current proposed with the associated implementation of standard construction and operational phase mitigation measures. In terms of implementation success, this scenario assumes a realistic / likely poor implementation scenario based on the author's experience with such developments. **It is important to note that it is our experience in similar development settings that contractor compliance with construction Environmental Management Programmes (EMPr) is poor and that operational maintenance is poor.**
    - **Realistic Good / Best Practical Mitigation Scenario**: This scenario involves the implementation of the development plan and designs that are current proposed with the associated implementation of the construction and operational phase mitigation measure

recommended by the author. In terms of implementation success, this scenario assumes a realistic best case scenario for implementation based on the author's experience with such developments.

- The assessment of impact significance is informed by a method developed specifically for application to freshwater ecosystems (Eco-Pulse Consulting, 2015) included in **Annexure B**.

2.7 Assumptions, Limitations & Gaps

The following limitations and assumptions apply to this assessment:

- Formal sampling and assessment focussed on those watercourses currently crossed and/or in close proximity (within 15m upslope and 32m downslope) of the existing road.
- Access to some of the streams south of the road was not possible due to the dense and impenetrable alien vegetation present. Many of these streams were assumed to be located in excess of 32m downslope and thus were not considered critical to the assessment in light of the localised impacts.
- The following delineation limitations must be noted:
  - The boundary between the lower fill embankment and Unit S02 was not sampled due to access being restricted by dense, impenetrable vegetation.
  - The right hand boundary of Unit W03 upstream of the road was not sampled due to access being restricted by dense, impenetrable vegetation.
- The accuracy of the delineations are based solely on the recording of the onsite wetland indicators using a GPS. GPS accuracy will therefore influence the accuracy of the mapped sampling points and therefore water resource boundaries, and an error of 1-5m can be expected. All soil/vegetation/terrain sampling points were recorded using a Garmin Montana™ Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- All vegetation information recorded was based on the onsite observations of the author and no formal vegetation sampling was undertaken. Furthermore, the vegetation information provided only gives an indication of the dominant and/or indicator wetland and riparian species and only provides a general indication of the composition of the vegetation communities. Thus, the vegetation information provided has limitations for true botanical applications.
- Although every effort was made to correctly identify the plant species encountered onsite, wetland plants, particularly the Cyperaceae (sedge) family, are notoriously difficult to identify to species level. Every effort as made to accurately identify plants species but where identification to species level could not be determined, such species were only identified to genus level.
- With ecology being dynamic and complex, there is the likelihood that some aspects (some of which may be important) may have been overlooked. Similarly, sampling by its nature, means that generally not all aspects of ecosystems can be assessed and identified.
- The PES and EIS assessments undertaken are largely qualitative assessment tools and thus the results are open to professional opinion and interpretation. We have made an effort to substantiate all claims where applicable and necessary.

- PES and EIS assessments were applied at a unit scale, meaning the entire unit was assessed and not only the area sampled. However, what was observed at the sample site represented the entire unit unless aerial photography showed clear and distinct differences.
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar development projects.
- The impact descriptions and assessment are based on the author's understanding of the proposed development based on the information provided.
- Evaluation of the significance of impacts with mitigation takes into account mitigation measures provided in this report and standard mitigation measures included in the Environmental Management Programme (EMPr).
- Although ratings of risk concepts like stressor, exposure and receptors was provided, no formal watercourse / water resource risk assessment was undertaken and the application of the DWS risk matrix was not part of the appointed scope of work.
- The following assumptions are applicable to the DWS risk assessment undertaken:
    - All risk ratings generated by the DWS risk matrix are conditional on the effective implementation of the mitigation measures provided in this report.
    - For the purposes of this study, the term 'stressor' was favoured instead of the term 'aspect' referred to in the DWS risk matrix.
    - For the purposes of this study, the criterion 'frequency of stressor occurrence' was favoured instead of the criterion 'frequency of activity' referred to in the DWS risk matrix.
    - For the severity ratings, impacts to wetlands were assessed on their merits rather than automatically scoring impacts to wetlands as 'disastrous' as guided in the DWS risk matrix.
    - The severity assessment for changes in flow regime and physico-chemical impacts were interpreted in terms of the changes to the local freshwater ecosystem represented by the potentially affected reaches.

3. RESULTS & DISCUSSION: DESKTOP ASSESSMENT

3.1 Review of Freshwater Ecosystem Context

3.1.1 Local Climate

The town of Eshowe usually receives approximately 933mm of rain per year which falls primarily during mid-summer. The area receives the lowest rainfall in July (16mm) and the highest in January (137mm). The average midday temperatures range from about 21.8°C in July to 27.5°C in February. The coldest temperatures in the Eshowe area are observed in July where nightly temperatures are, on average, 9.3°C.

Source of above information: http://saexplorer.co.za/south-africa/climate/eshowe_climate.asp

3.1.2 Drainage Setting

The study area occurs within two DWA quaternary catchments; W11A (east) and W12B (west). The majority of the road upgrade will occur within the quaternary catchment W12B. Quaternary catchments W11A and W12B both form part of the Usutu to Mhlatuze Water Management Area (WMA). The provided alignment is located between KM 18.00 and KM 26.00 along the already established P50-1 provincial road. Watercourses within the study area occurring within W12B are within the uMhlatuze River catchment. The uMhlatuze River is the main collecting river of the catchment and is located approximately 8km downstream. More locally, the 1: 50000 2831CD topo-cadastral map indicates that the road under investigation currently crosses two tributaries of the Bomvana River. The Bomvana River is a right-bank tributary of the uMvazane River that is a right-bank tributary of the uMhlatuze River. The western tributary is called the Kwanonkolombelana Stream and the eastern tributary is unnamed.

Watercourses within the study area occurring within W11A are within the Matigulu River catchment. The Matigulu River is the main collecting river of the catchment and is located approximately 11.5 km south of the study site. According to the 1999 desktop PES assessment, the Mhlatuze River is in a 'Largely Natural' condition (Class B), whilst the Matigulu River is in an 'unmodified, natural' condition (Class A), potentially highlighting their ecological sensitivity.

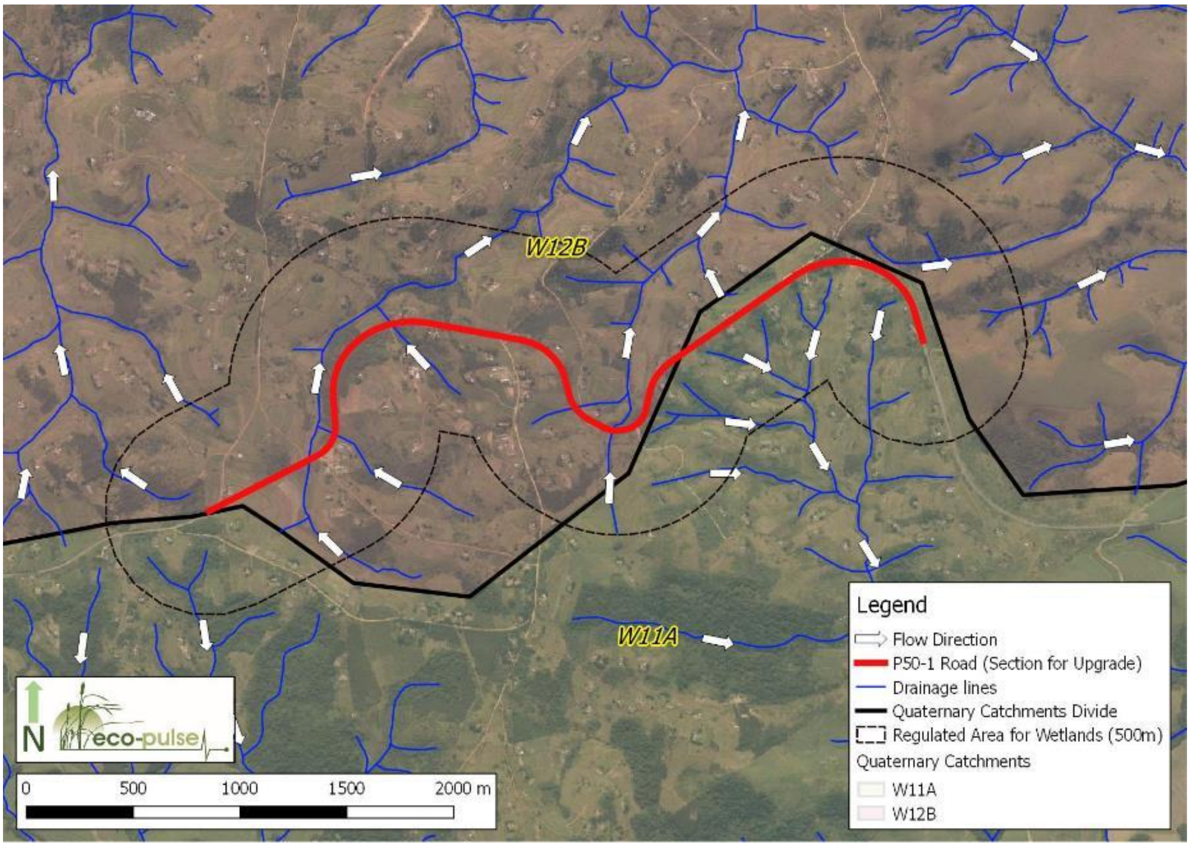


Figure 4 Local drainage setting within and downstream of the road upgrade site.

3.1.3 Geology and Soils

The site is primarily underlain by Natal Group Sandstone described as generally reddish, feldspathic and micaceous sandstone with subordinate quartz arenite, mudrock, granulestone and conglomerate. The central areas of the site are underlain to a lesser extent with Karoo dolerite which comprises a network of dolerite sills, sheets and dykes, mainly intrusive into the Karoo Supergroup (Department of Agriculture Land Cover Database).

Soils on site comprise primarily freely drained, red and yellow apedal soils with humic topsoils making up more than 40% of the land type with lesser extents of predominantly shallow soils (Mispah and Glenrosa forms) with little or no lime in the landscape (Department of Agriculture Land Cover Database).

3.1.4 Ecological Setting

In terms of the ecological context, the project area is situated within what has been mapped and described by Mucina and Rutherford (2006) in their National vegetation Map as Ngongoni Veld. In its untransformed state this vegetation type is described as a dense, tall grassland with a low species diversity as the vegetation is almost completely dominated by the unpalatable, wiry Ngongoni grass (*Aristida junciformis*) (Mucina & Rutherford, 2006).

Scott-Shaw and Escott (2011) in their provincial vegetation map of KZN have mapped and described the vegetation of the project area as Moist Coast Hinterland Grassland. Moist Coast Hinterland Grassland is confined to the KZN and Eastern Cape provinces on rolling and hilly landscapes from near Melmoth in the north to near Libode in the Eastern Cape and is characterised by dense, tall sour grassland dominated by *A. junciformis* with low associated species diversity (Scott-Shaw and Escott, 2011).. *Themeda triandra* and *Tristachya leucothrix* can become dominant when this vegetation type is in good condition (Scott-Shaw and Escott, 2011).

The wetland vegetation occurring within this vegetation type is generally described as Alluvial Wetlands: Temperate Alluvial Vegetation (Scott-Shaw and Escott, 2011). This vegetation is described as: "Flat alluvial riverine terraces supporting an intricate complex of macrophytic vegetation (channel of flowing rivers and river-fed pans), marginal reed belts (in sheltered ox-bows and along very slow-flowing water courses) as well as extensive flooded grasslands, ephemeral herblands and riverine thickets" (Scott-Shaw and Escott, 2011).

From a national freshwater ecological perspective, the project area falls within the sub-escarpment savannah wetland vegetation group defined in the NFEPA. Reference species composition and community structure for this vegetation has not been documented.

3.2 Conservation Context

Understanding the conservation context and importance of the study area and surrounds in terms of conservation planning is important to inform decision making regarding the management of the aquatic resources in the area. In this regard, national, provincial and regional conservation planning information available was interrogated to obtain an overview of the study site.

3.2.1 National Conservation Planning

In terms of the NFEPA project, the study area occurs within two sub-quaternary catchments. The northern sub-quaternary catchment is not classified as a River FEPA, however, the southern sub-quaternary catchment is classified as an Upstream Management Area. Upstream Management Areas are sub-quaternary catchments which have been identified as part of the NFEPA project where human activities need to be managed in order to prevent degradation of key downstream river FEPAs and Fish Support Areas (Driver et al. 2011). No wetland FEPAs are present in close proximity to the study area.

In terms of terrestrial component of the National Biodiversity Assessment (SANBI, 2011), Ngongoni Veld is listed as Vulnerable. In terms of the freshwater component (NFEPA), the sub-escarpment savannah wetland vegetation group is listed as endangered.

3.2.2 Provincial Conservation Planning

In terms of the provincial vegetation threat status assessment, the Moist Coast Hinterland Grassland Vegetation Type is listed as Endangered whilst the local wetland type, which occurs within the study area, Alluvial Wetlands: Temperate Alluvial Vegetation, is listed as Vulnerable.

In terms of the KZN Freshwater Systematic Conservation Plan (SCP), the planning units No. 2080, 2175 and 2179 which accounts for the majority of the area within the study site is classified as 'Available'. This means the catchment has been identified as being available for conservation purposes. Areas on the extreme western and eastern extents of the study site, namely: planning units No. 2074 and 2086, have been 'Earmarked' for conservation. This means the catchment has been identified as having a potential to conserve aquatic biodiversity.

In terms of the 2016 KZN Terrestrial Systematic Conservation Assessment (SCA), terrestrial and freshwater ecosystems within the study area are not classified as either Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs). In terms of the 2011 KZN Terrestrial Systematic Conservation Plan (SCP), the study area is classified as a Biodiversity Area ('0Co') and none of the sites have been classified as a Critical Biodiversity Area (CBA). Biodiversity areas are not flagged as biodiversity priorities but do still potentially host important species and thus are not open to wholesale development (EKZNW, 2011).

3.3 Desktop Watercourse Mapping

The watercourse units occurring within a 500m radius of the proposed project properties were mapped at a desktop level and classified in terms of their broad HGM type (see Figure 5, below). The upper reaches of the quaternary catchment W11A, on the south eastern extent of the site, are synonymous with very steep slopes which do not favour wetland formation, however, some localised wetland units were evident some distance downstream (Figure 5). The western extent of the study site, located within the upper reaches of quaternary catchment W12B, had a much gentler gradient which seemed to favour wetland formation; this was confirmed during the site visit (Figure 5).

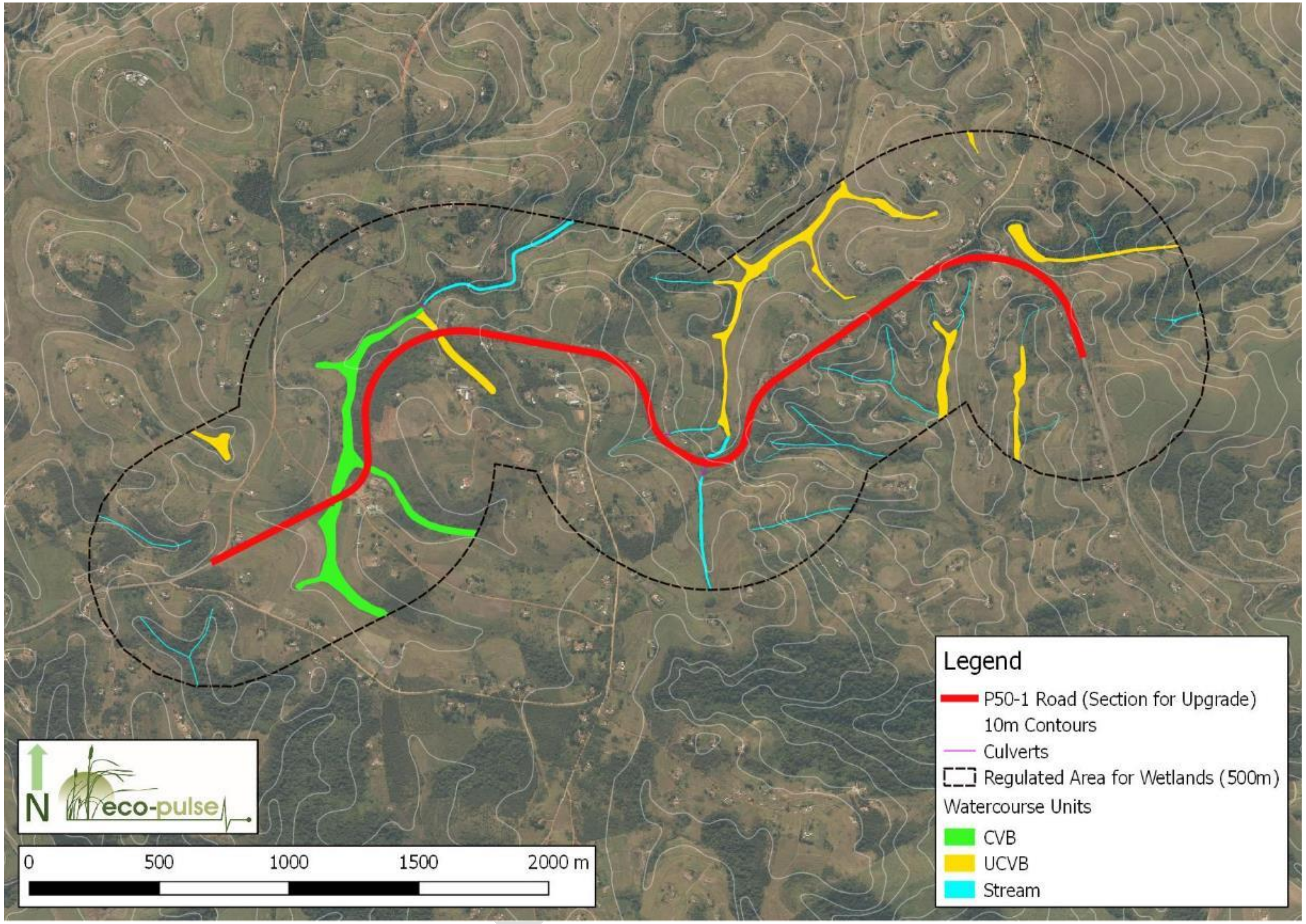


Figure 5 Desktop mapped watercourses classified according to hydro-geomorphic type.

3.4 Desktop 'Likelihood of Impact' Screening

An aquatic ecosystem screening exercise was undertaken to identify watercourses that are likely to be measurably negatively affected by the proposed road upgrade in order to delineate the extent of the study area for further assessment. The main risks associated with the construction and operation of the proposed road upgrade include:

1. **Direct physical modification and/or destruction** of watercourses within and in the vicinity of the road upgrade footprint, both planned and accidental;
2. **Erosion and sedimentation impacts** associated with working within and in close proximity of the watercourses;
3. **Water pollution impacts**.

Based on the above-mentioned risks, two (2) streams and five (5) wetlands were assessed as being at moderate to high 'likelihood of impact' (Table 2). These watercourses are shown shaded in orange for moderate 'likelihood of impact' and red for high 'likelihood of impact' (Figure 6). The moderate and high 'likelihood of impact' watercourse units were taken forward for further formal assessment and effectively formed the extent of the study area for this assessment. Watercourses at very low to low 'likelihood of impact' are shaded in "green" and "yellow", respectively (Figure 6), and were excluded from further assessment.

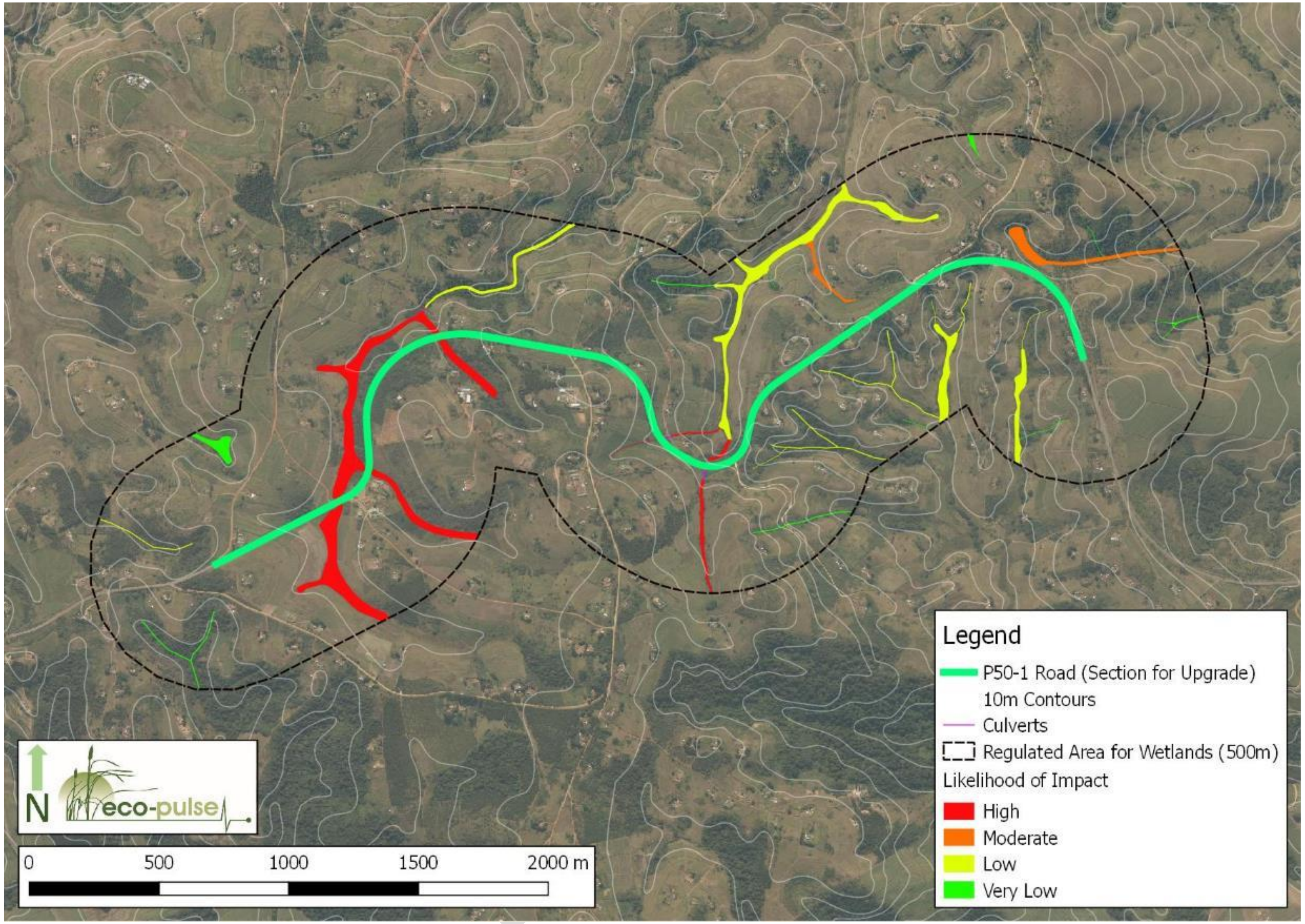


Figure 6 Likelihood of impact rating for the desktop mapped watercourses.

4. RESULTS & DISCUSSION: BASELINE HABITAT ASSESSMENT

The infield baseline habitat assessment focused on watercourse units rated as being at moderate and high 'likelihood of impact'. The extent (infield delineation), classification, habitat characteristics, present ecological state (PES) and ecological importance and sensitivity (EIS) of these watercourse units is discussed in this section.

4.1 Delineation, Classification & Habitat Characteristics

The infield sampling of soil and vegetation in conjunction with the recording of diagnostic topographical / terrain indicators and features, enabled the delineation of seven (7) watercourse units which could possibly be negatively affected by the road upgrade. The 7 units comprise five (5) wetland units and 2 (two) stream units.

The wetlands identified within the project area were primarily valley bottom wetlands, namely three (3) Un-channelled Valley Bottom (UCVB) units (W03, W04 and W05) and two (2) Channelled Valley Bottom (CVB) units (W01 and W02). The wetlands occurred within valley floor settings and were associated with gently sloping catchments whilst the two assessed stream units (S01 and S02) were found at the heads of valleys flanked by significantly steeper topography.

A summary of the key biophysical characteristics of each delineated watercourses unit is provided in Table 6 below.

Soil characteristics:
Permanently saturated soils sampled within Units W01 and W02 generally comprise dark grey soils characterised by low matrix values and chromas (e.g. 7.5YR 3/1). The soils were saturated with water tables occurring at 10-20cm depth.

Seasonally saturated within all wetlands generally comprised dark grey clay loam with low matrix values and chromas (e.g. 7.5YR 2.5/2) and a moderate to high abundance of distinct orange mottles.

. Temporarily saturated soils on site comprised a dark brown-grey to grey sandy loam (e.g. 7.5YR 3/2) with a low to moderate presence of orange mottling. Soils sampled in proximity of the streams were primarily terrestrial soils whilst soils sampled within the stream channels consisted of alluvial sediment.

A detailed description of the hydric soils encountered within each of the units assessed is provided in Table 6 below.

Vegetation characteristics:
Due to many of the wetlands largely being intact and dominated by permanently and seasonally saturated soils, vegetation was a strong indicator of the presence and extent of wetland habitat within the study area. Intact wetland vegetation communities observed comprised *Cyperus latifolius* sedgeland

(W01), *Juncus lomatophyllis* rushland (W01), *Cyperus latifolius - Juncus lomatophyllis* marshland (W02), *Paspalum urvillei – Leersia hexandra* hygrophilous grassland (W02), *Dissotis canescens* hygrophilous grassland (W03), *Ischaemum fasciculatum - Andropogon eucomus* hygrophilous grassland.

In the more disturbed and secondary vegetation communities dominated by opportunistic, weedy alien invasive species, the presence of obligate wetland plants was still notable.

The riparian vegetation varied from woody alien thickets dominated by *S. anceps* and *L. camara* to mixed forb and grassland communities with high abundances of *Sporobolus africanus* and *Panicum maximum* with co-dominant forbs including *Ranunculus meyeri*, *Commelina erecta* and *Desmodium incanum*. Instream vegetation was limited to *Fimbristylis complanata* subsp. *complanata* in Unit S02 whilst the active channel in Unit S01 was devoid of vegetation.

A detailed description of the vegetation communities encountered within each of the units assessed is provided in Table 6 below. Selected photographs taken during the site visit(s) highlighting important features of the watercourse units assessed are provided following Table 6. :

Table 6. Summary of the key hydro-geomorphic and biophysical characteristics of the delineated watercourses.

Watercourse Units	Classification	Channel & Flow Characteristics	Dominant Wetness / Flow Regime & Soil Characteristics	Vegetation Communities
W01	Channelled valley bottom wetland	Active channel: 0,5m deep x 1m wide; flows approximately 30cm deep, very slow flowing.	Permanent saturation. The permanent hydric soils sampled typically comprised dark grey gleyed soils characterised by low matrix chroma (1) and faint orange mottling at a depth of 50cm. The seasonal hydric soils comprised dark grey clay loam characterised by low matrix chroma (1-2) and a high abundance of orange mottles, particularly within the rhizospheres.	The permanent wetland areas below the road comprise a medium height, monotypic sedgeland community dominated by *Cyperus latifolius* with moderate to low abundances of *Cyclosorus interruptus, Acroceras macrum* and *Phragmites australis*. Permanently wet areas above the road were characterised by localised shallow stagnant pools (caused by impoundment above the road) bordered by a *Juncus lomatophyllus* dominated rushland community with sub-dominant species including *Leersia hexandra* and *Setaria sphacelata* var. *sphacelata*. The seasonal wetland areas both above and below the road were fairly similar in composition comprising a mixed sedgeland-grassland transitional zone with *C. latifolius*, *Eragrostis plana*, *Cyperus eculentus*, *Kyllinga melanosperma and Ranunculus meyeri*. The temporary wetland areas comprised a mixed tall tufted grassland community dominated by *E. plana* and *Sporobolus africanus* with lower abundances of a rhizotomous Cynodon sp., *R. meyeri*, *C. esculentus*, *Verbena bonariensis* and *Verbena officinalis*.
W02	Channelled valley bottom wetland	Active channel: 0,5m deep x 2 m wide; flows approximately 5cm deep. .	Permanent and seasonal saturation. The soils within this unit, above the road, comprise saturated dark grey clay loam with low matrix chroma (1-2) and no mottling. The saturation regime appears to have been elevated from seasonal to permanent due to the impounding of flows above the road crossing. Seasonal soils below the road comprise a dark grey clay loam with a low abundance of orange mottles, has a noticeably light bulk density and	Wetland vegetation above the P50 road comprised a disturbed medium-tall grassland community with a low diversity of forbs. Dominant species included a mix of weedy and hardy obligate wetland and facultative species, namely *Paspalum urvillei*, *L. hexandra*, *Digitaria* sp. and *Rubus cuneifolius*, with lesser dominant species limited to *Commelina erecta*, *V. bonariensis*, *Pteridium aquilinium*, *Cyathea capensis*, *Solanum mauritianum* and *Cyperus congestus*. Wetland vegetation below the P50 road was a low-medium height *C. latifolius* and J. lomatophyllus dominated community with low abundances of including *Fimbristylis complanata* subsp. *complanata*, *Gomphocarpus physocarpus*, *R.*

Watercourse Units	Classification	Channel & Flow Characteristics	Dominant Wetness / Flow Regime & Soil Characteristics	Vegetation Communities
			contains high levels of organic matter.	*meyeri*, *Zantedeschia aethiopica* and an unknown *Helichrysum* sp.
W03	Un-channelled valley bottom wetland	n/a	Seasonal saturation. Seasonal soils below the road were a mix of light and dark grey sandy loam soils characterised by low matrix chroma (1-2) and high abundance of orange mottles. Soils above the road were marginally seasonal in nature and were characterised by grey sandy clay-loam with a low abundance of faint orange mottles.	The seasonal wetland areas above are characterised by a dense alien thicket dominated by *R. cuneifolius* and *Lantana camara* with lower abundances of *Canna indica*, *C. latifolius*, *L. hexandra*, *S. mauritianum, Dietes iridioides* and *Populus x canescens* Seasonal wetland vegetation below the road comprises a mixed fernland-grassland community dominated by Digitaria sp. and P. aquilinium with a moderate abundance of *C. latifoilus* and a low density of Dissotis canescens as well as various IAPs including *Solanum mauritianum,* *C. indica* and *R. cuneifolius*.
W04	Un-channelled valley bottom wetland	n/a	Temporary saturation. Temporary soils comprise a dark brown-grey sandy loam to grey clayey loam matrix with a moderately low matrix chroma (2-3) and a low abundance of faint orange mottles present.	The temporary wetland vegetation is an *Ischaemum fasciculatum* - *Andropogon eucomus* dominated grassland with lesser abundances of *D. eriantha*, *Tagetes minuta*, *Panicum maximum*, *Aristida junciformis*, *S. africanus*, *D. iridioides* and an unknown *Rhoicissus sp*.
W05	Un-channelled valley bottom wetland	n/a	Seasonal saturation. Seasonal soils comprise a grey sandy loam with a moderately low matrix chroma (2-3) and a low to moderate abundance of orange mottles.	The vegetation is a transitional zone between a *C. latifolius* sedgeland in the central areas of the wetland towards a tufted *D. eriantha* grasslandon the outer edges of the wetland. Sub-dominant species include *Plectranthus comosum* and Persicaria sp. whilst *R. cuneifolius* and *Smilax anceps* are also present along the fringe of the wetland habitat. It is important to note that large scale disturbance of wetland vegetation has occurred in the form of burning and deforestation. A small *Syzigium cordatum* forest community with other notable species including *A. macrum*, *Nephrolepis biserrata*, *Plectranthus ciliates* is located at the head of the wetland.
S01	Mountain headwater ephemeral stream channel (mountain stream)	Ephemeral stream; Active channel: 0,5m deep x 2m wide; no flow at time of assessment.	Flows through the channel are likely ephemeral and limited to high rainfall events. This is evidenced by the lack of flow during sampling (which was completed during a season of high	Below the road instream habitat comprises alluvium. . The riparian habitat is comprises dense alien thicket dominated by *S. anceps*, and *L. camara* with a lower abundance of *P. maximum*, *S. mauritianum*, *S. cordatum* and *Plectranthus comosum*.

Watercourse Units	Classification	Channel & Flow Characteristics	Dominant Wetness / Flow Regime & Soil Characteristics	Vegetation Communities
			rainfall) and the small upstream catchment.	Above the road the vegetation comprises secondary grassland community dominated by *S. africanus* and R. meyeri with lesser abundances of *T. minuta*, *P. maximum*, *Bidens pilosa*, *Ageratum conyzoides* and *Colocasia esculenta*. A small alien thicket, was present within the riparian zone immediately above the culvert, and comprised primarily *L. camara* and *S. mauritianum*.
S02	Mixed bedrock-alluvial stream channel (mountain stream)	Seasonal stream; Active channel: 1m deep x 2m wide; flow approximately 20cm deep.	Flows were present during the time of sampling however based of the size of the upstream catchment it is likely that these flows are not perennial but more seasonal in nature.	Instream vegetation was limited to marginal *F. complanata* subsp. *complanata* individuals along the edges of a shallow pool within the stream. The bed of the channel comprised mixed sand and bedrock. The majority of the vegetation within the riparian zone was a moderately sparse, forb dominated community with a high degree of woody alien species together with local weeds and other pioneer species. Dominant species within the riparian zone included *L. camara*, *S. africanus*, *D. eriantha* and *R. meyeri* with moderate abundances of *A. macrum*, *E. grandis*, *Commelina erecta*, *P. aquilinium, Ricinus communis and Desmodium incanum.*

	
P1. View across unit W01, from west to east, downstream of the road, showing the clear transition from secondary grassland (terrestrial) to a monotypic *C. latifolius* sedgeland.	**P2.** Upstream view of unit W01 showing the valley bottom setting of the wetland as well as *J. lomatophyllus* communities present around localised pooling resulting from impoundment caused by the road.
	
P3. View from road looking upstream of unit W02, giving an indication of the current intensity of IAP invasion. The foreground of this image is dominated by *R. cuneifolius* with larger *Eucalyptus* sp. in the background.	**P4.** View of W02 below the road showing short herbaceous wetland vegetation, in the foreground with the *C. latifolius* vegetation community in the background, which differs markedly from the vegetation above the road.
	
P5. View from east to west across unit W03, downstream of the road showing dead plant material within the unit with some alien vegetation in the foreground.	**P6.** View from the road looking upstream of unit W03, showing the high degree of alien plantation encroachment lining the edges of the unit and wetland vegetation communities in the central parts.

	
P7. View from east to west looking downstream from the head of unit W04. This unit comprises primarily a hygrophilous grassland community dominated by *I. fasciculatum* with low levels of IAP infestation.	**P8.** Clear habitat degradation to the south of the intact *S. cordatum* forest at the head of unit W05. This section of the wetland had been subject to anthropogenic disturbance in the form of burning and deforestation.
	
P9. View from north west to south east looking down the unit W05 showing a section of the intact C. latifolius community.	**P10** View from south to north across the stream channel, above the road of unit S01. Note the extensive clearing that has altered the vegetation characteristics of this area.
	
P11. View from west to east looking downstream of unit S01. Note the extensive alien thicket which is a dominant feature of the riparian zone.	**P12.** View of the Unit S02 channel looking downstream showing the mixed alluvial-boulder channel bed material and riparian vegetation along channel banks which was dominated by forbs and grasses such as *C. erecta* and *D. eriantha*.

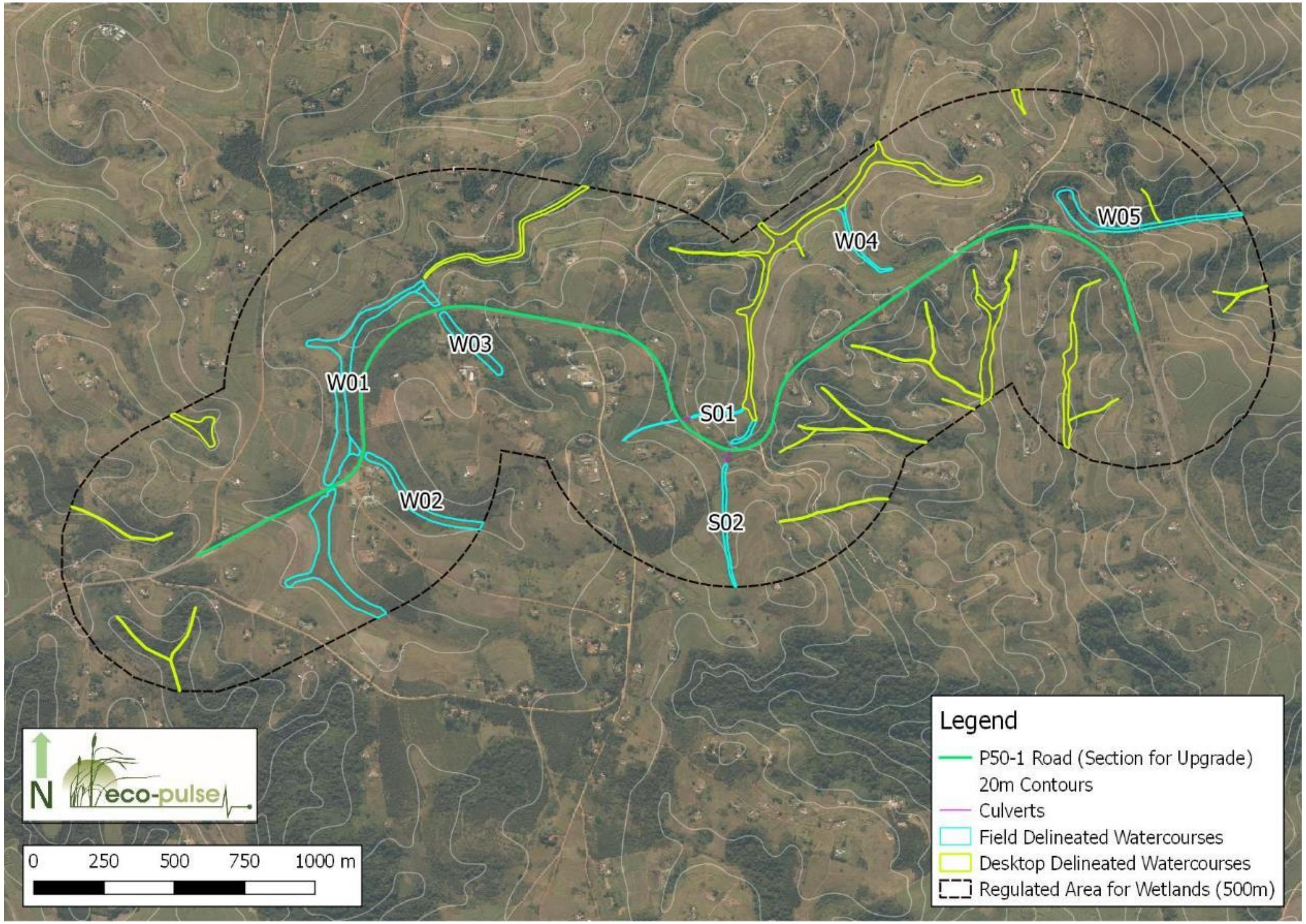


Figure 7 Field delineated watercourses and desktop delineated watercourses occurring within the regulated area for wetlands (500m buffer of P 50 Road).

4.2 Baseline Ecological Assessment of Wetlands

The Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) of the delineated wetland and stream units are presented in this section of the report.

4.2.1 Present Ecological State (PES)

Present Ecological State (PES) (also referred to as ecological condition / wetland health or integrity) is a measure of the deviation of an ecosystem from its reference state (Macfarlane et al., 2008).

Prior to assessing wetland PES, it is important to provide a hypothetical reference state (prior to anthropogenic disturbance) of the wetland units being assessed in order to assess the deviation from this state. A reference state summary is provided in Table 7 below.

Table 7. Comparing anticipated wetland reference state with present state for the wetlands in the study area.

Component of Wetland Health	Speculated Reference State
Unit W01 (CVB)	**Hydrology:** Water inputs to the wetland dominated by surface flows from overtopping of stream channel as well as by lateral subsurface inputs. Through flows are a mix of channelled surface flows and diffuse flows outside of the channel driven by lateral inputs. The wetland is dominated by permanently saturated wetness zones with seasonal zones occurring along the edges. **Geomorphology:** The wetland is naturally characterised by relatively low levels of clastic sedimentation with limited organic sedimentation, although organic rich sediments are likely a natural feature. **Vegetation:** Natural vegetation communities comprise herbaceous marshland of the Sub-escarpment Savanna vegetation group dominated by obligate wetland sedges, rushes and herbs / shrubs.
Units W02, W03 & W04 (UCVB)	**Hydrology:** Water inputs to the wetland dominated by incoming diffuse surface flows from upstream and surrounding catchment, as well as by lateral subsurface inputs. Through flows would have been largely diffuse. The wetland is dominated by seasonally saturated wetness zones. **Geomorphology:** The wetland is naturally characterised by relatively low levels of clastic sedimentation with limited organic sedimentation. **Vegetation:** Natural vegetation communities comprise herbaceous marshland and hygrophilous grassland of the Sub-escarpment Savanna vegetation group.
Unit W05 (UCVB)	**Hydrology:**

Component of Wetland Health	Speculated Reference State
	Being in a valley head, seep like setting, the dominant water input is lateral subsurface inputs. Through flows would have been largely diffuse. The wetland is dominated by seasonally saturated wetness zones. **Geomorphology:** The wetland is naturally characterised by relatively low levels of clastic sedimentation with limited organic sedimentation, although organic rich sediments are likely a natural feature. **Vegetation:** Natural vegetation communities comprise a mix of *Syzygium cordatum* swamp forest and herbaceous marshland of the Sub-escarpment Savanna vegetation group dominated by obligate wetland sedges, rushes and herbs / shrubs.

A summary of the WET-Health assessment results is included in Table 8 below. Three of the wetlands (W01, W04 and W05) were assessed as being in a good condition and **Largely Natural ("B" PES Category)** which indicates 'a slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place'. Wetland Units W02 and W03 have experienced higher levels of disturbance and modification and were assessed as being **Moderately Modified ("C" PES Category)** which indicates that 'a moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact'.

The key general impacts that influenced the health scores for each unit are listed in Table 8 below. It is important to note that the existing road is having a measurable and intense localised effect on the health of the wetland units that are currently crossed. The main impacts include flow impoundment immediately upstream of the crossings and increased flow velocities and rates of erosion below the culvert outlets. Increased channelization also appears to occur in some units above and below the road as a result of the establishment of artificial channels to probably allow for more efficient flow through the culverts and reduce ponding.

Table 8. Summary of the WET-Health assessment results and key impacts.

HGM Unit	TYPE	Extent	Hydrology	Geomorphology	Vegetation	Overall PES
			Impact Score	Impact Score	Impact Score	Impact Score
W01	Channelled valley bottom wetland	~3.2ha	2.0	0.3	3.3	**1.88**
PES Category			C	A	C	**B**

Impacts to this wetland include:

1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns.
2. Increased runoff and sediment from catchment due to land cover alteration.
3. Channel straightening below the road crossing to allow for the efficient removal of water away from the culvert.
4. Flow canalisation through the culvert and increased flow velocities at the culvert outlet leading to increased rates of erosion.
5. Flow impoundment immediately above the culvert due to 'bottle-necking' at the single culvert inlet.
6. Low abundance of alien plants within the wetland.
7. Infilling of a corridor of wetland habitat for the establishment of the road.

HGM Unit	TYPE	Extent	Hydrology	Geomorphology	Vegetation	Overall PES
			Impact Score	Impact Score	Impact Score	Impact Score
W02	Channelled valley bottom wetland	~1.7ha	3.5	2.0	5.2	**3.54**
PES Category			C	C	C	**C**
Impacts to this wetland include: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Increased runoff and sediment from catchment due to land cover alteration. 3. Flow canalisation through the culvert and increased flow velocities at the culvert outlet leading to increased rates of erosion. 4. Erosion and/or artificial channel establishment immediately above the road. 5. Flow impoundment immediately above the culvert due to 'bottle-necking' at the single culvert inlet. 6. Infilling of a corridor of wetland habitat for the establishment of the road. The effect of moderate abundances of woody and herbaceous alien plants within the wetland in terms of increased on-site water use and overall vegetation health. 7. Moderate alien plant invasion.						
W03	Unchannelled valley bottom wetland	~1.3ha	4.0	0.1	5.5	**3.31**
PES Category			D	A	D	**C**
Impacts to this wetland include: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Flow canalisation through the culvert and increased flow velocities at the culvert outlet leading to increased rates of erosion. A channel has thus formed below the road, decreasing saturation levels. 3. Flow impoundment immediately above the culvert due to 'bottle-necking' at the single culvert inlet. 4. The effect of a high density of woody alien plants within the wetland in terms of increased on-site water use and overall vegetation health. 5. Infilling of a corridor of wetland habitat for the establishment of the road.						
W04	Unchannelled valley bottom wetland	~0.5ha	1.0	0.0	3.1	**1.31**
PES Category			B	A	C	**B**
Impacts to this wetland include: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Increased runoff and sediment from catchment due to land cover alteration.						
W05	Unchannelled valley bottom wetland	~1.6ha	1.5	0.0	5.3	**2.17**
PES Category			B	A	D	**C**
Impacts to this wetland include: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Increased runoff and sediment from catchment due to land cover alteration. 3. Anthropogenic activities including burning and deforestation within the unit.						

Note that individual WET-Health assessment Excel™ spreadsheets can be made available by Eco-Pulse upon request.

4.2.2 Wetland Functionality (Ecosystem Services) Assessment

Wetlands are known to provide a range of ecosystem goods and services to society, and it is largely on this basis that policies aimed at protecting wetlands have been founded. This section of the report provides a summary of the predicted level of importance of the various wetland ecosystems in providing ecosystem services (and goods).

The predicted level of importance of the various potential goods and services have been summarised in Table 9 below.

Units W01 and W03 were assessed as providing moderately important water quality enhancement services and as such should be considered important in this regard. These ratings were driven by the high surface roughness of the wetlands, presence of good vegetation cover, presence of some diffuse flows, the high likelihood that stormflows spread across the wetland annually, and the seasonal to permanently saturation conditions. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

Unit W01 was assessed as providing moderately important sediment trapping services and as such should be considered important in this regard. This rating was driven by the high surface roughness of the wetland, presence of good vegetation cover, presence of some diffuse flows outside of the central channelled areas, and the high likelihood that stormflows spread across the wetland annually. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

Units W01 and W04 were assessed as providing moderately important streamflow regulation services. These ratings were driven by the seasonal to permanently saturation conditions and the predominance of subsurface flows and strong surface-groundwater linkages typical of low lying areas underlain by sandstone. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

Units W01, W02 and W05 were assessed as providing moderately important carbon storage services due to their seasonal to permanent saturation condition and dense vegetation. It is important to note the Unit W01 has organic rich sediments and is the most important in this regard. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

In terms of biodiversity maintenance, Unit W01 was assessed as being of moderately-high importance due to the wetland being a large and significant system in the region and being relatively intact with low to moderate driver and habitats modification, and thus being representative of the endangered Sub-escarpment Savanna wetland vegetation group. Units W04 and W05 were assessed as being of moderate importance in terms of biodiversity maintenance due to having some representative herbaceous habitat the endangered Sub-escarpment Savanna wetland vegetation group but having higher levels of habitat fragmentation and smaller patch sizes. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

In terms of provisioning and cultural services, only Units W01, W03 and W05 were assessed as providing moderately important harvestable resources for the local communities. This importance ratings was driven largely by the assumed high demand for harvestable subsistence resources in the rural setting although the actual supply of such services was moderately-low. The rest of the units were assessed as being of low to moderately-low importance in terms of providing such services.

Table 9. Summary of the importance of wetlands in terms of ecosystems services.

Ecosystem Service/Benefit		Overall Importance Rating				
		W01	**W02**	**W03**	**W04**	**W05**
REGULATING AND SUPPORTING SERVICES	Flood attenuation	Moderately Low	Moderately Low	Low	Very Low	Very Low
	Stream flow regulation	Moderate	Moderately Low	Moderately Low	Moderate	Moderately Low
	Sediment trapping	Moderate	Moderately Low	Moderately Low	Low	Low
	Erosion control	Moderately Low	Moderately Low	Moderately Low	Moderately Low	Moderately Low
	Phosphate removal	Moderate	Low	Moderate	Moderately Low	Low
	Nitrate removal	Moderate	Very Low	Moderate	Moderately Low	Moderately Low
	Toxicant removal	Moderate	Low	Moderate	Moderately Low	Low
	Carbon storage	Moderate	Moderate	Moderately Low	Moderately Low	Moderate
	Biodiversity maintenance	Moderately High	Low	Very Low	Moderate	Moderate
PROVISIONING SERVICES	Water supply	Low	Very Low	Very Low	Very Low	Very Low
	Harvestable natural resources	Moderate	Moderately Low	Moderate	Moderately Low	Moderate
	Food for livestock	Moderately Low	Low	Low	Moderately Low	Moderately Low
	Cultivated foods	Low	Moderately Low	Moderately Low	Low	Low
CULTURAL SERVICES	Cultural significance	Low	Low	Low	Low	Low
	Tourism & recreation	Very Low	Very Low	Very Low	Very Low	Very Low
	Education and research	Very Low	Very Low	Very Low	Very Low	Low

Note that individual WET-Ecoservices assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

4.2.3 Ecological Importance & Sensitivity (EIS)

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales (Duthie, 1999). Therefore, ecological importance encompasses the role water resources play in maintaining biodiversity as well as the importance of regulating and supporting functions / services for maintaining and buffering freshwater ecosystems. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Duthie, 1999). As an overarching measure of the importance of an ecosystem, EIS provides a guideline for determination of the Ecological Management Class (EMC) (Duthie, 1999).

Although distinct from ecological importance, the socio-cultural importance of provisioning and cultural goods and services provided is also important to integrate into the overall importance of water resources.

For these reasons, the EIS assessment involved the assessment of the importance of the following:

- Biodiversity maintenance (informed by WET-EcoServices assessment)
- Regulating and supporting services (informed by WET-EcoServices assessment)
- Ecological / ecosystem sensitivity
- Provisioning services (informed by WET-EcoServices assessment)
- Cultural services (informed by WET-EcoServices assessment)

A summary of the EIS and socio-cultural importance assessment scores and ratings is provided in Table 10 below.

Unit W01 was assessed as being of moderately-high EIS due to the moderately-high importance of the biodiversity maintenance services provided. The rest of the units were assessed as being of moderate EIS due to the provision of one or more moderately important regulating and supporting services as well as providing moderately important biodiversity maintenance services in the case of Units W04 and W05. Units W01, W03 and W05 were assessed as being of moderate socio-cultural importance due to providing moderately important provisioning services, particularly harvestable resources.

Table 10. Summarised EIS rating results for the wetland units.

	W01	W02	W03	W04	W05
Ecological Importance	**2,43**	**1,78**	**1,73**	**2,10**	**2,20**
Biodiversity maintenance	2,43	0,51	0,40	2,10	2,20
Flow regime regulation	2,11	1,50	1,50	1,70	1,50
Water quality enhancement	2,15	0,75	1,73	1,23	1,00
Sediment & erosion regulation	1,89	1,25	1,50	1,20	1,30
Climate regulation	2,07	1,78	1,40	1,50	1,70
Ecological Sensitivity	**1,00**	**1,40**	**1,30**	**1,60**	**1,50**
EIS	**2,43**	**1,78**	**1,73**	**2,10**	**2,20**
EIS Rating	**Moderately -High**	**Moderate**	**Moderate**	**Moderate**	**Moderate**
Socio-cultural Importance	**1,67**	**1,41**	**1,70**	**1,30**	**2,10**
Provisioning services	1,67	1,41	1,70	1,30	2,10
Cultural services	1,00	1,00	1,00	1,00	1,00
Socio-cultural Importance Rating	**Moderate**	**Moderately Low**	**Moderate**	**Moderately Low**	**Moderate**

Note that individual wetland EIS assessment Excel™ spreadsheets can be made available by Eco-Pulse upon request.

4.3 Baseline Ecological Assessment of Streams

4.3.1 Present Ecological State (PES)

The results of the IHI assessment is summarised in Table 7 below. The key results of the IHI assessment are as follows:

- The **ephemeral stream channel S01** was assessed as being in a **Moderately Modified** condition (reflected by a "C" PES Category). The moderate level of modification is primarily attributed to the modification of the channel immediately above and below the existing road crossing, the infilling of a section of channel for the establishment of the road, and the modification of the riparian vegetation manifested in the high levels of localised alien plant invasion, particularly immediately above and below the culvert.

- The **seasonal stream channel S02** was assessed as being in a **Moderately Modified** condition (reflected by a "C" PES Category). This unit had a range of similar disturbances to unit **S01**, however, this unit was much larger and, as a result, the magnitude of the impacts affected a much smaller extent of the unit even though, in some cases (particularly flow modification), the intensity of the disturbances were slightly higher.

Like the wetland units, key impacts to the stream units were the direct and indirect impacts of the P50-1 road crossing. Catchment impacts on flows and alien plant invasion of the riparian zones were also measurable impacts.

Table 11. Summary results of the river IHI (Index of habitat Integrity) assessment for streams S01 and S02.

Watercourse Unit	***Habitat Component***		
	Instream PES Category with % intact	**Riparian PES Category with % intact**	**Overall PES (weighted 60:40)**
S01 ***Ephemeral stream***	C: Moderately Modified (75% intact)	D: Largely Modified (56% intact)	C: Fair (65% intact)
	Key Habitat Modifications and Observations: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Flow canalisation through the culvert and increased flow velocities at the culvert outlet leading to increased rates of bed and bank erosion. 3. Infilling of a corridor of instream and riparian habitat for the establishment of the road. 4. Woody and herbaceous IAP invasion of riparian zone which have formed an almost impenetrable thicket in the lower sections of the stream channel (below the road).		
S02 ***Seasonal stream***	C: Moderately Modified (75% intact)	C: Moderately Modified (68% intact)	C: Moderately Modified (70% intact)
	Key Habitat Modifications and Observations: 1. The negative effects of sugarcane and plantation agriculture in the catchment on flow volumes and flood patterns. 2. Flow canalisation through the culvert and increased flow velocities at the culvert outlet leading to increased rates of bed and bank erosion. 3. A high percentage of flows have also been diverted out of the channel just above the road along an informal drainage line alongside a secondary road. 4. Infilling of a corridor of instream and riparian habitat for the establishment of the road. 5. Moderate level of woody and herbaceous IAP invasion above the road, and high level of woody and herbaceous IAP invasion below the road.		

Note that individual aquatic IHI assessment spreadsheets (Microsoft Excel™) can be made available by Eco-Pulse Consulting upon request.

4.3.2 Ecological Importance & Sensitivity (EIS)

The outcomes of stream habitat EIS assessment is summarised below in Table 12. Units S01 was assessed as being of very low EIS and Unit S02 of moderately-low EIS. Although PES was only assessed as moderately modified for both units, both units are characterised by a fairly low diversity of instream biotopes, highly intermittent flow regimes, and instream and riparian habitat was assessed as not being rare. The slightly higher EIS rating for Unit S02 is driven by a higher (moderate) sensitivity to change compared to Unit S01. It is also important to note that neither the two stream units have been flagged as being of particular importance in terms of aquatic / freshwater ecosystem conservation planning information interrogated at a desktop level.

Table 12. Summarised EIS assessment results for the stream units.

Unit	Ecological Importance	Sensitivity	Overall EIS Rating
S01 Ephemeral Channel	**0.0**	**0.5**	**0.25 (Very Low)**
S02 Seasonal Channel	**0.5**	**1.7**	**1.1 (Mod-Low)**

Note that individual aquatic EIS assessment spreadsheets (Microsoft Excel™) can be made available by Eco-Pulse Consulting upon request.

4.4 Recommended Ecological Category (REC) & Management Objectives (RMOs)

The future management of the freshwater ecosystems (streams and associated aquatic habitat) within the project area should be informed by the 'Recommended Ecological Category' (REC) and associated recommended management objectives (RMO's) for the water resource which, in the absence of formal classification, is generally based on the Present Ecological State/ Ecological Category (PES/EC) and the Ecological Importance and Sensitivity (EIS) of water resources (DWAF, 2007) (Table 13, below). However, this idealised table needs to be interpreted in terms of the viability/feasibility for improvement in EC and the desired characteristics based on the context of the streams catchment in terms of existing threats and future development pressures.

The REC is the target or desired state of resource units required to meet water resource management objectives and quality targets. It is determined through the consideration of the PES, EIS and realistic opportunities to improve the PES that is driven by the context / setting. The modus operandi followed by DWAF's Directorate: Resource Directed Measures (RDM) is that if the EIS is high or very high, the ecological management objective should be to improve the condition of the watercourse (Kleynhans & Louw, 2007). However, the causes related to a particular PES should also be considered to determine if improvement is realistic and attainable (Kleynhans & Louw, 2007). This relates to whether the problems in the catchment can be addressed and mitigated (Kleynhans & Louw, 2007). If the EIS is evaluated as moderate or low, the ecological aim should be to maintain the watercourse in its PES (Kleynhans & Louw, 2007). Within the Ecological Reserve context, Ecological Categories 'A' to 'D 'can be recommended as future states depending on the EIS and PES (Kleynhans & Louw, 2007). Ecological Categories 'E' and 'F'(PES) are regarded as ecologically unacceptable, and remediation is needed if possible (Kleynhans & Louw, 2007). A generic matrix for the determination of RECs and RMOs for water resources is shown in Table 13 below.

Table 13. Generic matrix for the determination of REC and RMO for water resources.

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Based on this matrix (Table 13) and the catchment context, the RMO for all of the watercourse units should be at a minimum to 'maintain the current status quo of aquatic ecosystems without any further loss of integrity/condition or functioning' (Table 14).

Table 14. REC and RMO for the delineated watercourse unit based on its PES and EIS ratings.

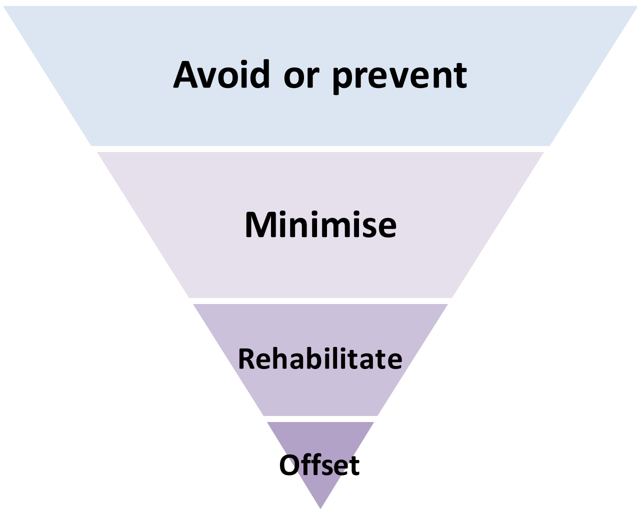
Watercourse Units	PES Class	EIS Rating	REC	RMO
W01	B	Moderately-High	B	Maintain
W02	C	Moderate	C	Maintain
W03	C	Moderate	C	Maintain
W04	B	Moderate	B	Maintain
W05	C	Moderate	C	Maintain
S01	C	Low	C	Maintain
S02	C	Moderately Low	B	Maintain

5. PLANNING AND DESIGN RECOMMENDATIONS

Before assessing the significance of the potential impacts of the proposed road upgrade, it is critically important that best practice and/or specialist recommended mitigation measures are provided to the applicant and incorporated into the site development plan wherever possible.

5.1 Application of the Offset Hierarchy and Recommended No-Go Areas

Generally, it is best practice for most developments to first incorporate sensitive / important environmental features like watercourses and associated buffer zones into the layout, alignment and design planning with the aim of first avoiding and/or minimising impacts to these features in line with the internationally accepted 'mitigation hierarchy' illustrated in Figure 8 below. Only when such avoidance or minimisation is not possible for well substantiated reasons and/or need and desirability, should impacts to sensitive features be remediated or, as a last resort, offset / compensated for.



Refers to considering options in project location, sitting, scale, layout, technology and phasing **to avoid impacts** on biodiversity, associated ecosystem services, and people. This is the best option, but is not always possible. Where environmental and social factors give rise to unacceptable negative impacts mining should not take place. In such cases it is unlikely to be possible or appropriate to rely on the latter steps in the mitigation.

Refers to considering alternatives in the project location, setting, scale, layout, technology and phasing that would **minimise impacts** on biodiversity and ecosystem services. In cases where there are environmental and social constraints every effort should be made to minimise impacts.

Refers to **rehabilitation** of areas where impacts are unavoidable and measures are provided to return impacted areas to near-natural state or an agreed land use after mine closure. Although rehabilitation may fall short of replicating the diversity and complexity of a natural system.

Refers to measures over and above rehabilitation to compensate for the residual negative effects on biodiversity, after every effort has been made to minimise and then rehabilitate impacts. **Biodiversity offsets** can provide a mechanism to compensate for significant residual impacts on biodiversity.

Figure 8 Diagram illustrating the 'mitigation hierarchy' (after DEA et al., 2013).

In this case, the road is existing and as such the upgrade cannot be re-aligned to avoid habitat impacts. The proposed expansion of the road by 2m at the crossings of Units W01, W02, W03 and S01 will involve some habitat infilling. Furthermore, an additional 2-3m of habitat will be disturbed at these crossings points during the construction phase. The exact area of wetland to be permanently infilled and temporarily cleared is unknown at this stage. This can only be calculated once the detailed upgrade layout including embankments and culverts is provided to the authors. Nevertheless, a relatively small are of wetland and stream habitat is predicted to be lost. Assuming that wetland and stream habitat within 10m of the existing road surface (factoring 5m for embankment and 5m for expansion) is either infilled and/or cleared, a total loss of **<u>711.28m² (0.071ha)</u>** is predicted.

Therefore, the key planning measures relate to the design of the watercourse crossings and stormwater management.

5.2 Culvert Design Recommendations

As already mentioned in the wetland PES assessment, the existing road crossings are having measurable impacts of the hydrology of the wetland units due to the concentration of flow through single pipe culverts and flow impoundment due to flow 'bottle-necking. Thus, it is recommended that flow concentration at the crossings be reduced as far as practically possible, especially for Unit W01. The key recommendation in this regard is that the number of box culverts to be established at each of the three wetland crossings be maximised as far as practically possible to increase the width of flow through the crossings. Ideally, box culverts should span entire width of the valley bottoms comprising the wettest parts of the wetlands, specifically the permanent and seasonal zones. However, it is assumed that such a high number of box culverts would be financially unfeasible, hence the recommendation of the maximisation of the number of culverts with particular focus on maximising the number of culverts for Unit W01.

Other design recommendations include:

- Box / portal culverts should be used where possible rather than large diameter pipes.
- Culverts should ideally be sized to transport not only water, but the other materials that might be mobilized, as well as provide passage of aquatic species such as fish.
- Selection of culvert shape should be based on water depth, roadway embankment height, hydraulic performance, and allowing for species movement.
- The culvert outlet apron must be established at the same level as the wetland and stream beds.
- The base (invert) of the new portal/box culvert must be at the exact same elevation as the existing one so that there are no significant upstream and downstream adjustments in channel form. In this regard, the levels must be accurately pegged out by an engineer and the engineer must be onsite to guide the settling of the foundation.
- The inlet of the culvert base must match the elevation of the wetland and stream bed so that there is no culvert base perching (if culvert inlet higher than river bed) or a drop into the culvert (if culvert inlet lower than bed).
- Erosion protection structures must be established at all culvert outlets to reduce wetland and bed erosion / scour. Such structures include Reno-mattresses and/or stilling basins established at the current wetland / stream bed surface.

Note: Inadequate design and installation of culverts may result in culvert failure. Box 2 (below) summarises some key causes of culvert failure for consideration.

Box 2: Possible causes of culvert failure

Culvert failure can have far reaching impact on aquatic resources, particularly those related to system hydrology, erosion/ sedimentation and aquatic biota. Attention must therefore be given to the following to mitigate against possible failure of installed culverts:

- Inadequate culvert capacity for the calculated stream flow.
- Structural failure due to excessive soil loading.

- Wash-out due to water overtopping the road.
- End scouring from poor end treatment and lack of erosion protection.
- Improper jointing resulting in water piping along the outside of the culvert.
- Erosion due to excessive water transport of sand and gravel, arising from the acceleration of flow through the culvert.
- Corrosion from acid or salt laden soils and water.
- Improper inlet and outlet structures, resulting in embankment failures.
- Improper alignment of the culvert relevant to the natural channel, resulting in scour of the embankment at the inlet.
- Poor installation and/or bedding condition resulting in settlement, joint separation, or structural failure of the culvert.

5.3 Stormwater Management Design Recommendations

The following road stormwater management measures are recommended:

- Stormwater generated by the upgraded road should be discharged at regular intervals and many small outlets should be favoured over few large.
- As far as practically possible, stormwater conveyance should be via open drains rather than pipes and conveyance from the road drains to the outlets should via open drains with rough surfaces that are armoured with erosion protection.
- All outlets must be designed to dissipate the energy of outgoing flows to levels that present a low erosion risk. In this regard, suitably designed energy dissipation (e.g. stilling basins) and erosion protection structures (Reno-mattresses) will need to be installed at appropriate locations. Pre- and post-discharge velocities at each outlet should be calculated to inform the appropriate design of the energy dissipation and erosion protection measures.
- All erosion protection measures (e.g. Reno-mattresses) must be established to reflect the natural slope of the surface and located at the natural ground-level.
- Stormwater outlets should not be located at low points within the watercourses.
- Where concrete side drains have been planned, the design team should consider disconnecting the impervious sections at regular intervals with vegetated sections to reduce flow velocities and promote infiltration.

6. IMPACT ASSESSMENT

This section deals with the prediction, description and assessment of the potential construction and operational impacts and risks of the proposed P50-1 road upgrade as described in the introduction (Section 1). The significance and risk assessment spreadsheets are included in **Annexures C and D** respectively.

6.1 Construction Phase Impacts

The potential impacts that are likely to occur during the construction phase of the proposed road upgrade were grouped into the following impact categories:

1. Direct habitat loss and modification impacts (C1).
2. Flow, erosion and sedimentation impacts (C2).
3. Water quality impacts (C3).

Each one of these impacts are briefly described and assessed as follows.

6.1.1 Impact Assessment Overview and Summary

A summary of the impact significance and risk ratings for each impact group under both poor and good mitigation scenarios is provided in Table 10 below. Each of the impacts are discussed in more detail in the following sections.

Under the realistic poor mitigation scenario, the significance of the combined construction phase impacts to water resources and freshwater habitat conservation was assessed as moderately-low. The most significant impacts are C1 and C2 driven by habitat loss and the indirect impacts of working within and in close proximity to the watercourses. Under the good mitigation scenario, the significance of all impacts except C1 can be reduced to low significance.

In terms of risk, as assessed using the DWS risk matrix, Impacts C1 was rated as moderate risk under a good mitigation scenario despite moderately-small changes to the PES of the units assessed. This is largely due to the way that the risk score is calculated in the tool where a direct impact to freshwater habitat like infilling requires a maximum intensity score (of 5). However, the C1 risk score is within 25 points of the low risk category and are thus considered borderline cases. As the predicted impacts on the overall PES of the affected watercourse as a result of the small infilling proposed is low irrespective of impact duration, it is the author's opinion that these impacts can be reduced to low risk provided the mitigation measures provided in this report are strictly adhered to.

Table 15. Summary of significance ratings for construction phase impacts.

Impact No.	SIGNIFICANCE: Quantity and Quality of Water	SIGNIFICANCE: Ecosystem / Habitat Conservation	SIGNIFICANCE: Species Conservation	SIGNIFICANCE: Human Subsistence & Livelihoods	RISK
Realistic Poor Mitigation Scenario					
C1	Low	Moderately-Low	Low	Low	n/a
C2	Moderately-Low	Moderately-Low	Low	Low	n/a
C3	Low	Low	Low	Low	n/a
Combined	Moderately-Low	Moderately-Low	Low	Low	n/a
Realistic Good Mitigation Scenario					
C1	Low	Moderately-Low	Low	Low	Moderate
C2	Low	Low	Low	Low	Low
C3	Low	Low	Low	Low	Low
Combined	Low	Low	Low	Low	n/a

6.1.2 Direct freshwater habitat modification and destruction impacts (C1)

A. Impact Prediction, Description & Assessment:

This impact type refers to the direct physical destruction or disturbance of freshwater habitat caused by vegetation clearing, excavation and/or infilling and alteration of soil and river bank / bed profiles), and associated impacts to ecosystem condition and ecosystem services. This impact does not include the indirect flow, erosion and sedimentation impacts of physical disturbance and modification. This is considered in Impact C2 below.

The proposed expansion of the road by 2m at the crossings of Units W01, W02, W03 and S01 will involve some habitat infilling. Furthermore, an additional 2-3m of habitat will be disturbed at these crossings points during the construction phase. The exact area of wetland to be permanently infilled and temporarily cleared is unknown at this stage. This can only be calculated once the detailed upgrade layout including embankments and culverts is provided to the authors. Nevertheless, a relatively small are of wetland and stream habitat is predicted to be lost. Assuming that wetland and stream habitat within 10m of the existing road surface (factoring 5m for embankment and 5m for expansion) is either infilled and/or cleared, a total loss of **711.28m² (0.071ha)** is predicted.

It is also important to note that if post-construction rehabilitation is poorly implemented, there is a possibility that he disturbed areas will be colonised by opportunistic and disturbance-tolerant species, including Invasive Alien Plants (IAPs) and local weeds. This could also contribute to decreased habitat quality over time.

A summary of the predicted stressor, exposure and impact characteristics is provided in Table 16 below. The potential changes in the PES of the receiving freshwater environment is predicted to be moderately-low under both poor and good mitigation scenarios with no drops in PES class. There is no differences in impacts between the poor and good mitigation scenarios due to the infilling being a permanent and irreversible impact. The potential change in the supply of ecosystem goods and services is predicted to be low under the poor mitigation scenario. Under the good mitigation scenario, the predicted changes in unit PES and ecosystem service supply is predicted to be low. This is largely a result of the small extent of the direct impact.

Table 16. Summary of key impact and risk characteristics for Impact C1.

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Stressor & Exposure Characteristics		
Ecosystem stressor(s)	Physical habitat disturbance and modification	
Intensity of stressor(s)	High	High
Duration of stressor(s)	Permanent	Permanent
Frequency of stressor(s)	Single Event	Single Event
Likelihood of ecosystem exposure to stressor(s)	Definite	Definite
Extent of ecosystem exposure to stressor(s)	Site	Site
Receptor Impact Characteristics		
Predicted change in the ecosystem & habitat PES	Moderately-Low	Moderately-Low
Predicted change in populations of freshwater biota	Low	Low
Predicted change in regulating and supporting ecosystem services	Low	Low
Predicted change in provisioning and cultural ecosystem services	Low	Low

B. Recommended Mitigation Measures:

The following mitigation measures are recommended:

i. Plant Rescue

All intact wetland and riparian vegetation to be infilled or cleared should be rescued and temporarily stored onsite for later rehabilitation. A detailed rescue plan should be included in the detailed rehabilitation plan for the project.

ii. Rehabilitation Plans

A broad-level construction phase rehabilitation plan is provided in Section 7.1 below. A detailed construction phase rehabilitation plan for the construction of road watercourses crossings must be compiled and appended to the construction (EMPr) prior to construction commencing. Such information must be included in the relevant method statements.

iii. Method Statements for Working in Watercourses

A detailed method statement for the construction within the wetlands and streams must be compiled and appended to the construction (EMPr) prior to construction commencing.

iv. Demarcation of Construction Servitudes and No-Go areas

- The construction working servitude must be established within the new/upgraded road reserve. No construction should take place outside of the construction servitude.
- The construction servitude outside of watercourses must accommodate soil and material stockpiles, sediment barriers, campsites, "traffic accommodation facilities" and all other construction related activities.
- The construction servitude within watercourses must be limited to the actual development footprint and a small working area buffer (maximum of 3m). The construction servitude must be clearly demarcated using orange hazard bonnox fencing or brightly coloured shade cloth which should be erected and approved by the Environmental Control Officer (ECO) prior to the commencement of any construction activities.
- All freshwater habitats outside of the demarcated areas must be considered no-go areas for the duration of the construction phase. Any contractors found working inside the no-go areas should be fined as per fining schedule/system setup for the project.

v. Accidental Incursions into 'No-Go' Areas

- Wetlands and riparian areas outside of the construction servitude that are disturbed during the construction phase must be rehabilitated immediately. The potentially disturbed areas must be suitably prepared and then re-vegetated until the ECO is confident the rehabilitation objective has been achieved.

vi. Alien Plant Control

- All alien invasive vegetation that colonise the construction site must be removed, preferably by uprooting. The contactor should consult the ECO regarding the method of removal.
- All bare surfaces across the construction site must be checked for IAPs every two weeks and IAPs removed by hand pulling/uprooting and adequately disposed.
- Herbicides should be utilised where hand pulling/uprooting is not possible. ONLY herbicides which have been certified safe for use in wetlands are to be used. The ECO must be consulted in this regard.

6.1.3 Flow, Erosion and Sedimentation Impacts (C2)

C. <u>Impact Prediction, Description & Assessment:</u>

This impact refers to the temporary alteration of hydrological and geomorphological inputs and processes as a result of catchment transformation and within watercourse flow modification during the construction phase, as well as includes all associated secondary ecological impacts including habitat degradation and ecosystem services loss.

The key construction phase flow modification activities are:

- Flow diversion around working areas within the watercourses and/or dewatering of working areas.

- Physical disturbances of watercourses both planned and accidental e.g. soil stripping / grubbing, vegetation clearing.
- Physical disturbances of catchment slopes in close proximity to the watercourses.

All three of these impacts will alter flows to and within the watercourses as well as potentially alter the current rates of erosion and sedimentation.

Firstly, it is assumed that the upgrading of the road culverts will require that flow be temporarily impounded and/or diverted away from the working areas. At this stage no information on the technique to be employed has been provided to the author. The use of the coffer dam or flume pipe techniques is typical in such circumstances. Coffer dams can result in habitat backflooding, flow reductions downstream of the impounded area, and increased rates of sedimentation and plant stress (in the case of wetlands) as well as flow concentration with the narrowing of the width of flow. Flume pipes with associated berms / dams can also cause habitat backflooding upstream, flow reductions downstream. The discharge of concentrated water from working area dewatering also poses an erosion risk to wetlands and river beds and banks, especially if position poorly in sensitive areas or inadequate energy dissipation and erosion protection measures are implemented.

Secondly, disturbance of vegetation and soils and the exposure of soils to the elements within and in close proximity to the watercourses will likely increase the rates of erosion and sedimentation within and in close proximity to the construction area, and downstream.

A summary of the key impact and risk characteristics is provided in Table 17 below. Ultimately, the key manifestation of the abovementioned impacts is increased erosion and sedimentation. For the wetlands in particular, increased erosion and associate changes in flow distribution and retention can have measurable impacts on PES and the supply of ecosystem services and as such the predicted change in PES and services was assessed as moderate under the poor mitigation scenario. In this case, the worst case impacts were only assessed as having moderate impacts on the functioning of the watercourses due to the relatively small impact footprint and the fact that the project is a road upgrade. With the implementation of the recommended mitigation measures, the impacts on PES and services supply can be reduced to moderately-low and short-term in duration.

Table 17. Summary of key impact and risk characteristics for Impact C2.

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Stressor & Exposure Characteristics		
Ecosystem stressor(s)	Sediment and erosive runoff / flow	
Intensity of stressor(s)	Moderate	Moderately-low
Duration of stressor(s)	Medium-term	Short-term
Frequency of stressor(s)	High frequency episodic (wet season), low frequency episodic (dry season)	High frequency episodic (wet season), low frequency episodic (dry season)

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Likelihood of ecosystem exposure to stressor(s)	Definite	Definite
Extent of ecosystem exposure to stressor(s)	Surrounding Area	Surrounding Area
Receptor Impact Characteristics		
Predicted change in the ecosystem PES	Moderate	Moderately-Low
Predicted change in populations of freshwater biota	Low	Low
Predicted change in regulating and supporting ecosystem services	Moderate	Low
Predicted change in provisioning and cultural ecosystem services	Low	Low

D. <u>Recommended Mitigation Measures:</u>

The following mitigation measures are recommended to avoid and/or reduce / minimise the potential impacts:

i. Timing of Construction Activities

- Culverts should ideally be installed during the dry season to reduce the risk of erosion and sedimentation during construction. This is especially relevant to culverts where large seasonal flows are likely to be encountered.

ii. Temporary Flow Diversion and Working within Watercourses

- For all required within-watercourse structures (e.g. running tracks, berms / dams), a detailed implementation plan for such structures must be included in the detailed method statement for working within the watercourses. The method statement must be compiled by an aquatic specialist in conjunction with the appointed contractor.
- Erosion and sediment control measures (e.g. silt fences / curtains, sandbags etc.) must be implemented prior to any works within the watercourses. These structures will need to be maintained for the entire duration of the activity and monitored on a weekly basis. The location of these structures must be determined in conjunction with the project ECO. Such measures should be located downstream of the working area as well as along the edges of the construction servitude to protect freshwater habitat.
- No clearing of indigenous vegetation outside of the defined working servitudes is permitted for any reason.
- For all works within the watercourses, the use of heavy machinery should be minimized as far as practically possible. If heavy machinery is required to access freshwater habitat, a running trach to the working areas will need to be created that are suitable to the prevailing soil wetness conditions. For wetter areas, bog mats will likely be required to be laid down. For drier areas the use of crusher rock underlain by a geofabric will be sufficient. This is to avoid mixing of foreign material with the wetland soils.
- The duration of temporary flow impoundment and diversion must be minimised as far as practically possible.

- Diversions shall be temporary in nature and no permanent walls, berms or dams may be installed.
- Under no circumstance shall a new channel or drainage canals be excavated to divert water away from construction activities.
- Upon completion of the construction activities within the watercourse, all temporary structures must be removed immediately and the disturbed soils, beds, banks and vegetation rehabilitated in line with a detailed rehabilitation plan. Under no circumstances must temporary structures be left insitu for more than a day after completion and rehabilitation must commence within a day of completion. Financial penalties should be instituted if this is not adhered to.
- If excess debris and sediment has collected upstream of the structure, this material must be removed and responsibly disposed of before the dam is decommissioned.
- If dewatering is required, pumped water must be discharged back into the watercourses in a manner that does not cause erosion of elevated levels of sedimentation. In this regard, pumped water should be discharged into erosion control and sediment trap structure designed for such a purpose. Such a structure should not be located near steep banks or slopes where water re-entering the watercourses could cause erosion.

iii. General erosion control measures

Stormwater and erosion control measures must be implemented during the construction phase to ensure that erosion and sedimentation impacts to watercourse habitats are at least minimised. In this regard, the following measures must be implemented:

- Wherever possible, existing vegetation cover should be maintained during the construction phase. The unnecessary removal of groundcover from slopes must be prevented, especially on steep slopes.
- Clearing activities must only be undertaken during agreed working times and permitted weather conditions. If heavy rains are expected, clearing activities should be put on hold. In this regard, the contractor must be aware of weather forecasts.
- Temporary downslope erosion and sediment protection must be established in the form of silt fences, hay-bales, sandbags and/or earthen berms aligned along the buffer zones or areas upslope not affected by construction activities.
- Steep slopes at risk of erosion and/or slumping must either be temporarily re-graded or temporarily stabilised using sandbags or other available material like dump rock.
- All bare slopes and surfaces to be exposed to the elements during clearing and earthworks must be protected against erosion using rows of hay-bales, sandbags and/or silt fences aligned along the contours and spaced at regular intervals (e.g. every 2m) to break the energy of surface flows.
- Once shaped, all exposed/bare surfaces and embankments must be re-vegetated immediately as per the detailed construction phase rehabilitation plan.
- If re-vegetation of exposed surfaces cannot be established immediately due to phasing issues, temporary erosion and sediment control measures must be maintained until such a time that re-vegetation can commence.
- All temporary erosion and sediment control measures must be monitored for the duration of the construction phase and repaired immediately when damaged. All temporary erosion and

sediment control structures must only be removed once vegetation cover has successfully re-colonised the affected areas.

- After every rainfall event, the contractor must check the site for erosion damage and rehabilitate this damage immediately. Erosion rills and gullies must be filled-in with appropriate material and silt fences or fascine work must be established along the gulley for additional protection until vegetation has re-colonised the rehabilitated area.

With regards to the above measures, it is important that the costs of the implementation of such measures are factored into the tender specification and awarded contract. Quantities and costs of measures must be determined by the project engineer in conjunction with the appointed contractor and ECO.

iv. Soil Management Measures (Stockpiles)

Where deemed relevant, the following measures should be implemented:

- Soil stockpiles must be established on flat ground at least 50m away from delineated watercourses to prevent unnecessary sedimentation of the watercourses.
- Erosion/sediment control measures such as silt fences or low soil berms must be placed around the stockpiles to limit sediment runoff from stockpiles.
- Topsoil is to be handled twice only – once to strip and stockpile, and once to replace and level.
- The height of stockpiles must be limited to 2m to avoid soil compaction and destruction of soil micro-organisms.
- Stockpiled soil must be replaced in the reverse order as to which it was removed (subsoil first followed by topsoil).
- Stockpiled soils must be kept free of weeds and must not be compacted.
- Stockpiles of construction materials must be clearly separated from soil stockpiles to limit any contamination of soils.

6.1.4 Water Quality Impacts (C3)

A. <u>Impact Prediction, Description & Assessment:</u>

Potential construction phase contaminants and their relevant sources may include:

- Hydrocarbons – leakages from petrol/diesel stores and machinery/vehicles, spillages from poor dispensing practices.
- Oils and grease - leakages from oil/grease stores and machinery/vehicles, spillages from poor handling and disposal practices.
- Cement - spillages from poor mixing and disposal practices.
- Bitumen - spillages from poor application, handling and disposal practices.
- Sewage – leakages from chemical toilets and/or informal use of surrounding areas by workers.
- Suspended solids – suspension of fine soil particles as a result of soil disturbance and altered flow patterns.
- Soil waste – Workers are likely to generate solid waste during construction which if not properly managed and monitored may lead to increased litter entering the watercourse.

During the construction phase, leakages, mishandling or poor disposal of the above-listed hazardous substances pose an immediate soil and runoff contamination threat and ultimately pose a threat to the onsite and downstream watercourses. Where measurable changes in water quality do occur as a result of large spills or leakages cumulative impacts or high sensitivity to physicochemical change, increased biotic stress, reduced competition for space and a shift in species composition is the typical response that favours tolerant species and results in the reduction of sensitive species where they are still present. In certain cases where the range of tolerance of sensitive species are exceeded, localised extinctions may result.

In general, construction related spills and leakages are relatively small compared to most operational pollutant concentrations and volumes. Nevertheless, even the small pollution of watercourses is undesirable in the South African context where cumulative water quality impacts are significant.

A summary of the predicted stressor, exposure and impact characteristics is provided in Table 18 below. The intensity of the impacts to local water quality as a result of the construction phase is predicted to be low and the existing physico-chemical conditions are expected to experience a small negative change. With the effective implementation of the recommended mitigation measures, the likelihood of the exposure of the receiving environment to the stressor would be reduced to moderately-low (fairly unlikely) with small impacts on ecosystem PES and negligible impacts to ecosystem services supply.

Table 18. Summary of key impact and risk characteristics for Impact C3.

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Stressor & Exposure Characteristics		
Ecosystem stressor(s)	Chemical, organic and biological pollutants	
Intensity of stressor(s)	Low	Low
Duration of stressor(s)	Short-term	Short-term
Frequency of stressor(s)	Episodic	Episodic
Likelihood of ecosystem exposure to stressor(s)	Possible	Fairly Unlikely
Extent of ecosystem exposure to stressor(s)	Surrounding Area	Site
Receptor Impact Characteristics		
Predicted change in the ecosystem PES	Low	Low
Predicted change in populations of freshwater biota	Low	Low
Predicted change in regulating and supporting ecosystem services	Low	Low
Predicted change in provisioning and cultural ecosystem services	Low	Low

Recommended Mitigation Measures:

The following mitigation measures are recommended to avoid and/or reduce / minimise the potential impacts:

i. Establishment and Management of Construction Camp, Storage and Laydown Areas

Location:

- When locating the construction camp and equipment yard, watercourses and areas susceptible to soil erosion and/or water contamination must be avoided. The camp must be situated at least 100m away from the edge of the nearest watercourse.
- The camp should be established on level ground.
- The location of the camp site should be approved by the appointed Environmental Control Officer (ECO).

Camp Site Ablutions:

- The Contractor shall make adequate provision for temporary chemical toilets for the use of their employees during the Construction Phase. Such facilities, which shall comply with local authority regulations, shall be maintained in a clean and hygienic condition. Their use shall be strictly enforced.
- All chemical toilets must be situated at least 100m away from the edge of the nearest watercourse.
- The location of the toilets should be approved by the appointed ECO.
- An adequate number of self-contained chemical toilets must be established on site – at least one toilet for every 15 workers.
- Weekly servicing of the chemical toilets on site needs to be practiced by the supplier and service records are to be submitted to the ECO on a monthly basis. Toilets on site need to be kept in a clean and hygienic state.
- Contractors must ensure that no spillage occurs when chemical toilets are cleaned and that the contents are properly stored and removed off-site.

If asphalt or concrete/cement batching plants are required to operate on site, these are to be located a minimum of 100m away from any watercourse.

ii. Pollution Prevention Measures

- Hazardous storage and refuelling areas must be bunded prior to their use on site during the construction period following the appropriate SANS codes.
- The bund wall should be high enough to contain at least 110% of any stored volume.
- The surface of the bunded surface should be graded to the centre so that spillage may be collected and satisfactorily disposed of.
- Mixing and/or decanting of all chemicals and hazardous substances must take place on a tray, shutter boards or on an impermeable surface and must be protected from the ingress and egress of stormwater.

- Drip trays should be utilised at all dispensing areas.
- No refueling, servicing nor chemical storage should occur within 50m of the delineated wetland/aquatic habitat or within the 100-year flood line, whichever is applicable.
- No vehicles transporting concrete, asphalt or any other bituminous product may be washed on site.
- Vehicle maintenance should not take place on site unless a specific bunded area is constructed for such a purpose.
- Ensure that transport, storage, handling and disposal of hazardous substances is adequately controlled and managed. Correct emergency procedures and cleaning up operations should be implemented in the event of accidental spillage.
- If a water pump is required, the water pump must operate inside or on top of a drip tray to prevent any spillage of fuel and limit the risk of soil/water contamination. The drip tray will need to be lined with absorbent pads and checked daily while in use.
- All equipment to be used within the sensitive working areas (within the channel) must be checked daily for oil and diesel leaks before gaining access to these working areas.
- An emergency spill response procedure must be formulated and staff are to be trained in spill response. All necessary equipment for dealing with spills of fuels/chemicals must be available at the site. Spills must be cleaned up immediately and contaminated soil/material disposed of appropriately at a registered site.
- 44-gallon drums must be kept on site to collect contaminated soil. These should be disposed of at a registered hazardous waste site.
- Fire prevention facilities must be present at all hazardous storage facilities.
- Waste from chemical toilets must be disposed of regularly (at least once a week) and in a responsible manner by a registered waste contractor.

iii. Solid Waste Pollution Control

- Eating areas must not be located within 30m of the wetland/aquatic habitats.
- Waste bins must be provided at the eating areas.
- Bins and/or skips need to be supplied at convenient intervals on site for disposal of waste within the construction camp. The bins should have liner bags for easy control and safe disposal of waste.
- Bins should be provided to all areas that generate waste e.g. worker eating and resting areas and the camp site. General refuse and construction material refuse should not be mixed.
- Regular clearing/maintenance of bins is required.

6.2 Operational Phase Impacts

The potential impacts that may occur during the operation of the proposed road upgrade were grouped into the following impact categories:

1. Direct habitat loss and modification impacts (O1).
2. Flow, erosion and sedimentation impacts (O2).

Each one of these impacts are briefly described and assessed as follows.

6.2.1 Impact Assessment Overview and Summary

A summary of the impact significance ratings for each impact group under both poor and good mitigation scenarios is provided in Table 19 below. Each of the impacts are discussed in more detail in the following sections.

The assessment results clearly indicate that the potential operational impacts are generally of low significance and risk. With the implementation of the mitigation measures recommended in this report, the significance of all of the operational impacts will definitely be low.

In terms of risk, as assessed using the DWS risk matrix, all operational impact were assessed as being of low risk. This is due to the low intensity / severity ratings for the two impacts.

It is also important to note that the proposed development presents an opportunity to improve the hydrological functioning of the affected wetlands through installing more culverts and spreading out flow as recommended in Section 5 above. However, the project engineers have not yet confirmed their acceptance of the culvert recommendations in this report. If the culvert design recommendations are adhered to, the proposed activities will actually have a positive impact on wetland functioning.

Table 19. Summary of significance ratings for operational phase impacts.

Impact No.	SIGNIFICANCE: Quantity and Quality of Water	SIGNIFICANCE: Ecosystem / Habitat Conservation	SIGNIFICANCE: Species Conservation	SIGNIFICANCE: Human Subsistence & Livelihoods	RISK
Realistic Poor Mitigation Scenario					
O1	Low	Low	Low	Low	n/a
O2	Low	Low	Low	Low	n/a
O3	Low	Low	Low	Low	n/a
Combined	Low	Low	Low	Low	n/a
Realistic Good Mitigation Scenario					
O1	Low	Low	Low	Low	Low
O2	Low	Low	Low	Low	Low
O3	Low	Low	Low	Low	Low
Combined	Low	Low	Low	Low	n/a

6.2.2 Direct freshwater habitat modification and destruction impacts (O1)

A. <u>Impact Prediction & Description:</u>

Once the road upgrades are completed and the freshwater habitats have been rehabilitated, no planned physical disturbance of freshwater habitat is planned. However, with road crossings, there is always the chance that infrastructure will need to be maintained or repaired which may necessitate some habitat disturbance. At worst similar impacts to those of Impact C1 are predicted and as such the assessment is the same as that for Impact C1. A summary of the predicted stressor, exposure and impact characteristics is provided in Table 20 below.

Table 20. Summary of key impact and risk characteristics for Impact O1.

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Stressor & Exposure Characteristics		
Ecosystem stressor(s)	Physical habitat disturbance and modification	
Intensity of stressor(s)	High	Moderate
Duration of stressor(s)	Long-term	Long-term
Frequency of stressor(s)	Every few years	Every few years
Likelihood of ecosystem exposure to stressor(s)	Probable	Probable
Extent of ecosystem exposure to stressor(s)	Site	Site
Receptor Impact Characteristics		
Predicted change in the ecosystem & habitat PES	Moderately-Low	Moderately-Low
Predicted change in populations of freshwater biota	Low	Low
Predicted change in regulating and supporting ecosystem services	Low	Low
Predicted change in provisioning and cultural ecosystem services	Low	Low

Recommended Mitigation Measures

All the mitigation measures provided for Impact C1 related to minimising habitat disturbance and rehabilitating affected areas must be adhered to and incorporated into the long-term operational EMPr and maintenance programmes.

6.2.3 Flow, Erosion and Sedimentation Impacts (O2)

B. Impact Prediction & Description:

The two key flow modification impacts are:

- Increased concertation of flow within culverts, although this impact is already present.
- Increased volume of stormwater runoff discharge and increased velocities at outlets although this impact is already present.

Presently, the existing culverts are having a measurable impact of wetland flow through flow impoundment upstream of the culverts due too few culverts creating a 'bottle-neck' effect and the concentration of flow within single culverts with increased flow velocities at the outlet as well as the degradation of certain wetland areas immediately below the road crossing embankments. The lebgthening of the culverts will likely not increase the severity of the impact too much. However, the proposed development presents an opportunity to improve the hydrological functioning of the affected wetlands through installing more culverts and spreading out flow as recommended in Section 5 above.

With regards to road stormwater management, it is our understanding based on details provided by the client that stormwater generated by the road upgrade will be diverted off the road into concrete lined drains along the extent where the road is to be widened The proposed upgrade will result in a relatively small increase in catchment surface hardening that will result in an increase surface runoff volumes, a reduction in soil infiltration and the diversion and point-source discharge of surface water. Such a change in catchment hydrology will increase the volume and velocity/rate of surface water reaching the closest watercourse, as well as increase the time water takes to reach the closest watercourses (time of concentration), which will likely result in a small increase the floodpeaks through the wetland systems downstream of the outlets. Furthermore, the velocity of flow discharged at outlets will be slightly higher and, as a result, an increase in the present rates of erosion and sedimentation may occur below outlets. If gully erosion occurs within the buffer zones, sediment plumes are likely to be deposited within the wetlands which will smother and bury wetland vegetation and encourage further disturbance and invasion by weedy and invasive plant species. Erosion is also likely to further reduce soil saturation rates.

A summary of the predicted stressor, exposure and impact characteristics is provided in Table 21 below. Erosion and sedimentation impacts could have a moderately-low impact on ecosystem PES and ecosystem services under the poor mitigation scenario. Under the good mitigation scenario, impact predicted impacts to PES and ecosystem services should be low. It is important to mention that of the culvert design recommendations are adhered to, the proposed activities will actually have a positive impact on wetland functioning.

Table 21. Summary of impact assessment ratings for Impact O2.

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Stressor & Exposure Characteristics		
Ecosystem stressor(s)	Erosive flow, stormwater runoff and sediment	
Intensity of stressor(s)	Moderately-low	Moderately-low
Duration of stressor(s)	Long-term	Long-term
Frequency of stressor(s)	High frequency episodic (wet season), low frequency episodic (dry season)	High frequency episodic (wet season), low frequency episodic (dry season)
Likelihood of ecosystem exposure to stressor(s)	Definite	Definite
Extent of ecosystem exposure to stressor(s)	Surrounding Area	Surrounding Area
Receptor Impact Characteristics		
Predicted change in the ecosystem PES	Moderately-low	Low
Predicted change in populations of freshwater biota	Low	Low
Predicted change in regulating and supporting ecosystem services	Moderately-low	Low

Impact Aspects	Poor Mitigation Scenario	Good Mitigation Scenario
Predicted change in provisioning and cultural ecosystem services	Low	Low

C. <u>Recommended Mitigation Measures</u>

The following mitigation measures are recommended to avoid and/or reduce / minimise the potential impacts:

- Adhere to the culvert design measures provided in Section 5 earlier.
- Adhere to the stormwater management system design measures provided in Section 5 earlier.
- The applicant is responsible for ensuring that road embankments and servitudes adjacent to wetlands are maintained in perpetuity so that long-term erosion and sedimentation risks are reduced.
- The applicant is responsible for the periodic monitoring of the road embankment and servitude vegetation cover and taking corrective action where necessary.

7. CONCEPTUAL REHABILITATION AND MANAGEMENT PLAN

For those watercourses affected by the road upgrades, the developer / applicant is responsible for rehabilitation all construction impacts thereafter which the local municipality is responsible for the maintenance of the road servitude. Construction phase rehabilitation guidelines are provided in Section 7.1 below and a long-term rehabilitation and management strategy is provided in Section 7.2 below.

7.1 Construction Phase (Short Term) Rehabilitation and Management

All construction phase impacts to freshwater habitats, both planned and unplanned, need to be rehabilitated successfully before the contractor's scope of work and responsibilities can be considered completed. The desired state for the areas to be rehabilitated is to rehabilitate all physical disturbances and establish an indigenous plant cover that effectively stabilises the soil, minimises long-term erosion, and minimises long-term alien pant invasion. The key rehabilitation interventions should be to:

1. Reshape all physically disturbed and modified freshwater habitat including the plugging of the artificial diversions / drains and the repair of all potential erosion damage to more-or-less similar slope and morphological characteristics that existed prior to construction commencing.
2. Revegetate the affected habitats with suitable indigenous vegetation with the aim of achieving an adequate cover in the shortest time that is financially practical. In this regard it is recommend that re-vegetation be undertaken as follows:
   a. Wetlands and riparian zones:
      i. For the central wet permanent zones, mixes of *Cyperus latifolius, Juncus lomatophyllis, Leersia hexandra* and *Ischaemum fasciculatum* must be replanted. These plants must be sourced from rescued sods / turfs or translocated from a local

population. Alternatively, mega-plugs of these species must be purchased and planted.

ii. For the seasonal wetland areas, mixes of *Cyperus latifolius* and *Ischaemum fasciculatum* must be replanted. These plants must be sourced from rescued sods / turfs or translocated from a local population. Alternatively, plugs of these species must be purchased and planted.

iii. For the temporary wetland areas, re-vegetation should be undertaken by hydroseeding with *Cynodon dactylon*. Alternatively, if sods are available from the rescue operation that are suitable for replanting in temporary areas, these should also be used. A wetland ecologist will need to advise in this regard.

iv. For the riparian zones: re-vegetation should be undertaken by hydroseeding with *Cynodon dactylon*.

b. Dryland buffer zones: Hydroseeding with a seed mix of *Digitaria eriantha*, *Eragrostis curvular, Eragrostis chloromelas* and *Cynodon dactylon*.

Although hydroseeding does not offer instant protection like sodding or relatively quick cover establishment like plugs, it provides protection within a few months and is a lot cheaper than sods.

Table 22 outlines the recommended rehabilitation measures specific to this project that will need to be included in a detailed construction phase rehabilitation plan and a detailed method statement for working within the watercourses. As part of the approval of the final construction EMPr, a detailed construction phase rehabilitation plan should be compiled and appended to the EMPr.

Table 22. Post construction rehabilitation guidelines disturbed freshwater habitats.

Rehabilitation Step	Rehabilitation Guidelines
STEP 1: Planning, timing and sourcing of materials	• The reshaping and general soil preparation can be undertaken by the appointed civil contractor, but the re-vegetation and associated specific soil preparation should be undertaken by a suitably qualified and experienced planting contractor. • The planting contractor will need to confirm the seed mix ratios as well as other required materials including fertiliser, mulch and geofabric. • All seed must be sourced from local nurseries which obtain their plant material from local genetic stock. • The germinability of the seeds must be confirmed prior to acceptance of seeds by the planting contractor. • Hydroseeding should ideally be undertaken early in summer. Irrigation will likely not be required during the wettest four months. Irrigation will be required outside of the optimal growing season period. Alternatively, the use of hygroscopic gels and similar products should also be investigated if replanting is undertaken in less than optimal seasonal conditions. • All intact vegetation occurring within areas to be cleared must be turfed and temporarily stored onsite for later use in re-vegetation.

STEP 2: Remove any waste products	• All waste products (spoil, construction materials, hazardous substances and general litter) need to be removed from the site and disposed of at an appropriate landfill site. • Minimise additional disturbance by limiting the use of heavy vehicles and personnel during clean-up operations. • Any large plumes of sediment collected in temporary stormwater infrastructure must be removed, taking care not to remove or disturb the natural soil profile.
STEP 3: Remove/control invasive alien plants	• All exotic/alien plants and weeds to be removed and properly disposed of prior to the implementation of rehabilitation measures. • Note that frequent hand removal is the most preferred option and only in the event that this is not a viable means of control, should chemical means be considered. • Herbicides which have been certified safe for use in aquatic environments by an independent testing authority must be given preference. The ECO must be consulted in this regard.
STEP 4: Stabilise, reshape and prepare soil profiles	• Artificially created drains or erosion features must either by infilled, compacted and reshaped or plugged with earthen structures. • Exposed slopes are to be stabilized and re-vegetated as soon as practically possible. • Erosion control and soil protection measures such as geofabric, eco-logs and biodegradable silt fences must generally be installed prior to revegetation. • Rip and / or scarify all disturbed and compacted areas of the construction site. The ECO with the assistance of the engineer will specify whether ripping and / or scarifying is necessary, based on the site conditions. • Do not rip and / or scarify areas that are saturated with water, as the soil will not break up. • If required, topsoil must be imported. Imported or stored topsoil must be re-spread across the reshaped surfaces prior to revegetation. • For the hydroseeding the soil will need to be prepared to optimise germination. Such preparation may be undertaken by racking. The soil in the seedbed should be loosened to facilitate good contact between the seeds and the soil. • No fertilizers should be applied. The need for mulch will need to be determined.
STEP 5: Re-vegetation of disturbed areas	• The soil which is to be planted should be watered to within 10% of field capacity the day before planting ('Field Capacity' is the amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2–3 days after a rain or irrigation in pervious soils of uniform structure and texture. • Revegetation should focus primarily on all bare exposed/ unstable soils within and in close proximity to watercourses.
STEP 6: Monitor re-vegetation progress and administer alien plant control	• It is the responsibility of the appointed planting contractor to ensure successful vegetation establishment and to undertake regular maintenance for a year after successful establishment. • The first 8 weeks after re-vegetation are the most critical in terms of maintenance and monitoring and weekly audits by an ECO with the planting contractor must be undertaken to monitor re-vegetation success. Only once an adequate ground cover is established (>80%) should the ECO sign-off on the completion re-vegetation. Targets for re-vegetation success include: o Low levels of Invasive Alien Plants (<10% IAP cover). o >80% indigenous vegetation cover.

	• Thereafter, monitoring visits by the ECO and contractor should be undertaken every 3 months for the first 6 months (two monitoring visits) after the completion of construction. At such visits the need for further re-vegetation, IAP clearing and erosion control / damage repair must be addressed where necessary. If problems persist, further maintenance and monitoring may be required as instructed by the ECO.

8. LEGISLATIVE IMPLICATIONS

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

This will need to be confirmed by the Environmental Assessment Practitioner (EAP).

8.2 National Water Act (No. 36 of 1998) (NWA)

The proposed upgrade activities, in particular the road widening, the stormwater infrastructure upgrades and the lengthening of the culverts considered water uses under Section 21(c) and 21(i) of the NWA. Using the DWS risk assessment matrix for Section 21(c) and 21(i) water uses, the risk of the proposed activities were assessed as being low to moderate, with the proposed habitat infilling triggering a mdoerate risk. As such the activities do not meet the risk levels required for General Authorisation in terms of Section 39 of the NWA. However, the moderate risk score is within 25 points of the low risk category and thus is considered a borderline case. Considering this and the fact that impact on the overall functioning of the affected units is predicted to be moderately-low, it is the author's opinion that the risks of all the impacts can be reduced to low significance assuming that all mitigation measures provided are implemented. It is also important to note that the proposed development presents an opportunity to improve the hydrological functioning of the affected wetlands through installing more culverts and spreading out flow as recommended in Section 5 above. However, the project engineers have not yet confirmed their acceptance of the culvert recommendations in this report. If the culvert design recommendations are adhered to, the proposed activities will actually have a positive impact on wetland functioning. Nevertheless, it is up to the DWS to provide formal correspondence on whether the proposed activities can be authorised under a GA or not.

9. CONCLUSION

An assessment of freshwater wetland aquatic habitats to be impacted by the proposed road upgrade revealed that five wetland units and two stream units stand to be potentially measurably impacted. One of the wetland units, Unit W01, is an extensive channelled valley bottom wetland system that is regionally important, while other units vary in importance and are tributaries to Unit W01.

The watercourses on site ranged from Largely Natural ("B" PES) to Moderately Modified ("C" PES) present ecological states. The wetlands were generally in a better condition than the streams encountered. With the exception of Unit W01, the wetlands were assessed as being of moderate ecological importance and sensitivity (EIS). Unit W01 was assessed as being of moderately-high EIS because it represents an intact permanent wetland vegetation / habitat that is representative of the endangered Sub-escarpment Savanna wetland vegetation.

Although the wetlands to be impacted are considered important and sensitive systems, the impact assessment revealed that potential impacts are not that significant. This is largely due to the road already being present and the proposed upgrade being small in extent and involving low levels of encroachments into the wetland and stream habitats. The impact assessment also revealed that the construction impacts are the most significant impacts, particularly the impacts of freshwater habitat infilling, clearing and disturbance and the associated indirect impacts of working within the watercourses and altering flow patterns.

Similarly, risks were generally assessed as low, with the exception of the proposed infilling impacts that were assessed as being of moderate risk. However, the moderate risk score is within 25 points of the low risk category and thus is considered a borderline case. Considering this and the fact that impact on the overall functioning of the affected units is predicted to be moderately-low, it is the author's opinion that the risks of all the impacts can be reduced to low significance assuming that all mitigation measures provided are implemented. It is also important to note that the proposed development presents an opportunity to improve the hydrological functioning of the affected wetlands through installing more culverts and spreading out flow as recommended in Section 5 above. However, the project engineers have not yet confirmed their acceptance of the culvert recommendations in this report. If the culvert design recommendations are adhered to, the proposed activities will actually have a positive impact on wetland functioning. Nevertheless, it is up to the DWS to provide formal correspondence on whether the proposed activities can be authorised under a GA or not.

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