CULVERT REPLACEMENT ALONG P230 ROAD IN EMPANGENI WITHIN THE UMHLATHUZE LOCAL MUNICIPALITY, KWAZULU-NATAL

Freshwater Habitat Impact Assessment Report

Version 1.0

Date: 18th November 2016

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Report No: EP265-02

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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:	Culvert Replacement along P230 Road in Empangeni within the uMhlathuze Local Municipality, KwaZulu-Natal: **Freshwater Habitat Impact Assessment Report**
Report No.	EP265-02
Version	1.0
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Client:	Royal HaskoningDHV on behalf of the KZN Department of Transport

I, Adam Teixeira-Leite, 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: 18 November 2016

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
Adam Teixeira-Leite Pr. Sci. Nat. Senior Scientist	Project leader and internal reviewer	Adam is a Senior Environmental Scientist at Eco-Pulse with a BSc. Honours degree in *Environmental Science: Earth Sciences*. He is a registered Professional Natural Scientist (Pr. Sci. Nat.) with over 9 years' experience, having worked extensively on numerous specialist ecological assessment projects, both for wetland/aquatic and terrestrial (grasslands and forests) habitats and ecosystems in KZN, the Free State, Gauteng, Eastern Cape, Western Cape and Lesotho. He is also experienced in undertaking alien plant surveys and developing ecological rehabilitation and management plans and programmes.
Brian Mafela Environmental Scientist	Undertaking fieldwork and lead author	Brian Mafela is an Environmental Scientist at Eco-Pulse with a BSc. Honours Degree in Forest Resources and Wildlife Management. He has experience in undertaking EIA processes, wetland and riparian assessments, identifying and evaluating impacts of developments on the environment and providing BMP (Best Management Practice) mitigation measures. He is a registered Candidate Natural Scientist (Cand. Sci. Nat.)

EXECUTIVE SUMMARY

This report sets out the findings of a **Specialist Freshwater Aquatic Habitat Impact Assessment**, associated with the proposed upgrading/replacement of a road culvert associated with provincial Road P230 near Empangeni, KwaZulu-Natal. An assessment of the freshwater aquatic habitats and ecosystems (namely wetland and riparian habitat) associated with the planned road/culvert upgrade was undertaken by the wetland/aquatic specialist from Eco-Pulse Environmental Consulting Services over a period of 1 day in spring (October 2016) to inform the environmental assessment and water use licensing requirements for the project. The main findings of this specialist aquatic assessment report have been summarized below:

- Following a desktop mapping and preliminary risk assessment of water resources within 500m of the proposed road culvert upgrade, an onsite delineation of potentially affected water resources was conducted. Based on this assessment, the proposed culvert upgrade project stands to measurably impact only a channelled valley bottom wetland (W01) and weakly seasonal river system (R01), triggering water use and the need for impact assessment.
- The results of the Present Ecological State/Condition (PES) assessment of the Wetland Unit W01 revealed that the wetland is currently in a Largely Modified state (PES category "D"), with a large change in ecosystem processes and loss of natural habitats having taken place. The assessment of riverine habitat integrity of the instream and riparian zone of River Unit R01 indicated that the river unit is deemed to be in a Largely Natural to Moderately Modified state (PES category "B/C"), with a moderate change in natural habitat having taken place.
- The results of the Ecological Importance and Sensitivity (EIS) assessments undertaken indicate that both Wetland Unit W01 and River Unit R01 are of **Low EIS**. This suggests that wetland/riverine features can be regarded as somewhat ecologically important and sensitive at a local scale but typically play a very small role in providing ecological services at the local scale.
- Given the current 'C/D' PES/EC and Low EIS rating for both watercourses assessed, the minimum recommended management objective for the wetland W01 and river R01 should be to ***'maintain the current status quo of aquatic ecosystems without any further loss of integrity/condition or functioning'***. According to the NEMA (National Environmental Management Act), sensitive, vulnerable, highly dynamic or stressed ecosystems, such as rivers/streams, require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. The identified potential direct and indirect negative impacts of the proposed development on the local freshwater environment can be divided into the following impact categories:
  - **Physical destruction and/or modification of aquatic habitat;**
  - **Flow modification and erosion/sedimentation impacts**; and
  - **Water quality impacts**.

- In general, with good environmental management and adequate mitigation of potential ecological impacts at the site, the overall impact of the proposed culvert upgrade on the ecological condition and functioning of wetland unit W01 and river unit R01 is unlikely to be of such an intensity and extent that the Present Ecological State (PES) will be significantly altered and it is therefore **unlikely that the proposed development activities will compromise the ability to meet the water resource management objectives** as defined by the Recommended Ecological Category (REC). **Residual impacts in terms of meeting ecosystem conservation targets are likely to be negligible**, as will the impact on potential species of conservation concern which were not flagged as being of importance for the habitats assessed. The expected disturbances associated with the proposed activities are also **unlikely to result in the loss of important ecosystem services** for local communities and wildlife. Nevertheless, managing impacts such as the direct disturbance of aquatic vegetation/habitat, pollution and erosion/sedimentation risks will be necessary to maintain the current level of integrity and functioning of aquatic ecosystems (i.e. the management objectives set for watercourses assessed).
- **Most aquatic ecological impacts can probably be quite effectively mitigated** through appropriate culvert design recommendations and supplemented by the application of on-site practical mitigation measures and management principles to control direct wetland/riverine habitat destruction, soil erosion & sedimentation, flow modification and pollution impacts and risks in conjunction with post-construction rehabilitation and ecological monitoring recommendations. Should the recommended mitigation and management guidelines be implemented timeously and to specification, impacts can be potentially reduced to acceptable Low/negligible significance levels. This should be sufficiently low to protect the aquatic environment from further deterioration and can then be considered to be generally acceptable as no loss of critical resources, habitats, services or threatened/endangered species is likely to be associated with the development project. **No fatal flaws were identified from an aquatic ecosystems perspective.**
- Impact mitigation and management would be best achieved by incorporating the recommended environmental design, management & mitigation measures into an Environmental Management Programme (EMPr) for the site with appropriate monitoring recommendations also included. Post-construction freshwater habitat Rehabilitation Guidelines for aquatic habitats (instream and riparian areas) disturbed during construction have also been included in the report.
- Given that planned development activities will take place within a watercourse, a Water Use License Application (WULA) would generally apply for Section (c) and/or (i) at a minimum, however, the recent Government Notice (509 of 2016) pertaining to General Authorisation (GA) in terms of Section 39 of the National Water Act (No. 36 of 1998) for Section 21(c) and/or (i) water use, indicates that Low Risk Activities located within the regulated area of a watercourse will generally qualify for a GA. Based on the risk assessment undertaken using DWS Risk Based Matrix (DWS, 2015) whereby risk was determined after considering all listed control/mitigation measures (as defined in Section 6.2 of this report), the decommissioning and

replacement of the existing road culvert is generally considered to be of Low-Moderate Risk. The risk scores for borderline low/moderate cases were manually reduced to give a Low risk level, which implies that **the proposed development can essentially be authorised under the provisions of the GA for Section 21 c and i water use.** This is based on the assumption that best-practice mitigation and impact management will be applied strictly, as per the recommendations made in Section 6 of this specialist report. Should these not be strictly enforced, the low risk ratings should not apply and a full Section 21 c and i WUL is likely to be required. The various conditions of the GA (including impact mitigation and monitoring requirements) will need to be complied with during construction and operational phases of the project.

- A single protected plant species (*Crinum sp*.) was identified within Wetland Unit W01. In accordance with the provisions of the Natal Nature Conservation Ordinance of 1974 an Ordinary Permit is required to handle the *Crinum* plant. An ordinary permit can be obtained from Ezemvelo KZN Wildlife (EKZNW).
- It is further recommended that Section 6 of this report which deals with 'Impact Mitigation/Management' be referenced in the Environmental Authorisation (EA) for this project as a specific condition of the EA.

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1. INTRODUCTION

1.1 Project Locality and Description

The applicant, the KwaZulu-Natal Department of Transport ('KZN DoT'), is proposing to rehabilitate the existing Provincial Road P230 near the town of Empangeni, KwaZulu-Natal. The proposed development entails rehabilitating a stretch of ± 10km of the P230 Road and the replacement of one culvert at an existing watercourse crossing (see Figure 1 for location of the crossing/culvert). Eco-Pulse Consulting ('Eco-Pulse') was appointed by Royal HaskoningDHV (RHDHV) on behalf of the KZN DoT to undertake a **freshwater/aquatic habitat impact assessment** to inform the environmental assessment and water use licensing (WUL) process for the is the replacement of the single culvert associated with the section of P230 Road to be rehabilitated.

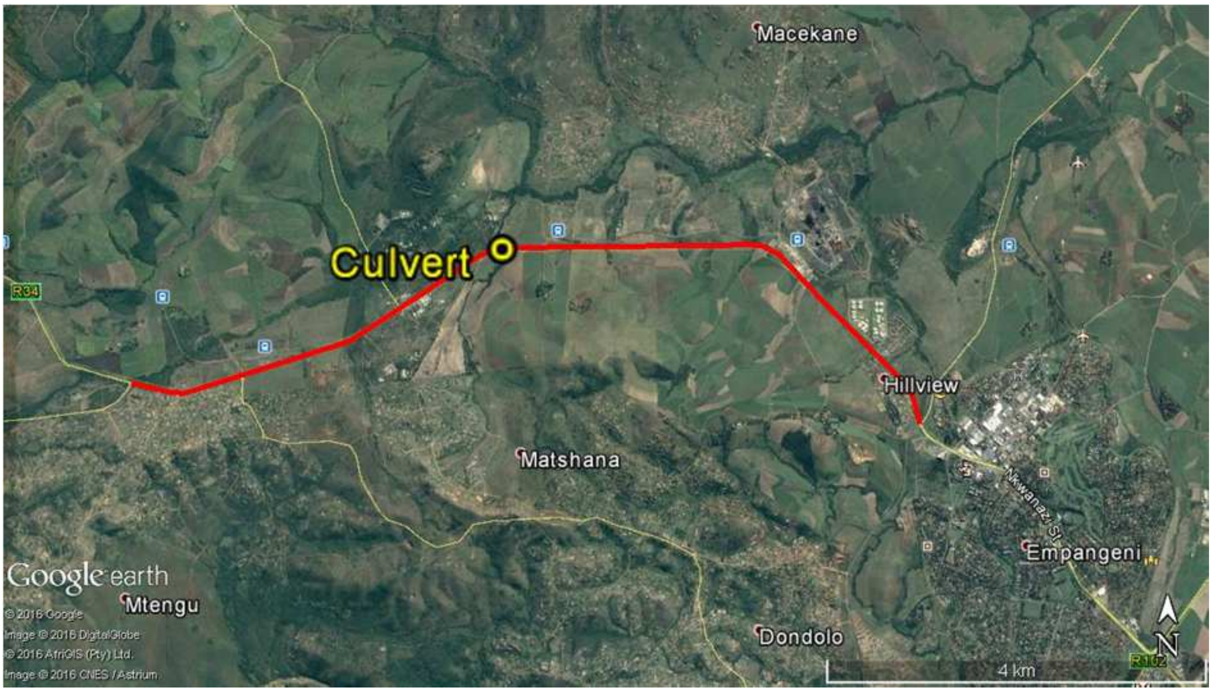


Figure 1 Google Earth ™ map showing the proposed section of the P230 Road near Empangeni, KZN, to be rehabilitated and the associated culvert to be replaced.

1.2 Scope of Work

The scope of work for the freshwater habitat impact assessment was as follows:

1. Desktop mapping and screening of all watercourses[1] (wetlands, rivers and streams) within the regulated area of a watercourses. For wetlands, the regulated area is a 500m radius from the delineated boundary of a wetland and for rivers and streams it is within 100m from the edge of a watercourse (which is the first identifiable annual bank fill flood bench).
2. Undertaking infield delineation of the outer boundary of wetlands and riparian zones within 32m of the identified culverts according to methods and techniques contained in the manual

[1] ***A watercourse:*** *means a river or spring; a natural channel in which water flows regularly or intermittently: a wetland, lake or dam into which, or from which, water flows: und 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 (National Water Act, 1998).*

'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005).

3. Subdivision of delineated wetlands and riparian zones into definable resource units and the classification of these units according to the National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013).
4. Undertaking baseline assessments:
   - For wetlands:
     - Brief description of vegetation communities.
     - Assessment of the Present Ecological State (PES) using WET-Health Level 1 Assessment (Macfarlane et al., 2008).
     - Assessment of the importance of the wetlands in providing ecosystem goods and services using WET-EcoServices Assessment Tool (Kotze *et al*., 2009).
     - Rating of the Ecological Importance and Sensitivity (EIS) of the wetlands using the WET-EIS tool (Rountree, in prep.).
   - For rivers / riparian zones:
     - Brief description of the riparian vegetation community.
     - Assessment of the present ecological state (PES) using the rapid Index of Habitat Integrity (IHI) version 2 (Kleynhans, 1996).
     - Rating of the Ecological Importance and Sensitivity (EIS) of the rivers / riparian zones using a tool adapted from the DWAF EIS tool (Kleynhans, 1999).
5. Review of the culvert designs and construction method statements.
6. Identification and description of construction and operational phase ecological risks and impacts to wetlands/rivers/streams and associated aquatic habitat.
7. Application of the DWS Risk Assessment Matrix for each watercourse likely to be impacted by the replacement of the culvert.
8. Provision of recommendations for managing and mitigating aquatic ecological impacts.
9. Provision of recommendations for further specialist studies based on the outcomes of this assessment.
10. Compilation of a streamlined Specialist Freshwater Habitat Impact Assessment Report as well as provision of all relevant maps and supporting GIS shapefiles.

2. METHODS

2.1 Desktop Review of Biophysical Setting & Conservation Context

As freshwater ecosystems are linear features connected over regional scales, it is of vital importance to first contextualise the onsite freshwater ecosystems in terms of local and regional biophysical and drainage setting as well as available conservation planning tools. 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 has been provided.

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

Data/Coverage Type		Relevance	Source
Biophysical Context	**Latest Google Earth ™ imagery**	*To supplement available aerial photography where needed*	Google Earth™ On-line
	1: 50 000 Relief Line (5m Elevation Contours GIS Coverage)	*Desktop mapping of drainage network*	Surveyor General (2006)
	1:50 000 River Line (GIS Coverage)	*Highlight potential onsite and local rivers and wetlands and map local drainage network*	Surveyor General (2006)
	DWA Eco-regions (GIS Coverage)	*Understand the regional biophysical context in which water resources within the study area occur*	DWA (2005)
	KZN Geology	*Understand regional geomorphology controlling the physical environment*	Surveyor General (2006)
	NFEPA: river and wetland inventories (GIS Coverage)	*Highlight potential onsite and local rivers and wetlands*	CSIR (2011)
Conservation Context	**South African Vegetation Map** (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation and its national threat status*	Mucina & Rutherford (2006)
	KwaZulu-Natal Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation and its provincial threat status*	Scott-Shaw and Escott (2011)
	NFEPA: River, wetland and estuarine FEPAs (GIS Coverage)	*Shows location of national aquatic ecosystems conservation priorities*	CSIR (2011)
	NFEPA: Wetland Vegetation Groups (GIS Coverage)	*Wetland vegetation type and threat status*	CSIR (2011)
	KZN Terrestrial Conservation Plan (GIS Coverage)	*Determination of provincial threat status of local vegetation types*	EKZNW (2011)
	KZN Aquatic Systematic Conservation Plan (GIS Coverage)	*Determination of provincial freshwater conservation priorities*	EKZNW (2007)

2.2 Flagging of Watercourses for Assessment

Following the desktop identification and mapping exercise, watercourses are assigned potential impact ratings based largely on their likelihood of incurring impacts resulting from the construction and operation of the proposed development and/or triggering potential water use, as dictated by Section 21 of the National Water Act. These impact ratings are then refined following the fieldwork. Each watercourse unit is ascribed a qualitative potential impact rating according to the ratings and descriptions provided in Table 2 below.

Table 2. Qualitative potential impact ratings and descriptions.

Impact potential	Description
Definite	These resources will require impact assessment and some form of Water Use License in terms of Section 21 (c) & (i) of the National Water Act for the following reasons: i. Resources are located within the proposed development footprint and/ or associated activities and will incur direct physical modification impacts associated with proposed project activities; and/or ii. Resources that are not directly impacted but will received secondary impacts (hydrological, water pollution, erosion and sedimentation) as a result of the nature of the project and its proximity to the water resource. Such resources are linked to the development via a drainage network and generally occur downstream of the planned activities. The distance to which definite secondary impacts will occur downstream is largely dependent of the proposed activities and are generally linked with resources in very close proximity to the development and/or resources located some distance downstream of a high risk development (i.e. water treatment plant).
Probable / Possible	These resources will require impact assessment and some form of Water Use License in terms of Section 21 (c) & (i) of the National Water Act for the following reasons: i. Resources will not incur direct physical modifications but are highly likely to incur secondary impacts (hydrological, water pollution, erosion and sedimentation) as a result of the nature of the project and its proximity to the water resource. Such resources are linked to the development via a drainage network and generally occur downstream of the planned activities. The distance to which secondary impacts will occur downstream is largely dependent of the proposed activities and are generally linked with resources in very close proximity to the development.
Not Impacted	These resources will not require impact assessment or Water Use License in terms of Section 21 (c) & (i) of the National Water Act for the following reasons: i. Resources located a distance upstream or upslope of the proposed development footprint and will not incur any direct or indirect impacts from the proposed development project; and/or ii. Resources linked to the proposed development via a drainage network but located at a distance downstream that is well beyond the range at which they are likely to incur secondary impacts (hydrological, water pollution, erosion and sedimentation). This will vary dependant of the nature of the project. e.g. >50-100m downstream for low impact developments and >500m downstream for high impact developments (except mining); and/ or iii. Resources located within another adjacent sub-catchment and which will not be impacted by the development in any way, shape or form as they are not hydrologically linked to the development activities.

2.3 Baseline Aquatic Assessment

Published methods of data collection and analysis were employed for the baseline delineation, classification and ecological assessments. Table 3 summarises the methods, techniques and tools that were used to assess watercourse units and impacts linked with the proposed development. The reader is referred to **ANNEXURE A** for descriptions of each of the baseline assessment methods used.

Table 3. Summary of methods used in the assessment of delineated water resource units.

Method/Technique	Reference for Methods/Tools Used	Annexure
Wetland and riparian areas delineation	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas'* (DWAF, 2005).	**A1**
Classification of Watercourses (wetland and river ecosystems)	National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2014). Classification system for channels.	**A2**
Wetland Condition/Present Ecological State (PES)	Rapid level 1 WET-Health tool (Macfarlane *et al.*, 2008).	**A3**
Wetland Functional / Ecosystem Services Assessment	Level 1 WET-EcoServices assessment tool (Kotze *et al.*, 2009).	**A4**

Method/Technique	Reference for Methods/Tools Used	Annexure
Wetland Ecological Importance & Sensitivity (EIS)	EIS tool developed by Eco-Pulse adapted from the DWAF Wetland EIS tool (Duthie, 1999).	**A5**
River/stream habitat condition	Index of Habitat Integrity (IHI) (1996) version 2 (Kleynhans, 2012).	**A6**
River/stream Ecological Importance & Sensitivity (EIS)	EIS tool developed by Eco-Pulse adapted from the DWAF River EIS tool (Kleynhans, 1999).	**A7**

2.4 Impact Assessment

While details of specific impacts will vary according to the site and development activity, aquatic impacts can typically be grouped into the following three categories based on distinct ecosystem components (drivers and habitat / biota) and associated broad impact pathways:

- Destruction and modification of aquatic habitat: This refers to the physical and direct modification, transformation and destruction of aquatic habitat and associated ecosystem goods and services.
- Flow 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 assessed in terms of impacts to PES and the supply of ecosystem services. Thereafter, the significance of each impact pathway and their associated changes in ecosystem functioning (PES) and supply of ecosystem services 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) **Water resource management**: This addresses impacts to the ***quantity*** and ***quality*** of water in affected water resources that affects use of the water resource by downstream users. Such impacts may be directly attributed to the development (e.g. water pollution / elevated flows) or may be caused indirectly by affecting the ability of watercourses (particularly wetlands) to provide supporting regulating and supporting services.

(ii) **Ecosystem conservation:** This deals specifically with impacts to ***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**: 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 2, below.

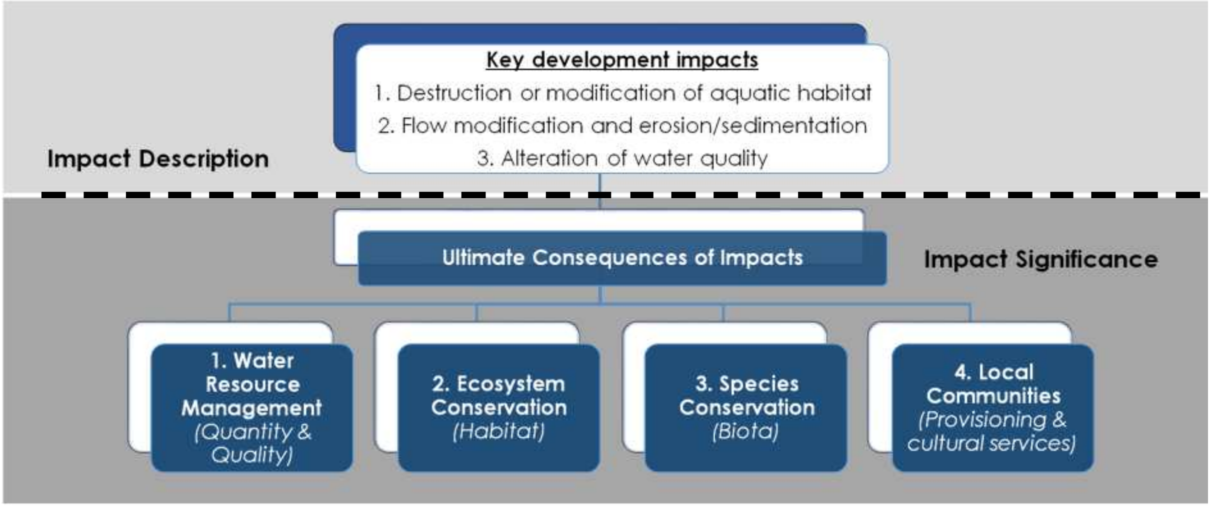


Figure 2 Diagram illustrating how the impact assessment framework is conceptualized.

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

- Review of project information to understand project activities and key risks to aquatic ecosystems.
- Description and assessment of potential aquatic ecological 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 methodology developed specifically for application to freshwater ecosystems (Eco-Pulse Consulting, 2015) as included in **Annexure A8** of this report.

2.5 Assumptions, Limitations & Gaps

The following limitations and assumptions apply to this assessment:

- This report deals exclusively with a defined study area and the extent and nature of aquatic ecosystems in that area.
- The watercourse boundaries delineated are based on sampling points obtained at regular intervals. Thus the outer boundary of riparian areas between the sampling points was extrapolated using knowledge of the site, aerial photography, contours and the author's experience.
- Watercourse boundaries are based largely on the GPS locations of key morphological features (e.g. top of an active/macro channel bank) and soil sampling points. 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 Monterra™ Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- Infield soil and vegetation sampling was only undertaken a strategic sampling points within the habitats likely to be negatively affected.
- The vegetation information provided is based on onsite / infield observations and not formal vegetation plots. As such, the species list provided only gives an indication of the dominant and/or indicator riparian species and only provides a general indication of the composition of the vegetation communities.
- No aquatic faunal sampling or faunal searches were conducted. The assessment was purely habitat based.
- With ecology being dynamic and complex, there is the likelihood that some aspects (some of which may be important) may have been overlooked.
- 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 every effort to substantiate all claims where applicable and necessary.
- The EIS assessment did not specifically address in detail all the finer-scale ecological aspects of the water resources such as a list of aquatic fauna likely to occur (i.e. invertebrates, amphibians and fish) within and make use of these systems.
- 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).
- Additional information used to inform the assessment was limited to data and GIS coverage's available for the Province at the time of the assessment.

3. DESKTOP ASSESSMENT FINDINGS

3.1 Review of Biophysical Setting & Conservation Context

3.1.1 *Biophysical Setting*

The key biophysical features associated with the study area are summarised in Table 4, below.

Table 4. Key biophysical details of the study area.

Biophysical Aspects	Desktop Biophysical Details	Source
Elevation a.m.s.l.	Approx. 115 – 130m a.m.s.l.	Google Earth™
Rainfall distribution	Mid-Summer, Early Summer, Late Summer	DWAF, 2007
Mean annual precipitation (MAP)	1041.3 mm	Schulze, 1998
Mean annual temperature	15 – 22 °C	DWAF, 2007
Potential Evaporation (mm) Mean Annual A-pan Equivalent	1784.5 mm	Schulze, 1998
Median annual simulated runoff (mm)	208.3 mm	Schulze, 1998
Geology and soils	Shale, Mudstone, Ecca Group arenite (sandstone) and Greenstone	KZN Geology dataset
Water management area	Mvoti to Umzimkulu	DWA, 1996
Quaternary catchment/s	W12H	DWA, 1996
Main collecting river in the catchment	Nseleni River	CSIR, 2011
DWA Ecoregion (Level 2)	North-Eastern Uplands (14.05)	DWA, 2007

3.1.2 *Conservation Context*

Understanding the conservation context and importance of the study area and surrounds 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 in terms of conservation. Key findings that have a bearing on the proposed development include the following:

A. National and Provincial Vegetation Type (Mucina & Rutherford, 2006):

- In terms of both the national and provincial reference vegetation type, the study area falls within the Zululand Coastal Thornveld (SVI 24 & 54) which is considered **Endangered** nationally and **Critically Endangered** provincially.

B. National Freshwater Ecosystem Priority Area (NFEPA) Assessment (CSIR, 2011):

- The Nseleni River and its associated sub-quaternary catchment (No. 3401) are not classified as river Freshwater Ecosystem priority Areas (FEPAs).
- No wetland FEPA has been identified within the impact zone of the proposed development or immediately downstream.

- The study area falls within the Lowveld Group 11 reference NFEPA wetland vegetation group, which is considered Vulnerable.

C. KwaZulu-Natal Aquatic/Freshwater Conservation Plan (EKZNW, 2007):

- The proposed section of the P230 Road to be rehabilitated traverses two sub-catchments (No. 1980 and 1986) classified as 'Available' according to the freshwater CPLAN, with no specific conservation priorities set for aquatic ecosystems in these catchment areas.

D. KwaZulu-Natal Terrestrial Systematic Conservation Plan (EKZNW, 2010):

- The study area has not been identified as a Biodiversity Priority Area and is therefore not currently considered critical for the maintenance of biodiversity.

3.2 Desktop Watercourse Delineation

Four (4) watercourse units including three (3) wetlands and a single weakly seasonal river occurring within a 500m radius of the culvert upgrade site were mapped at a desktop level, shown in Figure 3 and as follows:

i. **Wetland Unit W01**: channelled valley-bottom wetland (8.2 ha in extent)
ii. **Wetland Unit W02**: wetland seep (0.8 ha in extent)
iii. **Wetland Unit W03**: channelled valley-bottom wetland (4.7 ha in extent)
iv. **River Unit R01**: Weakly Seasonal River

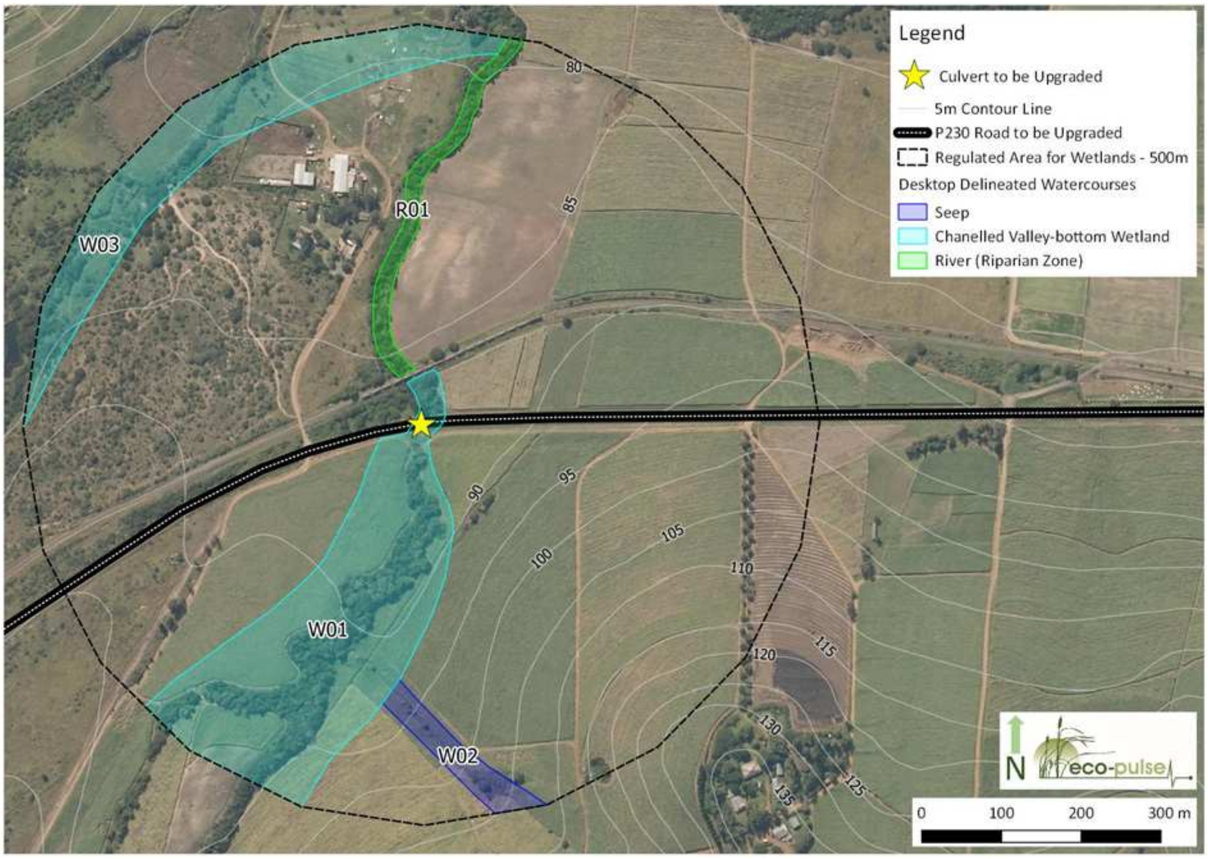


Figure 3 Desktop delineation of watercourses within the 500m regulated area for wetlands.

3.3 Screening and Flagging of Watercourses for Further Detailed Assessment

A qualitative screening assessment of the potential impact of the development on each watercourse identified and mapped at a desktop level (in Section 3.2 and Figure 3) was undertaken to identify watercourses that are likely to be measurably negatively affected by the proposed culvert replacement and/or likely to trigger a water use as contemplated in terms of Section 21 c and i of the National Water Act No. 36 of 1998. The principle ecological risks relevant to the construction and operation of the proposed culvert upgrade were deemed to include:

- **Direct physical modification / destruction of aquatic habitat** within the development site during the construction phase of the development;
- **Indirect modification of aquatic habitat during the operational phase** due to poor placement of the **culvert; and**
- **Concentration or impoundment of flows** during construction (short-term) and the operational phase (longer term).

Based on the above-mentioned risks, two watercourses: Wetland Unit W01 and River Unit R01 were assigned impact ratings of 'definite' and 'probable' (respectively) in terms of the probable risk of being measurably impacted by the proposed development and/or triggering water use. These watercourses were thus subject to further impact assessment and were investigated further in terms of water use and the need for a full water license application or whether a General Authorisation (GA) in terms of Section 21 c and/or i water use would be appropriate. The results of the desktop screening assessment explained in Table 5 and the watercourses are shown spatially in Figure 4.

Table 5. Summary of the impact/water use screening assessment results for each watercourse, including rationale[2].

Watercourse units	Impact rating	Rationale	Authorisation process	Need for further assessments
W01	**Definite**	The following impacts are likely to occur during the construction and operation of the proposed development: • Physical modification of the freshwater habitat including the physical structure of the watercourse. • Water pollution. • Temporary alteration of flow regime.	**Very likely to requires either a WUL or a GA**	**Requires a baseline and impact assessment**
R01	**Probable**	This unit is located downstream of the proposed development area and therefore likely to incur indirect impacts. Such impacts include flow modification, sedimentation and pollution impacts.	May require either a WUL or a GA	**Requires a baseline and impact assessment**

[2] *The impact ratings provided relates to the likelihood that a watercourse unit may be measurably negatively affected. This is not a risk assessment. Impacts ratings are not a representation of impact intensity or magnitude of the change likely to occur within freshwater habitats.*

Watercourse units	Impact rating	Rationale	Authorisation process	Need for further assessments
W02 & W03	**Not impacted**	These watercourses are either located in adjacent micro-catchments or some distance upstream of the zone of impact. No impacts resulting from the construction and operation of the culvert are likely to be incurred by these watercourses.	No water use	Further assessment not required

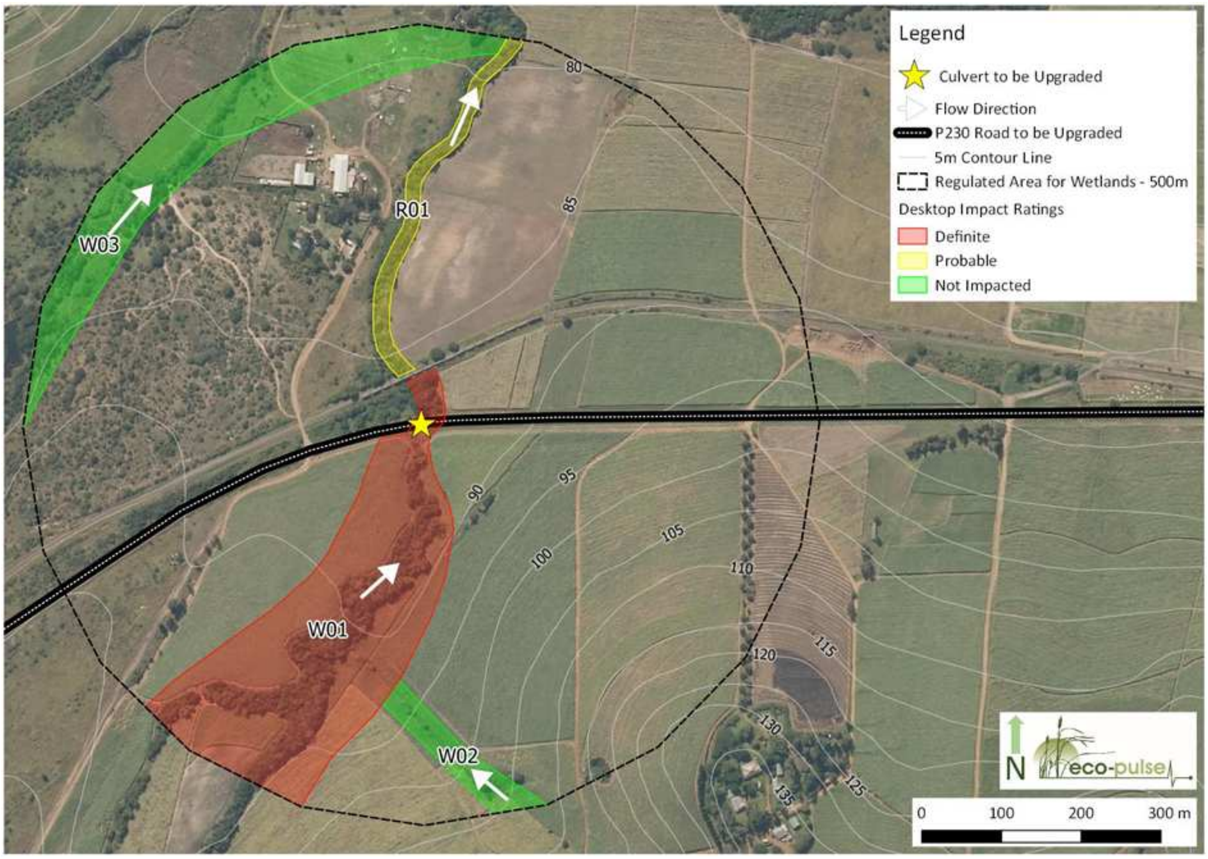


Figure 4 Impact screening and rating of desktop mapped watercourses within the 500m regulated area for wetlands in terms of Section 21 c and/or i water use (National Water Act).

4. BASELINE FIELD ASSESSMENT: *AQUATIC HABITAT*

Infield sampling and delineation of selected watercourse units (i.e. Wetland W01 and River R01, as per Figure 5) was undertaken based on the outcomes of the desktop impact/water use screening (*refer to specifically to Sections 3.2 and 3.3*).

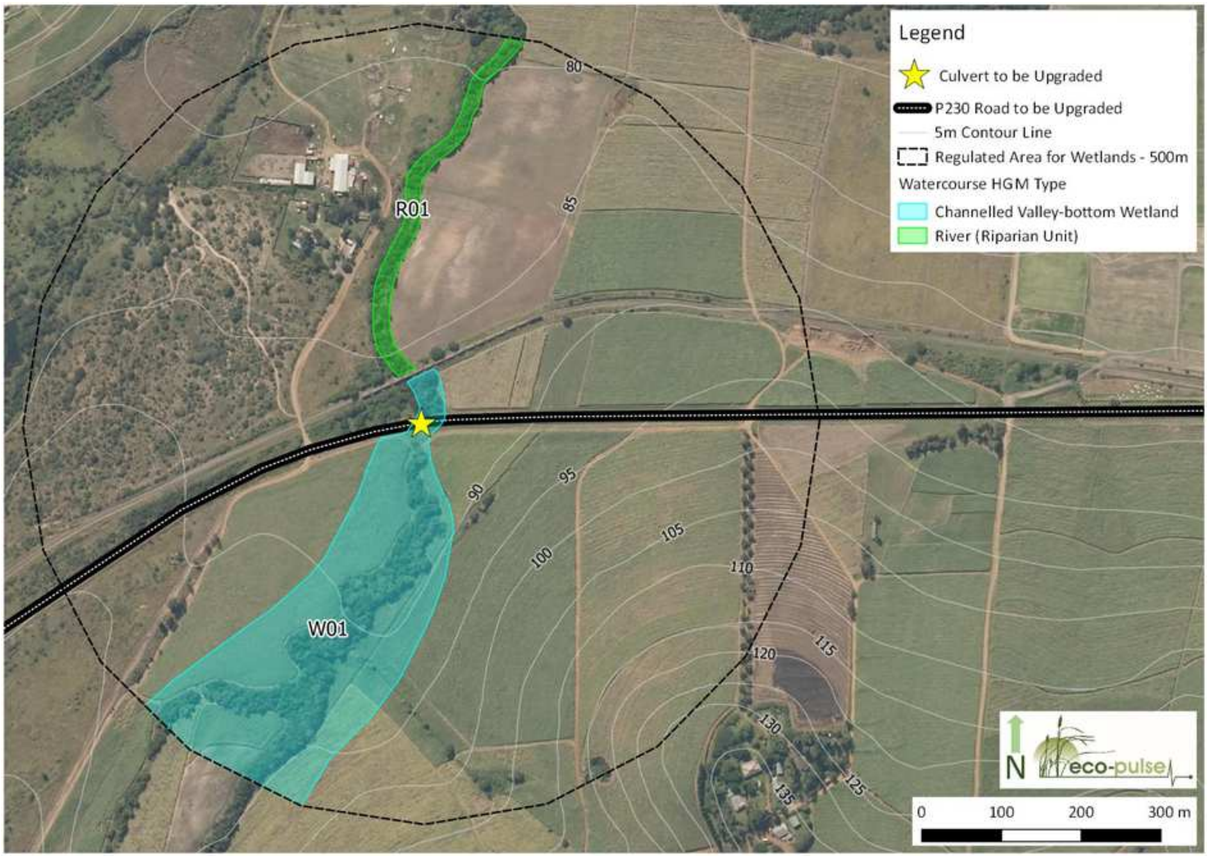


Figure 5 Map showing the location of watercourses identified as requiring further detailed delineation and field assessment (includes Wetland Unit W01 south of the P230 road and River Unit R01 to the north).

4.1 Classification & Habitat Characteristics

A summary of the key biophysical characteristics of the two (2) watercourse units assessed (W01 and R01), including dominant existing anthropogenic impacts, is provided below in Table 6.

Table 6. Summary of the biophysical description of river and wetland habitats assessed.

Unit	Classification	Description
W01	Channelled valley-bottom wetland	**Hydrology:** Water inputs are mainly in the form of overland flow with some subsurface interflow from the upstream catchment supporting the wetland, and adjacent valley sides. Water generally moves through the wetland system as concentrated/channelled flow via a central channel. **Vegetation/habitat**: The wetland comprises three different vegetation communities including (i) a secondary herbaceous marsh immediately upstream of the culvert, (ii) a wooded riparian community along the river channel and (iii) a cultivated sugarcane (*Saccharum officinarum*) plantation which covers a large portion of the wetland. The secondary herbaceous marsh comprises a mix of hygrophilous grasses, reeds, *Cyperus* species and a few ruderal forbs whilst the forested/wooded riparian community along

Unit	Classification	Description
		the river channel comprises typical coastal indigenous trees such as *Syzigium cordatum, S. cumini, Phoenix reclinata, Rauvolfia caffra, Trema orientalis, Trichilia emetica* and *Bridelia micrantha*. **Existing anthropogenic impacts:** included direct habitat loss associated with sugarcane cultivation within and adjacent to the wetland, sedimentation of the river channel due to blockage of a small culvert on an agricultural road, erosion of the river channel below the P230 culvert and some limited Invasive Alien Plant (IAP) infestation.
R01	**Weakly seasonal river**	**Hydrology and channel morphology:** The river was characterised by near vertical banks and ephemeral to weakly seasonal flows driven principally by upstream water inputs. **Vegetation/habitat:** The instream habitat comprised a few forbs mainly *Plectranthus* species established along the edges of the active channel. Channel banks were characterised by a wooded riparian community (lowland riverine forest) comprising the following indigenous trees: *Phoenix reclinata, Rauvolfia caffra, Trema orientalis, Trichilia emetica, Syzigium cordatum, S. cumini* and *Bridelia micrantha*. **Existing anthropogenic impacts**: included channel incision (particularly channel widening and deepening) and limited encroachment by invasive alien trees such as *Melia azedarach* and *Eucalyptus sp.*

A selection of digital photographs showing some of the habitat and vegetation/soil characteristics of the riparian/instream and wetland habitats sampled are provided below:

Photo 1: Weakly seasonal soil sample extracted from the wetland area under sugarcane cultivation. Note the dark grey soil matrix and orange mottles indicating weakly seasonally saturated soils.

Photo 2: General view of the wetland unit W01 located upstream (south) of the culvert to be upgraded. Note the wooded/tree community along the river channel.

Photo 3: Area of wetland W01 under sugarcane cultivation (cane recently harvested).

Photo 4: Secondary herbaceous marsh with *Cyperacae* within W01 immediately upstream of the culvert to be upgraded.

Photo 5: Instream habitat and river bed of the River Unit R01.

Photo 6: Dense, wooded riparian habitat of the River Unit R01.

4.2 Present Ecological State (PES) Assessment: River and Wetland

4.2.1 *PES for the Wetland Unit W01*

Present Ecological State (PES) (also referred to as ecological condition / health) is a measure of the deviation of the ecological condition of a definable ecosystem unit from its reference state (Macfarlane et al., 2008). This requires that the hypothetical (natural) reference state of the wetland (i.e. prior to anthropogenic impacts) first be estimated for the wetland type such that the deviation from reference due to the wetland in its present state can be established. This was assumed to be a mix of short sedge marsh with some wooded species along areas of channelled flow and with the absence of cultivation impacts and alien plants/ruderal species for the wetland in its natural/untransformed reference state. Channelled flow may or may have not been present for this wetland, historically.

The results of the PES assessment of the Wetland Unit W01 indicates that the wetland is in a **Largely Modified** state (ecological category = "D"). This suggests that ***a large change in ecosystem processes and loss of natural habitats has taken place***. A summary of the assessment results is presented in Table 7 including a description of the dominant impacts driving the PES, including the impact of sugarcane cultivation, alien plants and catchment impacts (roads and sugarcane farming impacts on wetland hydrological health and functioning).

Table 7. Summary of the WET-Health PES assessment results for Wetland Unit W01.

Unit	Component	Score/10	PES	Dominant Impacts
W01	Hydrology	6.3	E	• Extensive sugarcane cultivation within the wetland's catchment has resulted in a moderate reduction of water inputs.
	Geomorphology	1.4	B	• Increased on-site water use owing to extensive sugarcane cultivation within the wetland unit.
	Vegetation	6.9	E	• Increased sediment deposition upstream of the culvert resulting in modification of the natural wetland habitat.
	Overall	**5.06**	**D**	• Approx. 60% of the wetland vegetation has been lost to sugarcane cultivation.

4.2.2 PES for the River Unit R01

For the purposes of assessing river PES, the Index of Habitat Integrity (HI) was used (Kleynhans, 1996). The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). As such, the assessment of habitat integrity is also based on an interpretation of the deviation from the reference condition (Kleynhans et al, 2008) which first needs to be established.

The assessment of habitat integrity of the instream and riparian zone of River Unit R01 indicated that the instream habitat was found to be in a Largely Natural state and the riparian habitat was Moderately Modified. Overall, the river unit can be considered to be in a **Largely Natural to Moderately Modified** state (ecological category = "B/C") with ***a small to moderate change in natural habitat having taken place, however, the ecosystem functions are essentially unchanged***. A summary of the assessment results is presented in Table 8 including a description of the dominant impacts driving the PES, which included the negative effects of sugarcane cultivation in the catchment and the effect of roads on flows and erosional processes.

Table 8. Summary of the IHI assessment results for River Unit R01.

<table>
<tr><th>Unit</th><th>Component</th><th>Score/25</th><th>PES</th><th>Dominant Impacts</th></tr>
<tr><td rowspan="3">R01</td><td>Instream</td><td>4.7</td><td>B/C</td><td rowspan="3">Flow concentration created by culverts upstream of the river unit has resulted in the incision of the river bed and banks.
Vegetation removal along the edge of the riparian habitat has reduced availability of riparian habitat.
Extensive sugarcane cultivation within the river's catchment has reduced the quantity of water flowing through the river channel and reduced the quality of water as well (sediment and nutrient levels considered elevated).</td></tr>
<tr><td>Riparian</td><td>5.1</td><td>C</td></tr>
<tr><td>Overall</td><td>4.9</td><td>B/C</td></tr>
</table>

4.3 Wetland Ecosystem Services Assessment

Wetlands are known to provide a range of ecosystem goods and services to society. These goods and services may derive from outputs that can be consumed directly, indirect uses which arise from the functions or attributes occurring within the ecosystem, or possible future direct outputs or indirect uses. It is largely on this basis that policies aimed at protecting wetlands have been founded.

The predicted level of importance of the wetland HGM units in providing various ecosystem goods and services has been assessed using the WET-EcoServices assessment method (Kotze *et al*., 2009, with the results summarised in Table 9. The findings of the assessment reveal that most ecosystem goods and services are of low to moderately low importance, with only one (1) ecosystem service, cultivated foods, identified as being of noteworthy importance (i.e. of Moderate importance or higher). The moderately-high importance of the wetland for cultivated foods is attributed to extensive cultivation of sugarcane within the wetland, along with high regional demand for cultivation of sugarcane. High levels of transformation linked with sugarcane cultivation and general habitat degradation have impacted on the wetland's ability to supply other key services at significant levels.

Table 9. Summary of ecosystem services assessment for Wetland Unit W01.

Ecosystem Goods & Services		Supply Score	Demand Score	Importance Score	Importance Rating
REGULATING & SUPPORTING SERVICES	Flood attenuation	1.0	1.0	1.0	Low
	Stream flow regulation	1.2	2.0	1.5	Moderately-Low
	Sediment trapping	0.8	1.5	1.1	Moderately-Low
	Erosion control	1.0	2.5	1.5	Moderately-Low
	Water quality enhancement	1.2	1.7	1.4	Moderately-Low
	Carbon storage	0.5	2.0	1.0	Low
	Biodiversity maintenance	0.4	1.0	0.6	Low
PROVISIONING SERVICES	Water supply	0.5	2.0	1.0	Low
	Harvestable natural resources	0.0	1.0	0.3	Very-Low
	Food for livestock	0.0	2.0	0.7	Low
	Cultivated foods	3.0	2.0	2.7	Moderately-High
CULTURAL SERVICES	Cultural significance	1.0	1.0	1.0	Low
	Tourism & Recreation	0.0	1.0	0.3	Very-Low
	Education & Research	0.0	0.0	0.0	Very-Low

4.4 Ecological Importance and Sensitivity (EIS) Assessment: Wetland and River

The ecological importance of an ecosystem is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) on the other hand refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans, 1999).

The EIS assessment results indicate that Wetland Unit W01 and River Unit R01 are essentially of **Low EIS**, dominated by *features regarded as somewhat ecologically important and sensitive at a local scale*. The functioning and/or biodiversity features have a low-medium sensitivity to anthropogenic disturbances and generally play a very small role in providing ecological services at the local scale. The results of the assessment are presented in the Table 10 below.

Table 10. Summary of the EIS assessment results for Wetland Unit W01 and River Unit R01.

Unit	EIS Score & Rating	Rationale
W01	**Low EIS**	• About 60% of the wetland habitat is transformed for sugarcane cultivation and is no longer representative of the wetland in its natural reference state. • The sensitivity of the wetland has been reduced because of habitat transformation linked with cultivation. The transformation of about 60% of the wetland habitat has reduced ecosystem functioning and the loss of sensitive habitat features. • Due to extensive habitat transformation (sugarcane cultivation) there is likely to be no/very limited use of the wetland habitat by conservation important fauna. • The wetland has not been identified as an important water resource in available aquatic conservation planning information for KZN. • The wetland is of limited importance in term of providing ecosystem goods and services.
R02	**Low EIS**	• The incision if the instream habitat as discussed in the preceding section (Section 4.2) has resulted in the loss of intact and or unique habitat resulting in reduced diversity and quality of natural instream habitat types.

		• River sensitivity has been reduced due to the effects of habitat transformation which has reduced ecosystem functioning and the resulted in the loss of sensitive features which have been replaced by more tolerant types. • There is likely to be no/very limited use of the river unit by conservation important fauna due the loss of intact habitat and transformation of the habitat within river buffer for sugarcane cultivation.

4.5 Recommended Ecological Category (REC) & Management Objectives for Watercourses

The future management of the water resources within the project area should be informed by the 'Recommended Ecological Category' (REC) and associated recommended management objectives 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 11, 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 river's catchment in terms of existing threats and future development pressures.

The recommended ecological category (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 resource management objective is informed by the difference between the PES category and REC. If the PES category is lower than the REC, the objective should generally be 'to improve' (i.e. improve the current status quo of aquatic ecosystems). Where the PES category is the same as REC, the objective would generally be 'to maintain' (i.e. maintain the current status quo of aquatic ecosystems without any further loss of integrity/condition or functioning).

Table 11. 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

The Matrix in Tale 11 suggests that the management objective for Wetland Unit W01 and River Unit R01 should be to maintain the current state and functioning, with the REC set at Category "D": Largely Modified state for Wetland W01 and Category "B/C" Largely to Moderately Modified for River R01 (as per Table 12, below). The nature and extent of the proposed project does not warrant a directive to improve the current state of this ecosystem.

Table 12. Summary of REC and RMO for Wetland Unit W01 and River Unit R01 based on their PES and EIS ratings.

Unit	Type	PES	EIS	REC	RMO
W01	Channelled Valley-bottom Wetland	D: Largely Modified	Low	D: Largely Modified	*Maintain PES/EIS*
R01	Weakly Seasonal River	B/C: Largely Natural to Moderately Modified	Low	B: Largely Natural	*Maintain PES/EIS*

These minimum management objectives are further supported by Ezemvelo KZN Wildlife (EKZNW) in their guideline document: Guidelines for Biodiversity Impact Assessment (EKZNW, 2013). According to the document, the guiding principle with regards to biodiversity conservation and sustainable development adopted by EKZNW is one of **no net loss of biodiversity and ecosystem processes.**

To achieve this principle, a proactive approach to planning and biodiversity conservation must be adopted to ensure:

- The early identification and evaluation of potential ecological impacts that may constitute 'fatal flaws', or significant biodiversity related/management issues;
- The early identification and evaluation of conceptual alternatives which could prevent, avoid or reduce significant impacts on aquatic biodiversity, or enhance or secure opportunities for ecosystem conservation; and
- The appropriate design of mitigation through the mitigation hierarchy which should strive first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining residual negative impacts on biodiversity.

5. IMPACT DESCRIPTION

5.1 Identification & Description of Potential Ecological Impacts

This section focuses on impact identification, description and assessment under two mitigation scenarios and is structured as follows:

- Realistic 'Standard Mitigation' Scenario Impact Assessment including impact identification, description and significance assessment;
- Realistic 'Best Practical Mitigation' Scenario: Impact Significance Assessment including an assessment of impact significance in light of the impact mitigation and management measures provided by the author/s in Section 7 of this report.

For the purposes of this assessment 'physical habitat modification' associated with the culvert upgrade development is defined as the primary impact causing activity. The secondary impacts associated with this activity form part of the impact pathway that is initiated by this impact causing activity and will be described and assessed thereunder. For descriptive purposes an attempt had been made to sub-divide impacts associated with (a) Physical destruction and/or modification of aquatic habitat, (b) Flow modification and erosion/sedimentation impacts and (c) Water quality impacts. The significance of these impacts, however, has been assessed in in terms of the 'ultimate consequences' to the receiving watercourse in terms of the following:

(i) Impacts to water resources and the ability to meet water resource management objectives;
(ii) Impacts to ecosystem conservation and the ability to meet of ecosystem conservation targets;
(iii) Impacts to species conservation and the ability to meet species conservation targets; and
(iv) Impacts to ecosystem goods and services of direct value to communities and resultant potential impacts to human health, safety and livelihood.

The direct and indirect impacts associated with each of the impact causing activities is discussed in the following section based on a 'Standard Mitigation' scenario for both construction and operation phases.

5.1.1 *Impact 1: Physical destruction and/or modification of aquatic habitat*

This first impact type refers to potential to physically destroy, disturb or modify wetland/aquatic habitat (includes effects on vegetation condition and habitat suitability for biota) caused by vegetation clearing, excavation and/ or infilling (i.e. within the construction zone) and all associated unintended indirect/ secondary disturbances that are likely to persist during the operational phase of the culvert upgrade project.

Construction phase habitat destruction/modification impacts:

Direct habitat destruction and modification impacts are likely to be localised and remain largely within the construction footprint/impact zone. Given that the project entails the upgrading of an existing road culvert and not an entirely new e development, direct impacts are already present and additional direct loss or destruction of habitat is likely to be limited. The most noteworthy direct impacts will arise from bed modifications, as well as the disposal of demolished structural components of the damaged culvert within wetland/riparian areas. Direct impacts to wetland/aquatic vegetation/habitat caused by construction taking place within a wetland will likely include the following:

i. Destruction or modification of habitat.
ii. Destruction or modification of wetland/riparian vegetation and river banks (bank modification).
iii. Unintentional physical destruction or modification of wetland or riparian habitat outside of the construction zone caused by machinery and construction staff accessing areas upstream or downstream of the road crossing and culvert.
iv. Sedentary (slow moving) fauna such as invertebrates, slow moving reptiles and amphibians may be killed within the construction servitude or forced to migrate into adjoining habitats.

Indirect habitat modification and subsequent biota impacts will be localised to the affected wetland and fauna utilising the area. Furthermore, these impacts will be short-term. The intensity of these impacts is also negated by an abundance of available habit for fauna both upstream and downstream of the road crossing which should provide suitable refugia during the construction phase. Indirect/secondary impacts to aquatic vegetation/habitat caused by construction within and across the river channel and riparian zone may include the following:

v. Temporary noise, dust and light disturbance which will cause local fauna to move away from the construction zone in the short-term.
vi. Temporary instream habitat fragmentation impacts from coffer dams and / or temporary diversions which can inhibit/reduce the mobility of aquatic fauna between successive river reaches in the short-term.

Operation phase habitat destruction/modification impacts:

During the operational phase of the project (i.e. once construction upgrades cease, flows are reinstated and the new culvert structure becomes operational) any disturbance caused during construction is likely to promote the establishment of disturbance-tolerant species, including Invasive Alien Plants (IAPs), weeds and pioneer species within riverine habitats. Whilst initiated during construction, the persisting impact of invasive alien plants (IAPs) and pioneer plants is generally considered an operational and long-term issue. Since these species of plants typically have rapid reproductive turnover and are able to outcompete native species for environmental resources, alter soil stability, promote erosion, change litter accumulation and soil properties and promote or suppress fire, IAPs are widely recognised as one of the single largest impacts on biodiversity in South Africa. Encroachment by alien plants will result in the deterioration of freshwater habitat integrity if rehabilitation and monitoring are not implemented correctly. The extent and severity of existing alien plant populations within the disturbed wetland to be affected somewhat lowers the intensity of expected alien plant impacts; however, this should not negate the need to manage IAPs at the site.

Long-term wetland-river connectivity / fragmentation impacts as a result from poor design and installation of instream structures may result from the use of culverts, which can generally result in low light conditions not suited to species movement between river reaches and are also commonly associated with shallow, uniform flow (sheet flow) which may inhibit the movement of aquatic fauna with poor swimming abilities between river reaches. Culverts are also prone to blockages by river substrate and debris and may cause temporary barriers to species movement in this respect. If installed above the natural channel bed level, culverts can also impose height barriers to smaller instream fauna with poor jumping, swimming and crawling abilities.

5.1.2 Impact 2: Flow modification and erosion/sedimentation impacts

This impact category refers to the short term / temporary modification in local hydrological regimes as a result of construction activities occurring within a wetland/river channel, including coffer dams, diversions and dewatering activities. These activities will alter the volume, timing and pattern of flows within the immediate wetland/ river reach and downstream, ultimately affecting the rate of erosion and/or the distribution of sediment.

Construction phase flow modification and erosion impacts:

The process of decommissioning and constructing a new culvert will involve modification of flow patterns to maintain a dry working area and excavation of earth to construct the base for the new culvert. Given the need for construction works within a wetland, flow and associated erosion and sediment regime impacts will be largely unavoidable but short-term in nature and can be managed though the correct timing of construction and the implementation of key mitigation measures provided in this report. Temporary direct flow modifications likely to take place during culvert replacement may include:

i. Coffer dams and/or temporary diversions can result in a reduction in flows downstream if environmental flows are not catered for, thus affecting the maintenance of river biotopes directly downstream.
ii. Inundation or back-flooding upstream of cofferdams altering naturally occurring wetland and instream habitats.
iii. While no indication of any abstraction has been provided for construction purposes, where this does occur, abstraction can potentially result in the reduction of flows downstream, potentially affecting the maintenance of key wetland/river biotopes on which species rely.

Indirect flow related erosion and sedimentation/ turbidity impacts may include:

iv. Disturbance of bed and bank profiles associated within construction is likely to render soil particles ((i.e. sand, clay and silt) susceptible to suspension and transport downstream, resulting in the sedimentation and increased turbidity of downstream river reaches.

v. Dewatering and diversion of flows around instream work areas (usually required to ensure a 'dry working area') can focus flows downstream, thus altering the rate and distribution of flows and resulting in potential bed/bank scouring/erosion. This may also disconnect instream habitat reaches or microhabitats from flow or change the nature of flows in these biotopes.

vi. Flow related erosion (i.e. scouring) and/or sedimentation and turbidity impacts will be more pronounced during rainfall events and higher rainfall periods of the year and are directly linked with flow volumes and velocities. Some of the key ecological consequences associated with the sedimentation of freshwater habitat and increased water turbidity include:
   - Partial to complete burial of aquatic vegetation and instream biotopes such as runs, riffles and pools due to sediment deposition;
   - Reductions in soil saturation rates of areas buried with sediment and/or eroded,
   - Colonisation by alien invasive and weedy plant species associated with recent erosional and depositional features.
   - The creation of low light conditions reducing photosynthetic activity and the visual abilities of foraging instream aquatic biota;
   - Increased downstream drift by benthic invertebrates causing localised reductions in population densities; and
   - Reduced density and diversity in benthic invertebrate and fish communities as a result of reduced water quality (suspended solids impacting intolerant taxa).

Operation phase flow modification and erosion impacts

The potential long-term modification in local hydrological and sediment regimes as a result of instream structures is discussed below. Instream infrastructure can alter the volume, timing and pattern of flows within the immediate river reach and downstream, ultimately affecting the rate of erosion and/or the distribution of sediment. Key flow modifications during the operation of the road culvert may include:

- Box or portal culverts (where employed) can result in concentrated flows and a subsequent increase in flow velocity and erosivity of flows downstream, which may result in scouring and possible long-term channel incision. Channel incision lowers the local water table causing desiccation (drying) of the riparian zone and a shift in plant communities. Incision is quite unlikely in this case due to the presence of shallow underlying bedrock and the relatively gentle longitudinal gradient of the river bed.
- Undersized or blocked culverts may cause impoundment (increased saturation or inundation) on the upstream side of the road crossing and reduce water inputs downstream. This may alter instream biotopes upstream (causing pooling) and compromise sensitive riffle habitat downstream.
- Installation of culverts above or below the natural bed level may cause an increase or decrease in longitudinal profile of a watercourse and an increase or decrease in flow velocities at crossing points. This may result in sedimentation upstream if installed above the bed level and headward erosion if installed below the bed level. Incision is quite unlikely in this case due to the presence of shallow underlying bedrock and the longitudinal gradient of the river bed.

While the impacts discussed above are all potentially possible, where planning and design recommendations are strictly followed, these impacts are easily manageable and should not result extensive scouring, channel incision and sedimentation impacts in the long-term.

5.1.3 Impact 3: Water quality impacts

This impact refers to the alteration or deterioration in the physical, chemical and biological characteristics of the river water. The term 'water quality' must be viewed in terms of the fitness or suitability of the water for a specific use (DWAF, 2001). In the context of this impact assessment, water quality refers to its fitness for maintaining the health aquatic ecosystems and for domestic and livestock consumption.

Construction phase water quality impacts:

Pollutants/contaminants associated with construction projects vary and may enter the watercourses during construction activities and have the capacity to negatively affect receiving water resource integrity/quality, the direct result of which is reduced suitability for consumption (humans and livestock). Secondary to the direct use value of the water resource is the sensitivity of aquatic biota to changes physico-chemical water quality. Where significant changes in water quality occur, a shift in species composition will result, favouring tolerant species, and potentially resulting in the localised reduction of sensitive species. Sudden drastic changes in water quality can also have chronic effects on aquatic biota such as fish, invertebrates and amphibians which have specific pollution tolerances. Where these tolerances are exceeded localised extinctions may result. While water quality impact are possible and may have a measurable effect of water resource quality and aquatic biota sensitive to water quality modifications, these impacts are unlikely and in the event that they do occur will probably be short-lived. 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 and/or poor servicing of chemical toilets and/or informal use of surrounding bush by workers.
- Suspended solids – suspension of fine soil particles as a result of soil disturbance and altered flow patterns (covered above).
- Workers are likely to generate solid waste during construction which could easily end up contaminating the riparian zone and river water, and would migrate downstream to disturb downstream ecosystems.

Operation phase water quality impacts:

Potential operation phase contaminants and their relevant sources can be variable but are likely to be considerably fewer and of less of a concern than construction phase contaminant risks. Pollutants will however accumulate on the road surface where they will be flushed into adjacent/downstream watercourses after rainfall events albeit to a very low level. Operation phase water quality impacts are therefore likely to be of very low intensity or significance for a project of this nature and are unlikely to have a negative biotic response within the receiving river habitat. Operation phase contaminants/pollutant may include:

- Suspended solids (turbidity) – should scouring and channel erosion result from poor culvert design and installation leading to sedimentation and increased water turbidity downstream.
- Heavy metals – from car engine wear and fluid leakage.
- Hydrocarbons, oils and grease – from petrol/ diesel leakages from vehicles or incomplete fuel combustion.
- Solid waste- from littering associated with vehicle drivers.

5.2 Impact Significance Assessment

Impact significance is defined broadly as a measure of the 'desirability, importance and acceptability of an impact to society' (Lawrence, 2007). The degree of significance depends upon two dimensions: the measurable characteristics of the impact (e.g. intensity, extent, duration) and the importance societies/communities place on the impact. Put another way, impact significance is the product of the value or importance of the resources, systems and/or components that will be impacted and the intensity or magnitude (degree and extent of change) of the impact on those resources, systems and/or components.

An attempt has been made to quantify the relative significance of potential negative impacts identified in Section 5.1, with a summary of the results of the impact significance assessment provided in Table 12, below. The significance of the identified potential negative ecological consequences of the proposed development on freshwater ecosystems was assessed under a "realistic standard mitigation" scenario and "realistic best practical mitigation" scenario (additional of project specific mitigation measures provided by the author).

Table 13 (below) provides a summary of the impact assessment results. Detailed results are included in **Annexure B** of this report. During the construction phase of the development, physical destruction and / or modification of aquatic habitat under standard mitigation scenario was assessed as the most significant impact (as denoted by the Moderately-low significance impact rating). This is attributed to increased habitat clearing and disturbance outside the development servitude. With the implementation of good mitigation measures such as limited vegetation clearing only to the development footprint can result in the decrease of the significance rating from Moderately-low to Low. Other impacts were assessed as having a low significant impact which, under a best practical mitigation scenario, could be reduced from a significance rating of low to negligible. All operational phase impacts were assessed as having a Low impact significance but with most having a potential of being reduced to a negligible level if best practical mitigation measures are employed.

Table 13. Summary of the significance impact assessment.

POTENTIAL IMPACTS	SIGNIFICANCE	
	With Standard Mitigation	With Best Practical Mitigation
CONSTRUCTION PHASE		
1 Physical destruction and/or modification of aquatic habitat	Moderately-Low	Low
2 Flow modification and erosion/sedimentation impacts	Low	Negligible
3 Water quality impacts	Low	Negligible
OPERATION PHASE		
1 Physical destruction and/or modification of aquatic habitat	Low	Negligible
2 Flow modification and erosion/sedimentation impacts	Low	Negligible
3 Water quality impacts	Low	Low

5.3 Impact Significance Contextualised

In terms of implications for the project, all impacts assessed can be potentially mitigated and reduced from moderately low to low and even negligible impact significance levels, which can generally be considered acceptable as no loss of critical resources, habitats, services or threatened/endangered species is likely to be associated with the culvert upgrade development project. Based on this assessment then, there are unlikely to be any potential 'fatal flaws' associated with the proposed road/culvert upgrade project from a wetland and aquatic ecosystems perspective, granted that mitigation measures are applied to best practice standards and in accordance with the recommendations made in this specialist wetland/aquatic habitat impact assessment report. Basic duty of care should be adequate to mitigate all potential adverse impacts.

- The proposed development is non-water consumptive and has a low risk of contaminating water resources in the local area.
- Whilst localised impacts to habitat, flow and water quality and biota may result in a small reduction in wetland habitat condition (PES), these localised impacts are unlikely to translate into a significant reduction in ecosystem related services and the ability to meet water resource management objectives at a broader scale, should the mitigation measures recommended in this specialist report be applied reasonably and timeously.
- Although one species of provincially protected plants was recorded (*Crinum sp.*) the development is considered as having a negligible impact on species of conservation importance because *Crinum sp.* can be easily translocated resulting in no net loss. No other species of conservation concern (such as rare, endangered, protected plants/animals) were recorded onsite during field investigation, nor are any perceived to utilise the largely degraded wetland and wooded habitat at the site.

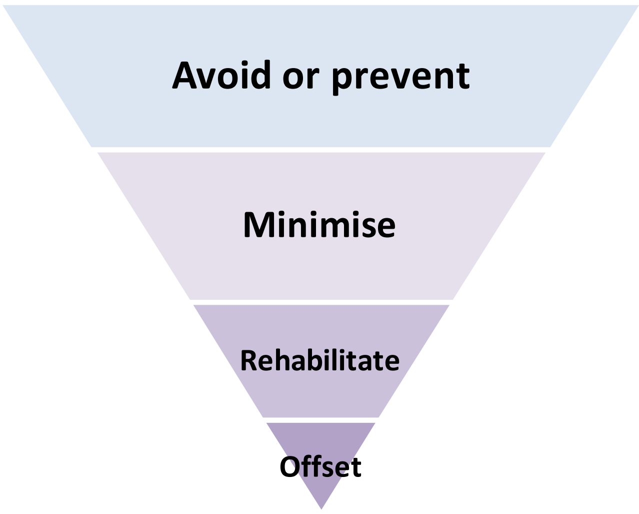
- The expected disturbances associated with the proposed activities are also unlikely to result in the loss of important ecosystem services for local communities, with no perceived use of the wetland/river by local people at present.

6. IMPACT MITIGATION

According to the National Environmental Management Act No. 107 of 1998 (NEMA), sensitive, vulnerable, highly dynamic or stressed ecosystems, such as wetlands, rivers and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. The management principles for sustainable development supported by NEMA includes the requirement that disturbance of ecosystems, pollution and degradation of the environment, generation of waste and loss of biological diversity be avoided and where they cannot be altogether avoided, are minimised and remediated. NEMA also requires "*a risk-averse and cautious approach which takes into account the limits of current knowledge about the consequences of decisions and actions*". The 'precautionary principle' therefore applies and cost-effective measures must be implemented to pro-actively prevent degradation of the region's water resources and the social systems that depend on it. ***Ultimately, the risk of water resource degradation and biodiversity reduction/loss must drive sustainability in any development design.***

The protection of water resources begins with the avoidance of adverse impacts and where such avoidance is not feasible; to apply appropriate mitigation in the form of reactive practical actions that minimizes or reduces in situ impacts. Driver *et al.* (2011) recommends that the management of freshwater ecosystems should aim to prevent the occurrence of large-scale damaging events as well as repeated, chronic, persistent, subtle events which can in the long-term be far more damaging (e.g. as a result of sedimentation and pollution). 'Impact Mitigation' is a broad term that covers all components involved in selecting and implementing measures to conserve biodiversity and prevent significant adverse impacts as a result of potentially harmful activities to natural ecosystems. The mitigation of negative impacts on aquatic resources is a legal requirement for authorisation purposes and must take on different forms depending on the significance of impacts and the particulars of the target area being affected. This generally follows some form of 'mitigation hierarchy' (see Figure 6 on the next page) which aims firstly at avoiding disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided, to minimise, rehabilitate, and then finally offset any remaining significant residual impacts.

The mitigation hierarchy is inherently proactive, requiring the on-going and iterative consideration of alternatives in terms of project location, siting, scale, layout, technology and phasing until the proposed development can best be accommodated without incurring significant negative impacts to the receiving environment. In cases where the receiving environment cannot support the development or where the project will destroy the natural resources on which local communities are wholly dependent for their livelihoods or eradicate unique biodiversity; the development may not be feasible and the developer knows of these risks, and can plan to avoid them, the better. In the case of particularly sensitive ecosystems, where ecological impacts can be severe, the guiding principle should generally be "*anticipate and prevent*" rather than "*assess and repair*".



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, siting, 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 6 Diagram illustrating the 'mitigation hierarchy' (after DEA *et al*., 2013).

Mitigation measures specific to the potential aquatic impacts identified and discussed in Section 6 of this report have been provided below and include:

- Pre-Construction Planning and Design Recommendations (Section 6.1);
- Construction Phase Mitigation Measures (Section 6.2);
- Post-construction Rehabilitation Guidelines (Section 6.3);
- Operation Phase Mitigation Measures (Section 6.4); and
- Ecological Monitoring Recommendations (Section 6.5).

Note: It is important that mitigation measures are costed for in the construction phase financial planning and budget so that the contractor and/or developer cannot give financial budget constraints as reasons for non-compliance. Proof of financial provision of these mitigation measures must be submitted to the ECO prior to construction commencing.

6.1 Pre-construction Planning & Design Recommendations

In line with the overarching principles of the mitigation hierarchy of 'avoid, minimise, remediate and offset', it is recommended that potential impacts to aquatic ecosystems be avoided and minimised as far as possible through implementation of the design/planning guidelines to be considered prior to construction. At the forefront of mitigating impacts to wetland/aquatic ecosystems should be the incorporation of ecological and environmental sustainability concepts into the design of the development project, with a central focus around:

1. Ensuring that direct impacts to wetlands and riparian areas are avoided wherever possible through ecologically sound and sustainable design that considers the location and sensitivity of

the remaining ecological infrastructure (i.e. the delineated wetlands/riparian habitat) at the site; and

2. Employing creative design principles and ecologically sensitive methods in infrastructure design and layouts to minimise the risk of indirect impacts.

To this end, a number of environmental design guidelines and recommendations have been proposed. These are discussed in detail below.

A. Culvert design recommendations:

The following best-practice environmental design considerations are to be considered in culvert design and construction:

- Structures must be designed to adequately allow for the natural through flows without impeding flows behind the road crossing structure or focusing flows within downstream reaches of watercourses (which can lead to scouring and channel incision).
- Best management practices for road engineering includes designing stream crossing culverts to convey a minimum discharge equal to the 100-year flow.
- 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.
- Contrary to the principle for piers of 'fewer and smaller is better', many large culverts are preferred over fewer small culverts. This ensures that these structures cater for the maximum flow volumes experienced by the river. To prevent culvert plugging, one large culvert is typically more effective than several smaller ones (Furniss *et al*., 1998).
- Box / portal culverts should be preferred over piped culverts. Road-stream crossings with undersized culverts can cause large inputs of sediment to streams if the culvert inlet is plugged and stream-flow overtops the road fill (Furniss *et al*., 1998).
- Structures that cater for through flows (e.g. box/pipe culverts) should not only allow for the maximum volume of flows but should distribute flows naturally so not to concentrate flows downstream (which could induce erosion/scouring).
- Appropriate measures to dissipate flow velocity below structures must be considered and designed for pre-construction.
- Erosion protection measures (e.g. Reno-mattresses) or energy dissipaters must be established below all pipe/box culvert outlets.
- Culverts should be installed during the dry season to reduce the risk of erosion and sedimentation during construction.
- Selection of culvert shape should be based on water depth, roadway embankment height, hydraulic performance, and allowing for species movement.
- Coarse stone material should be incorporated into culverts to mimic natural riffle/ run river biotopes. Furthermore, coarse culvert beds will reduce scoring downstream by reducing flow velocities through increased surface roughness.
- Culverts should be installed such that their invert levels match the natural stream bed levels that existed prior to construction.

- Culverts should not lower the base level of a watercourse and therefore not result in an increase in longitudinal gradient which could lead to headward erosion and channel incision.
- A headwall should be installed at the inlet of the culvert to protect crossing fill from saturation and scour and direct flow into the culvert. The stream should flow straight into the culvert inlet at all stream discharges without any ponding, eddying or abrupt changes in flow path which could result in increased potential for culvert blockage by woody material (Cafferata *et al.*, 2004).
- In situations where the new culvert discharges onto an unstable stream channel, an energy dissipater should be installed to prevent scour at the outlet. This can be constructed of appropriately sized rock armour and should have a concave cross-section to prevent the scouring of adjacent stream banks.
- Where flows are encountered, water should be diverted away from excavation areas to reduce turbidity and eliminate saturation of the crossing fill as it is excavated. A small diversion dam should be built upstream and stream flow piped around the worksite and discharged into the stream below the worksite or to a site where sediment can be captured.

Note: Inadequate design and installation of culverts may result in culvert failure. Box 1 (below) summarised some key causes of culvert failure for consideration.

Box 1: 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.

B. Traffic Management

Traffic must be diverted around the construction area (where necessary) using the proposed route highlighted in Figure 7. This should avoid unnecessary disturbance to more intact aquatic habitats in the area.

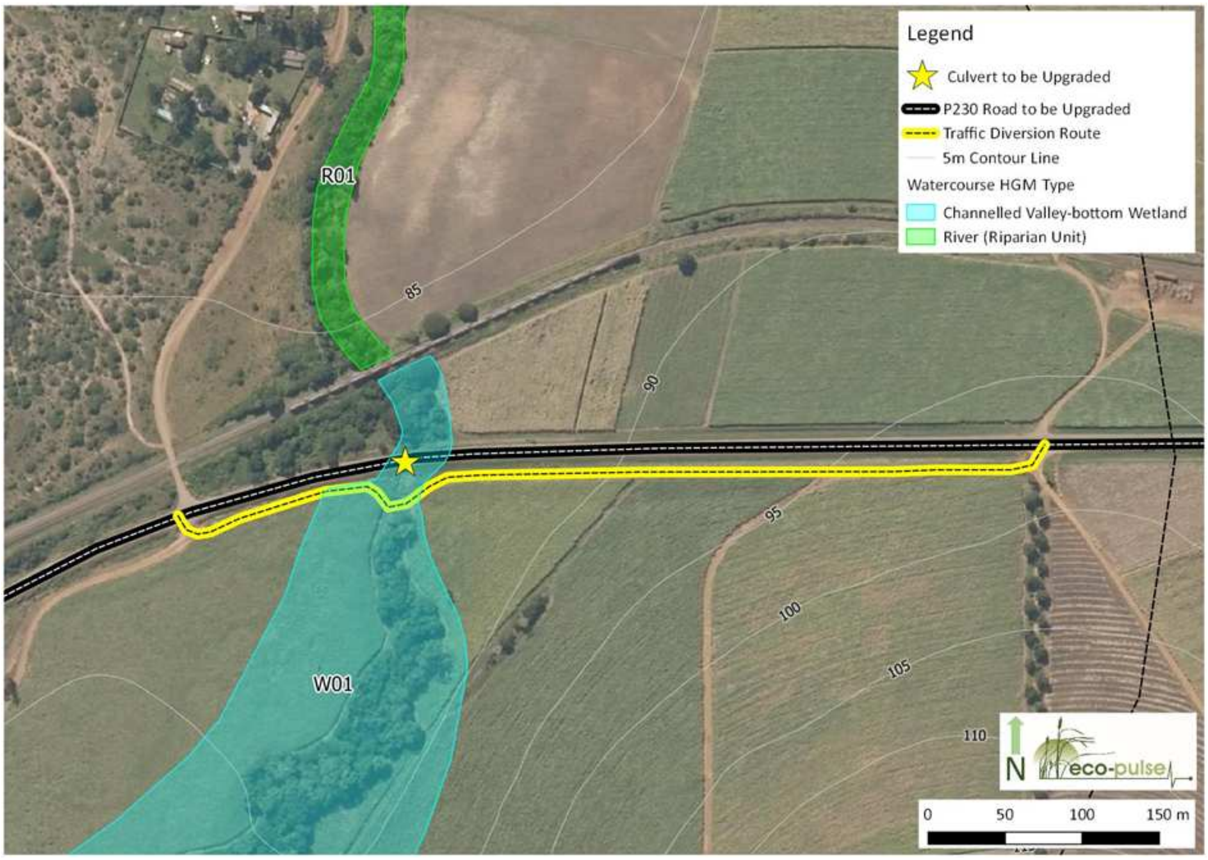


Figure 7 Map Showing the proposed traffic diversion route.

6.2 Construction Phase Impact Mitigation Measures

Mitigation measures specific to impacts identified and discussed above are provided below and are intended to augment standard mitigation measures included in the construction Environmental Management Programme (EMPr):

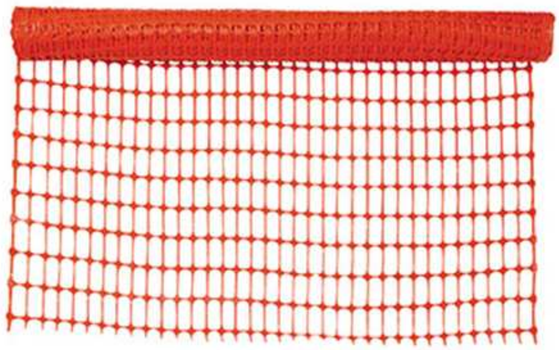
A. Timing of Construction Activities

It is recommended that construction within the watercourse take place in the winter/dry months (June-September) to reduce erosion and sedimentation risks during the construction phase. If construction is timed correctly the risk and intensity of temporary flow diversion and sedimentation impacts to downstream river reaches will be greatly reduced.

B. Demarcation of the Construction Servitude/Working Area and No-Go areas

- The construction servitude should be limited to the proposed development footprint and a 10m working servitude either side thereof. This working servitude must accommodate all construction related activities, including materials storage, access routes, etc.
- The outer edge of the construction servitude/working area (as defined above) must be clearly demarcated for the entire construction phase using a brightly coloured hazard fence (See Examples 1 & 2) or danger tape with steel droppers.

- Maintain site demarcations in position until the cessation of construction works.
- The location of stockpile areas, site camps and equipment lay down areas must be agreed to and demarcated to the satisfaction of the ECO prior to the clearing. A recommended set-back distance of at least 30m from the active river channel edge is recommended.
- All areas outside (including upstream and downstream) of this demarcated construction servitude must be considered 'No-Go' areas. **Any contractors found working inside the no-go areas should be fined as per fining schedule/system setup for the project.**
- The demarcation work must be signed off by the Environmental Control Officer (ECO) before any work commences.
- Do not paint or mark any natural feature. Marking for surveying and other purposes must be done using pegs, beacons or rope and droppers.



Example 1: Roll of an orange hazard fence

Example 2: Installed hazard fence

C. Accidental Incursions into 'No-Go' Areas

- Watercourses outside of the construction servitude that are disturbed during the construction phase must be rehabilitated immediately.
- All disturbed areas must be prepared and then re-vegetated to the satisfaction of the ECO as per the rehabilitation guidelines below.
- Where stream channels have been disturbed, the channels should be re-graded (where necessary) and stabilised using geofabric and re-vegetated as per the relevant re-vegetation/re-planting plan.

D. Protection of indigenous plants

- Before any work commences, sediment control/silt capture measures (e.g. bidim/silt curtains) must be installed downstream of the working areas, specifically above the pool habitats. A minimum of 3 rows of silt fences/curtains shall be installed across the river/stream channel established at regular intervals.
- Prior to the stripping, infilling, excavation and re-shaping of the aquatic habitat within the development footprint/corridor, a search and rescue of indigenous flora and fauna must be undertaken prior to habitat destruction.
- This must be followed by harvesting of all robust indigenous hygrophilous vegetation for later use during re-vegetation. In this regard, a wetland/aquatic ecologist must guide the contractor on the plants to rescue prior to clearing.

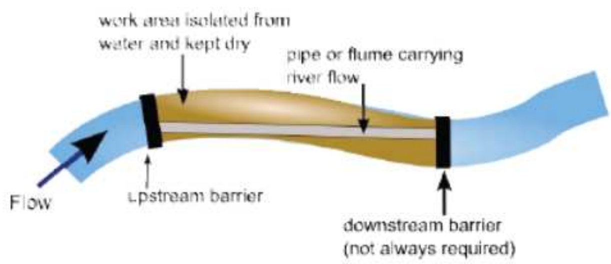
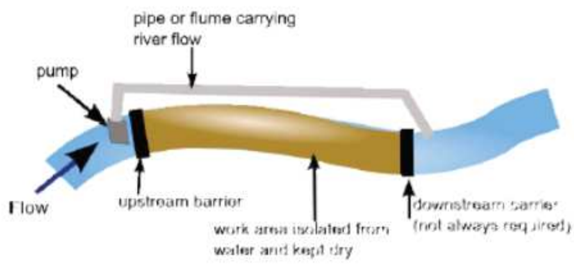
- No clearing of indigenous vegetation outside of the defined working servitudes is permitted for any reason (i.e. for fire wood or medicinal use).

E. Temporary flow diversion

One of two flow diversion methods is recommended for implementation during the construction phase:

- **Full isolation gravity / flume pipe** (See Table 14 below); or
- **Full isolation over pumping / siphon** (See Table 14 below).
- The temporary barrier should be constructed using sandbags.
- A method statement must be compiled by an aquatic specialist in conjunction with the appointed contractor to guide the flow diversion process from start to finish.
- Temporary diversions will need to be put in place to temporarily divert water away from activities and ensure a dry work area.
- 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 at the site, the diversions shall be removed to restore natural flow patterns, and the channel and riparian zone rehabilitated/restored to their original configurations as soon as practically possible.

Table 14. Best practise methods for partial and full isolation (after SEPA, 2009).

Description of Method	Schematic of Method
Full isolation gravity/flume pipe A whole section of the channel is isolated using barriers that span the full width of the river. This keeps a stretch of the river dry and the water is transferred downstream of the works area through gravity fed flumes/pipes. The flume(s) is normally placed on the bed of the watercourse through the works area and outfalls at the downstream barrier, if present, or far enough downstream to prevent the water backing up into the work area.	
Full isolation over pumping / siphon A whole section of the channel is isolated using barriers that span the full width of the river. This keeps a stretch of the river dry and the water is transferred downstream of the works area by mechanical assistance (pumping or siphon). The pump and associated pipe work need not be located in the isolated area.	

F. Surface water management and erosion control

Stormwater and erosion control measures must be implemented during the construction phase to ensure that erosion and sedimentation impacts to the wetland, riparian and in-stream habitats are minimised or avoided. In this regard, the following measures should be implemented:

- Construction activities should be scheduled to minimise the duration of exposure to bare soils on site, especially on steep slopes.
- The unnecessary removal of groundcover from slopes must be prevented, especially on steep slopes.
- All bare slopes and surfaces to be exposed to the elements of weather during clearing and earthworks must be protected against erosion using rows of silt fences and sandbags.
- Sediment barriers such as berms, sandbags and/or silt fences must be monitored for the duration of the construction phase and repaired immediately when damaged.
- Sediment barriers must only be removed once vegetation cover has successfully re-colonised the embankments.
- 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 grass has re-colonised the rehabilitated area.
- Where required sand bags must be used to retain banks vulnerable to collapse.

G. Water Abstraction and Use

The following guidelines pertain to the abstraction and general use of water from streams/rivers:

- No water is to be abstracted from the river for use in construction activities without a Water Use License in terms of Section 21 (a) of the National Water Act.
- The Contractor shall only be allowed to draw water from the source/s indicated in the WUL.
- Abstraction points should be carefully selected to minimize impacts to sensitive river biotopes.
- Care is to be taken not to disturb the channel bed of watercourses during abstraction of water using suction pumps.
- Locate the suction pump inlet at a sufficient height above the channel bed/floor where bed-load sediments accumulate.
- Where necessary, install a suitable sediment filter/screen in front of the suction pump inlet to remove undesirable sediments, particles and debris from entering the pump.
- Employees are not to make use of any natural water sources (e.g. rivers) for the purposes of swimming, bathing or washing of equipment, machinery or clothes.
- Drinking water is to be provided to all employees and labourers are to be discouraged from drinking directly from rivers on site.

H. Pollution prevention measures

- The proper storage and handling of hazardous substances (e.g. fuel, oil, cement, bitumen, paint, etc.) needs to be administered. Storage containers must be regularly inspected to prevent leaks and all hazardous storage must take place in a bunded area or within drip trays to prevent soil/water contamination.

- Mixing and/or decanting of all chemicals and hazardous substances must take place on trays, shutter boards or on impermeable surfaces and must be protected from the ingress and egress of stormwater.
- Drip trays should be utilised at all dispensing areas.
- No refueling, servicing or chemical storage should occur within 50m of the delineated 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 with an oil filter trap is constructed at the site camp 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 drainage 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 is 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.
- Waste from chemical toilets must be disposed of regularly (at least once a week) and in a responsible manner by a registered waste contractor.
- Workers need to be encouraged to use toilet facilities provided and not the natural environment.
- Toilets must not be located within the 1:100 year flood line of a watercourse or closer than 50m or from any natural water bodies including rivers, streams, riparian areas and wetlands.
- No building material, soils or rubble is to be disposed of within any watercourse (wetland or river).
- Excess rubble must be taken to a landfill site and a waybill must be retained as proof of safe disposal.
- Should rubble be required as a raw material for the construction, it must be taken to a designated stockpile area – which must be approved by the ECO and located outside of sensitive wetland/riverine areas designated as 'No-Go' areas.

I. Solid waste disposal

- Eating areas must not be located within 30m of the 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 of bins is required.

J. Soil management (stockpile areas)

Where deemed relevant, the following measures should be implemented:

- Erosion/sediment control measures such as silt fences or bricks placed around the stockpiles to limit sediment runoff from stockpiles.
- Subsoil and topsoil must be stockpiled separately. Stockpiled soil must be replaced in the reverse order to which it was removed (subsoil first followed by topsoil).
- Stockpiles of construction materials must be clearly separated from soil stockpiles in order to limit any contamination of soils.
- The stockpiles may only be placed within demarcated stockpile areas. The contractor shall, where possible, avoid stockpiling materials in vegetated areas that will not be cleared.
- Stockpiles shall be located outside of freshwater habitat (including wetlands and riparian zones).
- Stockpiled soils must be kept free of weeds and must not be compacted.
- The stockpiled soil must be kept moist using some form of spray irrigation on a weekly to bi-weekly basis.
- The height of stockpiles must be limited to 2m to avoid soil compaction and destruction of soil micro-organisms.

K. Alien plant control

- All invasive alien plants that have colonised the construction site must be removed, preferably by uprooting.
- 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 by independent testing authority are to be used.

L. Wildlife Management

- Education of workers/employees onsite on not to harm wildlife unnecessarily will assist in mitigating this impact. Contractor induction and staff/labour environmental awareness training needs are to be identified and implemented through staff/contractor environmental induction training. This should include basic environmental training based on the requirements of the EMPr, including training on avoiding and conserving local wildlife.
- No wild animal may under any circumstance be hunted, snared, captured, injured, killed, harmed in any way or removed from the site. This includes animals perceived to be vermin (such as snakes, rats, mice, etc.).

- Any fauna that are found within the construction zone must be moved to the closest point of natural or semi-natural habitat outside the construction corridor.
- The handling and relocation of any animal perceived to be dangerous/venomous/poisonous must be undertaken by a suitably trained individual.
- All vehicles accessing the site should adhere to a low speed limit (30km/h is recommended) to avoid collisions with susceptible species such as reptiles (snakes and lizards).
- No litter, food or other foreign material should be disposed of on the ground or left around the site or within adjacent natural areas and should be placed in demarcated and fenced rubbish and litter areas that are animal proof.
- Ensure that workers accessing the site conduct themselves in an acceptable manner while on site, both during work hours and after hours.
- Temporary noise pollution should be minimized by ensuring the proper maintenance of equipment and vehicles, and tuning of engines and mufflers as well as employing low noise equipment where possible.
- No activities should be permitted at the site after dark (between sunset and sunrise), except for security personnel guarding the development site.

M. Fire Management

- No open fires to be permitted on construction sites. Fires may only be made within the construction camp and only in areas and for purposes approved by the ECO.
- Fire prevention facilities must be present at all hazardous storage facilities.
- Ensure adequate fire-fighting equipment is available and train workers on how to use it.
- Ensure that all workers on site know the proper procedure in case of a fire occurring on site.
- Smoking must not be permitted in areas considered to be a fire hazard.
- Ensure that no refuse wastes are burnt or buried on the construction site or on surrounding areas.

6.3 Post-Construction Rehabilitation Guidelines

6.3.1 Purpose

Ecosystem 'rehabilitation' refers to the process of reinstating the natural hydrological, geomorphological and ecological processes of a degraded riverine/wetland habitat system with the aim of recovering system integrity and ecosystem service delivery (Russell, 2009). Rehabilitation in this context also refers to the halting and decline in integrity (stabilisation) of an ecological system that is in the process of degrading with the aim of maintaining system integrity and ecosystem service delivery (Russell, 2009).

The road culvert upgrade development will likely impact both directly and indirectly on wetland and riverine habitat at the site. Whilst a range of construction phase impact mitigation and management measures have been provided in Section 6.2, the need for post-construction aquatic habitat rehabilitation guidelines/recommendations was identified for areas that are likely to be directly impacted by construction activities and where residual impacts to wetland/riparian habitat after on-site mitigation will remain and require remediation.

Given the value of wetlands and aquatic ecosystems (such as rivers and estuaries) and the fact that humans depend on aquatic resources, it is also against the law to deliberately damage wetlands and rivers. The law places, directly and indirectly, the responsibility on landowners and other responsible parties, such as managers, to repair or rehabilitate damaged or lost wetlands and riparian areas (Armstrong, 2009). Of particular importance is the requirement of 'duty of care' with regards to environmental remediation: stipulated in Section 28 of NEMA (National Environmental Management Act, Act 107 of 1998):

> **Duty of care and remediation of environmental damage**: "(1) *Every person who causes has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot be reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.*"

The requirements for rehabilitation of disturbed wetland/riparian areas stipulated in the National Water Act (No 36 of 1998) are also noteworthy:

> *'A person who lawfully impedes or diverts the flow of water in a wetland, or who alters the beds, banks or characteristics of a wetland must take necessary measures to stabilise the diversion structure and surrounding area through:*
> - *rehabilitation of the riparian habitat using only indigenous shrubs and grasses;*
> - *rehabilitation of disturbed and degraded riparian areas;*
> - *restoring and upgrading the riparian habitat integrity to sustain a biodiverse riparian ecosystem;*
> - *removal of alien vegetation, and*
> - *conducting an annual habitat assessment.'*

6.3.2 Rehabilitation Objectives

These rehabilitation guidelines are therefore intended to address residual construction-related impacts and disturbances for the road culvert upgrade development project and provide guidance on the proposed methods of aquatic habitat rehabilitation. In light of the moderately low significance of anticipated impacts and the localised nature of planned disturbances, the rehabilitation plan should focus primarily on the rehabilitation of disturbed areas within the construction zone/development footprint, thus ensuring the channel bed and banks are adequately stabilised and re-vegetated similar to the pre-development scenario. The following key rehabilitation objectives are proposed:

1. To reshape, stabilise and re-vegetate (reinstate) wetland and riparian areas physically disturbed by construction activities, both planned and accidental. Rehabilitation should be

pragmatic and focus on the stabilisation and re-vegetation of disturbed areas, with less focus on biodiversity aspects (i.e. reinstating reference species diversity).

2. To remove all sediment and construction materials washed into wetlands/channels during construction and reshape and re-vegetate the affected surface (if applicable).
3. To eradicate and control invasive alien plants and weeds that invade and colonise the watercourses post-disturbance; and
4. To monitor the success of the rehabilitation actions and ensure that the above-listed objectives are achieved.

It must be emphasised however that these guidelines are not intended to be a detailed rehabilitation implementation plan for the site and detailed method statements, planting plans, bills of quantities and budget for rehabilitation will need to be developed based on these guidelines.

6.3.3 Conceptual Rehabilitation Strategy

Post-construction rehabilitation will aid the recovery of the disturbed ecosystems and is critical in preventing further impacts including those associated with IAP infestations, soil erosion and sedimentation, although it is important to note that the freshwater habitat within the construction servitude (road reserve) is already degraded and characterised by secondary vegetation. Table 15 below provides guidance on the approach and basic methods for rehabilitating disturbed aquatic habitat during culvert replacement:

Table 15. Post construction rehabilitation guidelines disturbed river and riparian habitat.

Rehabilitation Step	Rehabilitation Guidelines and Specific Actions
STEP 1: Initial planning and strategy	• Upfront it is important to note that these guidelines do not constitute a detailed rehabilitation plan that includes detailed implementation measures and bills of quantities. As part of the approval of the final construction EMPr, a detailed plan should be compiled and appended to the EMPr. • A budget including costing of all revegetation activities detailed in this report, and equipment costs, will need to be compiled prior to commencement of construction. Ideally the rehabilitation costs should be included in the contractual agreement for the project. • Rehabilitation should target all areas to be physically disturbed by activities, planned and unplanned. These areas must be identified prior to the implementation of the Plan. • It is important to keep in mind that quantities of required geofabric and plant material will need to be ordered at the right time to ensure that adequate quantities of the materials are available during implementation. • Rehabilitation of disturbed watercourses should ideally be initiated as soon as possible and occur as construction works progress. • Whilst appointment of external landscapers is a feasible and acceptable option, a lot of preparation will need to be undertaken exclusively by the main contractor at the inception of the project. Preparation activities include correct stockpiling of topsoil needed for rehabilitation, harvesting of indigenous plants for use later on in rehab, managing a nursery for rescued plants, etc. • A suitably qualified aquatic/ river ecologist with experience in rehabilitation may be required to provide practical input into the rehabilitation during implementation of the rehabilitation plan.

STEP 2: Plant Rescue and Topsoil Management	• Where indigenous vegetation can be harvested and retained for use in re-vegetation, this should be done so. Retained vegetation must be kept moist at all times until replanting can be achieved. • Where applicable topsoil stripped from the construction zones within the construction footprint must be conserved, stored and used in rehabilitation. • An effort must be made to ensure topsoils are not mixed with subsoils (to be kept separate). • Pre-emergent herbicide may be applied to stockpiled topsoil to rid of IAPs.
STEP 3: Remove any waste products	• All waste products (spoil, construction materials, hazardous substances and general litter) need to be removed from the construction footprint 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 washed into river from upslope must be removed, taking care not to remove or disturb the natural soil profiles including instream and riparian habitats.
STEP 4: 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 <u>hand removal is the most preferred option</u> and only in the event that this is not a viable means of control, should chemical means be considered. *See also Box 2 under Section 6.4* • ONLY herbicides which have been certified safe for use in aquatic environments by an independent testing authority may be considered. The ECO must be consulted in this regard.
STEP 5: Formulation of Revegetation Strategy	A formal, detailed re-vegetation strategy will need to be formulated for the disturbed aquatic habitat, with some guidance on vegetation provided below: • Based on the low diversity and existing disturbance at the site, we envisage a simple and functional re-vegetation strategy with the focus on achieving an adequate cover in the shortest time. A minimalistic approach to re-vegetation of the disturbed areas is thus proposed for this site that will involve the rapid re-establishment of an indigenous pioneer plant dominated vegetation cover via a combination of cost-effective planting methods. • At this stage we propose re-vegetation using a combination plugs of *Cynodon dactylon and Stenotaphrum secundatum,* with the hydroseeding of *Eragrostis tef* as a nursery cover. Although it does not offer instant protection as with sodding, planting of plugs has a high success rate and provides protection within a few weeks, while being comparatively cheaper than sods. • Plugs should ideally be planted at a high density of 16 plugs/m^2. This will ensure that a cover of 80% is achieved within 4 – 6 weeks (Granger, 2015). The planting density can be altered as required (Please note that this density needs to be confirmed during the finalisation of the detailed re-vegetation plan). • The plugs will need to be sourced from an appropriate nursery with capacity to produce the required quantities of plugs. • The planting of plugs should ideally be undertaken early in summer. However, as it is recommended that construction occur in winter months to avoid peak flows and associated erosion issues, hydroscopic gel with be required for the plugs • Geofabric will be generally be required for soil stabilisation on steep slopes. • Pease note that this strategy may be changed / revised following the finalisation of the detailed revegetation plan which will include the plating method, species and quantities / costs.
STEP 6: Stabilise, reshape and prepare soil profiles	• Any erosion features created by construction activities need to be stabilised. • Exposed banks and slopes are to be stabilized and re-vegetated as soon as practically possible. • Erosion control measures such as geofabric, eco-logs and biodegradable silt fences must generally be installed prior to re-vegetation. • Channel banks need to be shaped to a stable angle of repose to avoid slumping and prepared for re-vegetation immediately.

	• Where significant soil compaction has occurred, the soil may need to be ripped in order to reduce the bulk density of the soil such that vegetation can become established at the site. 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. • Stored topsoil must be re-spread across the reshaped surfaces prior to re-vegetation. • For the seeding of *E. tef*, the soil needs to be prepared to optimise germination. Such preparation is undertaken by hand hoeing. The soil in the seedbed should be loosened to facilitate good contact between the seeds and the soil. • In general, fertilizer/lime is not necessary nor is it recommended for re-vegetation in wetlands, rivers and riparian areas as this may promote increased weed growth • A weed-free mulch is recommended to help retain moisture for germination on channel banks. It is very important that mulch not be derived from stands of IAPs or weeds.
STEP 7: Re-vegetation of disturbed areas	• Once construction is completed and alien vegetation and waste products have been removed and soils are prepared for planting, re-vegetation must commence as per the strategy in Step 5 above as soon as weather conditions allow for good plant growth. • Re-vegetation should focus primarily on bare exposed/ unstable soils. Key focal areas include channel banks/margins of the active channel and riparian areas. • It would be advisable to plant at the onset of the wet season (early spring – August to October) so that watering requirements are minimal. This may however not coincide with the construction period and need to be carefully planned. • Do not use fertilizer, lime, or mulch unless required. • A trained re-vegetation/ rehabilitation expert should be contracted to oversee the rehabilitation of areas.
STEP 8: Monitor re-vegetation progress and administer alien plant control	• The first 6 weeks after re-vegetation are the most critical in terms of maintenance and monitoring and weekly audits by an ECO with the contractor must be undertaken to monitor re-vegetation success. Only once an adequate ground cover is established 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. Any areas that are not progressing satisfactorily must be identified and action must be taken to actively re-vegetate these areas. If natural recovery is progressing well, no further intervention may be required. • The ECO should assess the need / desirability for further monitoring and control after the first 6 months and include any recommendations for further action to the relevant environmental authority.

6.3.4 Potential Negative Impacts of Rehabilitation

While the intention of rehabilitation should always to benefit the environment and society through the protection or improvement of freshwater ecosystems and the services that they provide, poorly planned rehabilitation can often cause more harm than good (Armstrong, 2008). Rehabilitation interventions vary considerably in terms of their potential to cause environmental impacts both in terms of the type of impact caused as well as the magnitude of the impact. Thus it is appropriate that all rehabilitation efforts/ projects are scrutinized for their potential to cause unintended, negative environmental impacts (Armstrong, 2008). Potential negative impacts associated with rehabilitation projects are highlighted by Armstrong (2008), most relevant of which to this rehabilitation plan have been summarised in Table 16, below.

It is recommended that these and other potential negative impacts be noted by the Implementing Agent responsible for the rehabilitation and managed on-site according to means of avoidance/ mitigation described in Table 16 and in conjunction with the aquatic ecological impact management and mitigation measures discussed further in Section 6.2.

Table 16. Key potential negative environmental impacts associated with wetland, river and riparian rehabilitation activities and interventions and means of avoiding or mitigating these impacts (after Armstrong, 2008).

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
1	**A weir, earthen plug or sediment fence across a stream channel, artificial drainage channel or erosion gully**	Trapping of bedload and spreading of high flows.	Little that can be done to mitigate.
2	**Sloping of steep slopes and erosion gully head/sides**	Exposure of soils to risk of erosion, which may impact negatively on river/stream and riparian areas and downstream aquatic habitats.	Assess whether bioengineering will be adequate. Ensure revegetation takes place as rapidly as possible. Provide supplementary support (e.g., biomats, ecologs, etc.) to the vegetation, where required.
3	**Infilling of erosion gullies or artificial drainage channels**	Fill material may be washed away, which may impact negatively on the aquatic habitats nearby and downstream aquatic habitats. Obtaining fill will also have associated impacts	Re-vegetate the fill as quickly as possible. Temporarily divert flow, if required, until the fill has become adequately re-vegetated.
4	**Planting of vegetation**	Introduction of alien species that spread beyond the site. Use of plant material of indigenous species that is genetically different to that occurring locally, resulting in 'genetic contamination'.	Do not use species with invasive potential. Use local material only.
5	**Access to the site during rehabilitation by workers and equipment**	Soil compaction and disturbance and vegetation disturbance.	As far as possible, use existing roads and tracks. In very wet areas obtain foot access using boards. Rehabilitate access paths when work is complete (e.g. loosen compacted areas).
6	**Temporary storage of materials**	Disturbance of vegetation. Visual impact.	Remove all material on completion of the work. Rehabilitate site when work is complete.
7	**Mixing of concrete**	Local contamination of the soil.	Confine mixing of concrete to designated area/s not susceptible to flooding.
8	**Human waste associated with toilets**	Contamination of soil and water.	Locate toilets outside of the delineated watercourses.
9	**Disturbance associated with the noise and presence of workers**	Disturbance of fauna, particularly breeding Red Data species.	Consider timing of activities. Screening with shade-cloth, if required.
10	**Fuel spills or leaks**	Contamination of soil and water.	Maintain any machines (e.g., pumps) being used at the site in good working order, and any stored fuel should be located well outside of the delineated watercourses.
11	**Temporary diversion**	Temporary drying out or redirecting of flows as well as secondary erosion and sediment impacts.	Ensure that the diversion channel or coffer dam is removed and natural flow regimes are restored

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
12	**Removal of plugs of vegetation from donor sites**	Potential exposure of donor sites to erosion. Disturbance of sensitive habitat.	Remove plugs where the threat of erosion is low and the site is not considered sensitive.
13	**Cutting and filling (e.g. in order to slope a gully head or sides)**	Disturbance of soil and vegetation. Erosion and washing of sediment into downstream habitats.	Where the site is located in water flow paths, particularly where discharges are high, confine activity to the dry season. Divert flow until the intervention is well stabilised. Encourage rapid re-vegetation.
14	**Collection of rocks and material from the local environment**	Loss of habitat from rock removal.	Do not collect rocks or sediments from a stream channel bed.
15	**Collection of local sand**	Disturbance of vegetation, possible increase in risk of erosion.	Collect sand where risk of erosion is low and in areas where pioneer vegetation dominates.
16	**In all cases of disturbance of soil or vegetation, the opportunities for invasive alien species to invade are increased,**	Competition and displacement of native vegetation, loss of biodiversity, increased soil erosion/fire risk, increased water consumption (depending on species of IAPs).	Control alien plants and weeds.

6.3.5 Outstanding Tasks and Way Forward

The outstanding tasks still to be completed as part of the finalization of the rehabilitation planning needs to include the finalization of a detailed freshwater habitat rehabilitation plan for implementation (based on the conceptual guidelines in this report), that includes:

- Accurate location and extent of development footprint including infrastructure and the mapping of areas requiring rehabilitation.
- Finalisation of a site-specific re-vegetation plan including planting method, preferred species, plant spacing and densities, as well as recommended stabilization measures based on slope and soil types.
- Defining key roles and responsibilities.
- Finalisation of the bill of quantities and costs for all interventions.

6.4 Operational Phase Impact Mitigation Measures

A. Flow and Erosion/ Sedimentation Control

Once the culvert is in place very little can be done to manage instream flow and flow related erosion (scouring) and sedimentation impacts during operation. These impacts can and should be best addressed through careful design of the culvert that takes into account environmental and ecological considerations. The reader is referred to Section 6.1 for the culvert design recommendations that will serve to reduce the probability and intensity of operational instream impacts to reasonably low levels.

B. Alien Plant Monitoring and Control

It is the responsibility of the developer/applicant to eradicate and control alien invasive plants that invade all areas disturbed by the construction and operation of the proposed development. In terms of section 75 of NEMBA, the following applies to the control & eradication of invasive species:

- The control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs (*see Box 2 below for guidance on alien plant control methods*);
- Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment; and
- The methods employed to control and eradicate a listed invasive species must also be directed at the offspring, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.
- It is recommended that bi-annual annual alien plant clearing be undertaken by the applicant for the first year post-rehabilitation. Thereafter, alien plant clearing should be undertaken annually until such a time that further risks of alien invasion resulting from disturbance factors are considered negligible.

Box 2. Guidance Alien Plant Control

There are various means of controlling invasive alien plants in South Africa. The primary methods are discussed below. The suitability of control methods depends on a number of factors, including practical constraints, economic constraints and applicability of methods for particular species of alien plants. It is generally advised that a form of integrated control be implemented; however the final selection of the appropriate methods of control should be based on the following criteria:

- **Species to be controlled:** herbicides are registered for specific species. Selection should be based on "*A Guide to the use of Herbicides*" issued by the Directorate: Agricultural Production Inputs and labels and information brochures provides by herbicide suppliers.
- **Size/age of target plants:**
  - For **seedlings:** hand-pulling or hoeing and foliar applications of herbicides for dense stands.
  - For **saplings:** hand-pulling or hoeing, foliar applications of herbicides for dense stands, basal stem treatments and cut stump treatments recommended.
  - For **mature trees**: ring barking, frilling, basal stem treatments and cut stump treatments recommended.
- **Density of stands:** Overall applications of herbicide can be made to dense stands of seedlings or saplings. Where dense stands of large trees are present, treatment of standing trees may be appropriate to obviate the problem of disposing felled trees.
- **Accessibility of terrain:** In inaccessible areas, methods that rely on the minimum amount of transportation of equipment and chemicals should be given preference.
- **Environmental considerations:** Riparian/wetland areas require a careful approach to treatment/control. Only herbicides approved for use in wetland/riparian areas are to be considered. Washing of equipment or disposal of any chemical substances is prohibited in or near areas where there is a potential risk of contamination of wetlands/riparian areas.
- **Desirable vegetation:** Control methods that will cause the least damage to desirable vegetation must be considered. Selective herbicides or mixes that will not damage other desirable vegetation should be applied where relevant.
- **Disposal of dead vegetation:** Where possible, utilizable wood should be removed after tree felling. This is also the case for trees that could cause the blockage of water courses. Brushwood should be spread rather than stacked to limit soil damage in instances where burning is planned.
- **Cost of application:** the cost of application and re-treatment should be taken into consideration when selecting methods/herbicides, etc.

The **control methods** detailed below have been adapted from the ARC-PPRI (Agricultural Research Commission: Plant Protection Research Institute) Weed Research Programme (online at www.arc.agric.za/arc-ppri/), the DWA Working for Water Programme ((http://www.dwaf.gov.za/wfw/Control/) and eThekwini Municipality's *Practical tips on the management and eradication of invasive alien plants* (EcoFiles Sheet 4. Local Action for Biodiversity).

1. Mechanical control

Mechanical control entails physically damaging or removing the target alien plant. Mechanical control is generally labour intensive and therefore expensive, and can also result in severe soil disturbance and erosion. Different techniques can be applied and include uprooting/hand-pulling, felling, slashing, mowing, ring-barking or bark stripping. This control option is only really feasible in sparse infestations or on a small scale, and for controlling species that do not coppice after cutting. Species that tend to coppice (e.g. *Eucalyptus spp., Melia azedarach)* need to have the cut stumps or coppice growth treated with herbicides following mechanical treatment.

- **Hand pulling/uprooting:** The hand-pulling should be reserved for small plants and shrubs with shallow root systems (not recommended for trees with a stem diameter of more than 10cm). Grip the young plant low down and pull out by hand (using gloves). Uprooting is similar but is undertaken on slightly older individuals with the major drawback being that a relatively large area can be disturbed with the soils being altered and opening the area up to re-infestation.
- **Chopping/ cutting/ slashing:** This method is most effective for plants in the immature stage, or for plants that have relatively woody stems/trunks. An effective method for non re-sprouters or in the case of re-sprouts (coppicing), it must be done in conjunction with chemical treatment of the cut stumps. Cut/slash the stem of the plant as near as possible to ground level. Paint re-sprouting plants with an appropriate herbicide immediately after they have been cut.
- **Strip bark:** Using a bush knife, strip bark away from tree from waist height down to soil. Cambium is stripped with the bark. No herbicide used.
- **Felling:** Large trees can be cut-down in their entirety, however, this is often not recommended unless absolutely necessary as large trees can play a pivot role in soil protection and biodiversity maintenance.
- **Girdling:** Girdling involves cutting a groove or notch into the trunk of a tree to interrupt the flow of sap between the roots and crown of the tree. The groove must completely encircle the trunk and should penetrate into the wood to a depth of at least 1.5 centimetres on small trees, and 2.5 to 4 centimetres on larger trees. The effectiveness of girdling can be increased by using herbicides.

2. Chemical control

Chemical control involves the use of registered herbicides to kill the target weed. The use of herbicide is often essential to the success of an eradication/control programme as it greatly reduces the re-growth potential of alien plants. Unfortunately, if the wrong herbicide is chosen, one can potentially cause more harm than good to the environment. When choosing the most appropriate herbicide, one needs to consider the following:

- **Relative toxicity to humans/animals**
- **Selective vs non-selective herbicides**: There are advantages and disadvantages to using each type. When dealing with light to moderate infestations in grass-dominated veld types, a broad-leaf selective herbicide is recommended so as to reduce the danger that spray drift could kill natural grass. In areas of heavy infestation, a non-selective herbicide is recommended.
- **Residual effect**: Some active ingredients in herbicides will remain in the environment for months, even years, before denaturing. Others start to denature as soon as they enter the soil. If a persistent herbicide is used, ensure that it is not used near any watercourse or area with a high water table (such as wetlands & riparian areas).
- **Is the herbicide registered for the target species:** A list of registered herbicides can be obtained from the Department of Water Affairs: Working for Water Programme – Policy on the Use of Herbicides for the Control of Alien Vegetation (January 2002). Also see http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/Specific-IAP-Species-and-their-control-according-to-botanical-names.aspx

Some additional recommendations regarding herbicide use include:

- Herbicides should be applied during the active growing season.
- Always observe all safety precautions printed on the labels and manufacturer's instructions when mixing and applying herbicide.
- Herbicides can be applied in various ways. They can be sprayed onto dense infestations or painted onto the main stem of the plant or cut stump.
- Spraying herbicide on small infestations is not recommended, rather cut and apply herbicide to the stumps either with a brush.
- Spraying should be restricted to windless days when there is less risk of droplets drifting onto non-target species.
- Pressure or flow regulators should be fitted to sprayers for overall application. Spraying should be restricted to plants waist height or lower, but also ensuring there is sufficient foliage to carry the applied herbicide to the root system of the target plant.
- For water-based applications, Actipron Super Wetter should be added where recommended on the herbicide label, at a rate of 1.75/ha for dense-closed stands of alien vegetation.
- For all water-based treatments, a suitable brightly coloured dye should be added to the mix to ensure that all target plants are treated. For diesel-based applications, Sudan Red Dye should be added.
- Chemical control of IAPs is not recommended in aquatic systems due to the risk of water pollution, but may be used in conjunction with cutting or slashing of plants.
- Chemicals should only be applied by qualified personnel.
- Only herbicide registered for use on target species may be used.
- Follow the manufacturer's instructions carefully.
- Appropriate protective clothing must be worn.
- Only designated spray bottles to be used for applying chemicals.
- The number of herbicides for safe use under wet conditions is very limited.

3. Biological control

Biological weed control involves the releasing of natural biological enemies to reduce the vigor or reproductive potential of an invasive alien plant. Research into the biological control of invasive alien plants is the main activity of the Weeds Research Programme of ARC-PPRI and a list of biocontrol agents released against invasive alien plants in South Africa can be downloaded from their website. To obtain biocontrol agents, provincial representatives of the Working for Water Programme or the Directorate: Land Use and Soil Management (LUSM), Department of Agriculture, Forestry and Fisheries (DAFF).

4. Mycoherbicides

A mycoherbicide is a formulation of fungal spores in a carrier, which can be applied to weeds in a similar way as a conventional chemical herbicide (using herbicide application equipment). The spores germinate on the plant, penetrating plant tissues and causing a disease which can eventually kill the plant. Mycoherbicides are indigenous to the country of use and therefore are already naturally present in the environment and do not pose a risk to non-target plants. Under natural conditions they do not cause enough damage to the weed to have a damaging impact and are therefore mass produced and applied in an inundative inoculation, which leads to an epidemic of the disease knocking the weed population down. Mycoherbicides need to be re-applied at regular intervals.

5. Integrated control

It is frequently advisable to use a combination of two or more of the control method mentioned above, which is referred to as *integrated control*. Killing plants without cutting down causes the least disturbance to the soil and is the ideal.

The following integrated control options are available:

- **Basal bark and stem application**: apply recommended herbicide mixed in diesel carrier to the base of the stem of trees (<25cm stem height) and saplings. This method is appropriate for plants with thin bark or stems up to 25cm in diameter. Do not cut the bark. Apply herbicide mix with paintbrushes or using a coarse droplet spray from a narrow angle solid cone nozzle at low pressure. For multi-stemmed plants, each stem must be treated separately.
- **Ring barking**: Invasive trees growing away from any structures or roads can be ring-barked, poisoned and left standing rather than felled. They will slowly collapse over time and can establish habitat for birds, etc. Strip all bark and cambium from a height of 75cm to 100cm down to just below soil level. Cut a ring at the top and pull strips. All bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets should be used for debarking.
- **Frilling:** Using an axe or bush knife, make angled cuts downward into the cambium layer through the bark in a ring. Ensure to effect the cuts around the entire stem and apply herbicide into the cuts.
- **Cut stump treatment**: This is a highly effective and appropriate control method for larger woody vegetation that has already been cut off close to the ground. The appropriate herbicide should be applied to the stump using a paintbrush within 30 min of being cut. Apply recommended herbicide mixture to the cut surface with hand sprayers, a paintbrush or knapsack sprayer at low pressure. Apply only to the cambium or outer layer of large stumps and the entire cut surface of small stumps. Ensure the stumps are cut as low to the ground as practically possible (about 10 – 15 cm or as stipulated on specific herbicide label). Herbicides are applied in diesel or water as recommended for the herbicide. Applications in diesel should be to the whole stump and exposed roots and in water to the cut area as recommended on the label.
- **Scrape and paint**: This method is suitable for large vines and scrambling plants i.e. creepers. Starting from the base of the stem, scrape 20-100cm of the stem to expose the sapwood just below the bark. Within 20 seconds apply the herbicide to the scraped section. Do not scrape around the stem. Stems over 1cm in diameter can be scraped in 2 sides. Leave the vines to die in place to prevent damaging any indigenous plants they may be growing over.
- **Foliar spray:** This is not an advocated method of application by unqualified applicators due to the danger of spraying indigenous species. Should be restricted to droplet application made directly on the leaves on plants that are no higher than knee height. Use a solid cone nozzle that ensures an even coverage on all leaves and stems to the point of runoff. Do not spray just before rain (a rainfall-free period of 6 hours is recommended) or before dew falls. Avoid spraying in windy weather as the spray may come into contact with non-target plants. Spraying dormant or drought stressed plants is not effective as they do not absorb enough of the herbicide.
- **Burning**: Spindly invasive alien plant species, such as Triffid Weed (*Chromolaena odorata*), growing on sandy soils, where there is between 30-40% grass still present, can be eradicated using annual controlled burns. Moderate to low infestations in wetland areas can be treated by controlled burning at the beginning of autumn, followed by mechanical removal or herbicide application in mid spring. ***Note that burning would generally not be acceptable in an urban area due to fire hazard/risk and nuisance.***
- *Note that no heavy machinery should be used to remove invasive alien plants, no matter how high the infestation, without prior authorization from relevant government departments when operating in wetlands and riverine areas.*

6. Disposal of alien plant material

Treated/removed alien plant material will need to be removed from the site and disposed of at a proper/registered receiving area such as a local registered land fill site.

6.5 Ecological Monitoring Recommendations

Monitoring is required to ensure that freshwater resources (wetlands and rivers) associated with the proposed development are maintained in their current ecological state or improved but incurring no net loss to condition and functionality as a result of the project. It is recommended that a Monitoring Programme be developed and implemented in accordance with the following guidelines:

A. Responsibilities for Monitoring

Compliance monitoring will be the responsibility of a suitably qualified/trained ECO (Environmental Control Officer) with any additional supporting ESO's (Environmental Site Officers) having the required competency skills and experience to ensure that monitoring is undertaken effectively and appropriately.

B. Construction Monitoring Objectives

Key monitoring objectives during the construction-phase should include:

- Ensuring that management and mitigation measure are adequately implemented to limit the potential impact on aquatic resources; and
- Ensuring that disturbed areas have been adequately to stabilise and rehabilitated to minimise residual impacts to affected resources.

C. Record keeping

The ECO shall keep a record of activities occurring on site, including but not limited to:

- Meetings attended;
- Method Statements received, accepted and approved;
- Issues arising on site and cases of non-compliance with the EMPr;
- Corrective actions taken to solve problems that arise;
- Penalties/fines issued; and
- Complaints from interested and affected parties.

D. Construction Phase Monitoring Requirements

- **During construction:**

This involves the monitoring of construction related impacts as identified in this report. Regular monitoring of the construction activities is critical to ensure that any problems with are picked up in a timeous manner. In this regard, the following potential concerns should be taken into consideration:

- Destruction of habitat outside the construction servitude including 'No Go' areas;
- Erosion of river bed and banks;
- Erosion of disturbed soils and soil stockpiles by surface wash processes;

- Sedimentation of aquatic habitats downstream of work areas;
- Altering the hydrology and through flows to downstream aquatic habitat during construction;
- Pollution of water resource units (with a particular focus on hazardous substances such as fuels, oils and cement products);
- Poorly maintained and damaged erosion control measures (e.g. sand bags, silt fences and silt curtains).

These risks can be monitored visually on-site by the ECO (together with construction staff) with relative ease and should be reported on regularly during the construction process. Any concerns noted should be prioritised for immediate corrective action and implemented as soon as possible.

- **Directly after construction (rehabilitation effectiveness):**

This involves monitoring the effectiveness of rehabilitation activities. Monitoring recommendations for rehabilitated rivers/streams and riparian areas have been included in the **'Post Construction Rehabilitation Guidelines'** contained in Section 6.3 of this report.

E. Operation phase monitoring requirements

This involves annual monitoring of watercourse units (rivers/streams) affected by the development in order to ensure that operational impacts are being effectively managed. This can also be achieved through basic visual inspections by the ECO and support staff, documenting issues such as:

- Invasive Alien Plant infestation;
- Scouring and deposition associated with storm water runoff;
- Development of erosion 'headcuts';
- Channel incision downstream of development;
- Blockage/siltation of culvert infrastructure;
- Scouring around infrastructure at river/stream crossings; and
- Erosion or instability of road embankments.

7. LICENSING AND PERMIT REQUIREMENTS

7.1 Water Use Licensing Requirements

Section 21 of the National Water Act (No 36 of 1998) lists certain activities for which water use must be licensed, unless its use is excluded. There are several reasons why water users are required to register and license their water use with the Department of Water & Sanitation (DWS), the most important being: (i) to manage and control water resources for planning and development; (ii) to protect water resources against over-use, damage and impacts and (iii) to ensure fair allocation of water among users. Depending on the nature of the development and water use, Section 21 (a), (c) and (i) water uses could potentially be triggered by the development (and associated activities) and would then require a Water Use License (WUL) from the DWS. The potential for the culvert upgrade development project to trigger these water uses has been investigated by considering the proximity of the activity to the watercourses assessed in the specialist report and the risk of any related activities resulting in impacts to the resource quality of the water course, as specified under Chapter 4, Section 21 of the National Water Act No. 36 of 1998.

Given that planned development activities will take place within a watercourse, a Water Use License (WUL) would generally apply for Section (c) and/or (i) at a minimum (see Table 17, below).

Table 17. Water Uses applicable to the proposed development.

NWA Section 21 Water Use	Description (DWAF, 2009)	Relevance to the site
21 (a): *Taking water from a watercourse*	Abstraction of water from a water resource.	*Potential for minor abstraction of water from the river for construction purposes is currently unknown and will need to be verified.*
21(c): Impeding or diverting the flow of water in a watercourse	This water use includes the temporary or permanent obstruction or hindrance to the flow of water into watercourse by structures built either fully or partially in or across a watercourse; or a temporary or permanent structure causing the flow of water to be re-routed in a watercourse for any purpose.	*Instream works will likely require temporary flow diversion and impedance depending on the nature of flows at the time of construction and as such will constitute a water use.*
21(i): Altering the bed, banks, course or characteristics of a watercourse	This water use relates to any change affecting the resource quality of the watercourse (the area within the riparian habitat or 1:100 year floodline, whichever is the greatest).	*Instream works will likely result in alterations to the bed and banks of the watercourses.*

However, the recent General Authorisation (GA) 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) replaces the the need for a water user to apply for a license in terms of the National Water Act No. 36 of 1998, '*provided that the water use is within the limits and conditions of the GA*'. Note that the GA does not apply to:

I. Water use for the rehabilitation of a wetland as contemplated in GA 1198 contained in GG 32805 (18 December 2009).

II. Use of water within the 'regulated area'[3] of a watercourse where the Risk Class is **Medium or High.**

III. Where any other water use as defined in Section 21 of the NWA must be applied for.

IV. Where storage of water results from Section 21 (c) and/or (i) water use.

V. Any water use associated with the construction, installation or maintenance of any sewerage pipeline, pipelines carrying hazardous materials and to raw water and wastewater treatment works.

To this end, the DWS have developed a Risk Assessment Matrix/Tool to assess water risks associated with development activities. The DWS Risk Matrix/Assessment Tool (based on the DWS 2015 publication: 'Section 21 c and I water use Risk Assessment Protocol') was applied to the culvert upgrade project on the P230 road, with a summary of the results of the assessment in Table 18, below. Detailed DWS risk matrix assessment results are provided in **Annexure C** of this report. *Note that only Low Risk Activities located within the regulated area of a watercourse will qualify for a GA.*

Based on the risk assessment undertaken using DWS Risk Based Matrix (DWS, 2015) whereby risk was determined after considering all listed control/mitigation measures (as defined in Section 6.2 of this report), the decommissioning and replacement of the existing road culvert is generally considered as being a Moderate water risk activity; and therefore would theoretically be subject to a full Water Use Licence in accordance with the conditions of the GA. However, the risk matrix/tool of DWS allows for borderline low/moderate risk scores to be "*manually adapted downwards up to a maximum of 25 points from a score of 80, subject to listing of additional mitigation measures considered and listed in Red font*". After careful consideration of best practical mitigation measures (design and operational mitigation measures recommended in Section 6 of this specialist report), the risk scores for borderline low/moderate cases were manually reduced to give a Low risk level, which implies that **the proposed development can essentially be authorised under the provisions of the GA for Section 21 c and i water use.** Considering the Low Ecological Importance & Sensitivity (EIS) and degraded nature of the receiving aquatic environment, and the nature of the activity (upgrade of an existing impact causing activity), the low risk rating is deemed to be realistic for the development scenario.

Note that the low risk is also based on the assumption that best-practice mitigation and impact management will be applied strictly, as per the recommendations made in Section 6 of this specialist report. Should these not be strictly enforced, the low risk ratings should not apply and a full Section 21 c and i WUL is likely to be required.

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[3] The 'regulated area' of a watercourse; for Section 21 (c) or (i) of the Act refers to:

i. The outer edge of the 1:100 yr flood line and/or delineated riparian habitat, whichever is greatest, as measured from the centre of the watercourse of a river, spring, natural channel, lake or dam.

ii. In the absence of a determined 1:100 yr flood line or riparian area, refers to the area within 100m from the edge of a watercourse (where the edge is the first identifiable annual bank fill flood bench).

iii. A 500m radius from the delineated boundary of any wetland or pan.

Table 18. Summary of the DWS Risk Matrix/Tool assessment results applied to the P230 culvert upgrade development project.

No.	Phase	Activity	Aspect (Stressor)	Impact	Significance (score)	Risk Rating	Control measures	Revised Risk Score (manually adjusted)	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
1	Construction	Replacement of existing culvert with a new portal culvert at one crossing site	**1. Site clearing and disturbance of soil and vegetation, stripping and stockpiling**	Destruction of aquatic vegetation, disturbance of soils and habitat.	48	Low	i. Identify 'No-go' areas and limit vegetation clearing to the construction footprint. ii. Retain excavated soils and vegetation for use in rehabilitation. iii. Rehabilitate the construction site with indigenous plant species (*refer to Section 6.4 of specialist report for further details*).	48	Low	Wetland Unit W01 (PES "D", Low EIS)
			2. Temporary flow diversion to create a "dry" working area	Temporarily impeding/diverting the flow of water during construction, alteration of natural flow patterns and soil saturation rates, scouring and erosion due to redirection of flows.	78	Moderate	iv. Undertake all temporary flow diversions during dry winter months when flows are low/zero. v. Flows must be diverted using only best-practice suitable methods (*refer to Section 6.2 of specialist report for further details*): a. Full isolation gravity / flume pipe. b. Full isolation over pumping / siphon. vi. The flow diversion structure (berm & flume piers) must be designed such flows are piped through the construction site effectively and efficiently; and very little water is impounded behind the berm. vii. Flows coming out of the flume pipes must be attenuated such that no erosion takes place and not directed towards any erosion-prone areas such as channel banks.	55	Low	Wetland Unit W01 (PES "D", Low EIS) & River Unit R01 (PES "B", Low EIS)
			3. Excavation and removal of the existing culvert	Disturbance of soils, channel bed material and banks, sedimentation of watercourses downstream, potential for water pollution.	60	Moderate	viii. Undertake excavations during dry winter months when flows are minimal/zero. ix. Excavations must be limited to the construction footprint only. x. No machines must be allowed to work in highly saturated soils or within standing or flowing water.	55	Low	Wetland Unit W01 (PES "D", Low EIS)

No.	Phase	Activity	Aspect (Stressor)	Impact	Significance (score)	Risk Rating	Control measures	Revised Risk Score (manually adjusted)	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
			4. Replacement of old culvert with a new portal culvert to be constructed	Disturbance of soils, channel bed material and banks, sedimentation of watercourses downstream, potential for water pollution.	74.75	Moderate	xi. Undertake excavations/construction during dry winter months when flows are minimal/zero. xi. Cement slurry must be efficiently contained so as not to pollute the water column. xii. All disturbed areas to be properly back-filled, compacted and rehabilitated/re-vegetated according to the rehabilitation guidelines *(refer to Section 6.4 of specialist report for further details).*	50	Low	Wetland Unit W01 (PES "D", Low EIS)
2	Operation	Operation of culvert upgrade	**1. Post-construction disturbance of habitat where not properly addressed, inadequate culvert design and construction**	Alteration of natural flow patterns, channel bank instability, increased levels of Invasive Alien Plants (IAPs) and weeds, scouring/erosion and associated sedimentation of downstream areas.	65	Moderate	i. Culvert to be appropriately designed and constructed (including storm water and erosion control) in accordance with the environmental design guidelines *(as provided in Section 6.1 of the specialist report).* ii. All disturbed areas to be properly compacted and rehabilitated/re-vegetated according to the rehabilitation guidelines *(refer to Section 6.4 of specialist report for further details).*	50	Low	Wetland Unit W01 (PES "D", Low EIS)

7.2 Conditions of the GA

Note that conditions set for Section 21 (c) and (i) water use in terms of the GA specify that the water user must ensure that compliance with the following is achieved:

a. Impeding or diverting flow or altering the characteristics of a watercourse does not detrimentally affect other water users, property, health and safety of the general public or the resource quality.
b. The existing hydraulic, hydrologic, geomorphic and ecological functions of the watercourse in the vicinity of the structure is maintained or improved upon.
c. Full financial provision for the implementation of the management measures prescribed in the GA, including an annual financial provision for any future maintenance, monitoring, rehabilitation or restoration works (as may be applicable).
d. Construction camps, storage, washing and maintenance of equipment, storage of construction materials or chemical, sanitation and waste management facilities are located outside of the 1:100yr flood line or riparian habitat of a river, spring, lake, dam or outside any drainage feeding any wetland or pan and is removed within 30 days of completion of any works.
e. The site where water use will occur must not be located on a bend in the watercourse, must avoid high gradient areas, unstable slopes, actively eroding banks, interflow zones, springs and seeps; avoid or minimise realignment of a watercourse, minimise the footprint of alteration and construction footprint.
f. A maximum impact footprint around the works must be established, clearly demarcated, no vegetation cleared or damaged beyond this demarcation and equipment/machinery only operated within the delineated impact footprint.
g. Minimise the duration of disturbance and the footprint of disturbance of the bed and banks of the watercourse.
h. Prevent the transfer of exotic biota to the site.
i. All works must start upstream and proceed in a downstream direction to ensure minimal impact on the water resource.
j. Excavated material from the bed or banks of a watercourse must be stored appropriately and returned to the original locations upon completion of the works.
k. Adequate erosion control measures are to be implemented at and near all alterations, with an emphasis on erosion control on steep slopes and drainage lines.
l. Alteration or hardened surfaces must be structurally stable, not induce sedimentation, erosion or flooding, not cause a detrimental change in the quantity, velocity, pattern, timing, water level, water quality, stability or geomorphological structure of a watercourse, or cause nuisance or health or safety hazards.
m. Measures are undertaken to protect the breeding, nesting or feeding patterns of aquatic biota (including migratory species), allow for the continued movement of biota up and downstream and prevent a decline in the composition and diversity of indigenous and endemic aquatic biota.

n. Ensure that no substance or material that can potentially cause pollution of the water resource is being used in works.
o. Measures are undertaken to prevent increased turbidity, sedimentation and detrimental chemical changes to the composition of the water resource.
p. Instream water quality is to be measured on a weekly basis during construction (includes pH, EC/TDS, TSS/Turbidity, DO) both upstream and downstream of the works.
q. In-stream flow is to be measured on an on-going basis by means of instruments and devices certified by the SABS, with a baseline measurement at least one week prior to initiation of the works.
r. One or more photographs or video-recordings must be taken of the watercourse and its banks at least 20m upstream and 20m downstream from the structure/works. These must be taken on a daily basis, starting one week before commencement of any works and continuing of one month upon completion.

Furthermore:

- Rehabilitation[4] authorised in terms of the GA (i.e where risk is deemed "Low") must be conducted in terms of a rehabilitation plan, with implementation overseen by a suitably qualified SACNASP registered Pr.Sci.Nat.
- Upon completion of construction activities, a systematic rehabilitation programme must be undertaken to restore the watercourse to its condition prior to the commencement of the water use. All disturbed areas must be re-vegetated with indigenous vegetation suitable to the area.
- Active alien invasive plant control measures must be implemented to prevent invasion buy exotic and alien vegetation within the disturbed area.
- Upon completion of any works, an during any annual inspection to determine the need for maintenance at any impeding or diverting structure, disturbed areas are to be cleared of construction debris/blockages, alien invasive vegetation, must be re-shaped to free-draining and non-erosive contours and r re-vegetated with indigenous vegetation suitable to the area.
- Upon completion of any works, the hydrological functionality and integrity of the watercourse (bed, banks, riparian habitat and aquatic biota) must be equivalent or exceed that which existed before commencing with the works.
- The water user must establish and implement monitoring programmes to measure the impact on resource quality to ensure water use remains within the parameters in terms of water quality and quantity (maintaining instream flow).
- Baseline monitoring to be undertaken to determine 'present day values' for water resource quality before commencement of water use.

[4] 'Rehabilitation' means the process of reinstating natural ecological driving forces within part or the whole of a degraded watercourse to recover former or desired ecosystem structure, function, biotic composition and associated ecosystem services.

- Upon completion of construction activities, an Environmental Rehabilitation structures must be inspected regularly for the accumulation of debris, blockages, instabilities and erosion with remedial and maintenance actions where required.
- Audit is to be undertaken annually for three years to ensure that the rehabilitation is stable.

7.3 Threatened and Protected Plant Permit Requirement

A single protected plant species (*Crinum sp.*) was identified within Wetland Unit W01 (GPS Coordinates 28° 43' 29.46" S, 31° 50' 14.89" E). Basic information on *Crinum sp.* is provided in Table 19 with the location of the plants shown spatially in Figure 8. In accordance with the provisions of the Natal Nature Conservation Ordinance of 1974 an Ordinary Permit is required to handle the *Crinum* plant (i.e. to handle, remove, destroy, damage, and relocate the specimen*)*. An ordinary permit can be obtained from Ezemvelo KZN Wildlife (EKZNW) for this purpose.

Table 19. Basic information on *Crinum sp*., applicable legislation, approval required and the responsible authority.

Botanical name	Common name	Plant type	Conservation status	Applicable legislation	Photo
Crinum sp.	Crinum	Succulent	**Provincially Protected**	Natal Nature Conservation Ordinance of 1974: Schedule 12	

Figure 8 Map indicating the location of the protected *Crinum sp*. identified near the site of the culvert replacement that requires a permit to handle the plant species.

8. CONCLUSION

An assessment of the freshwater aquatic habitats and ecosystems, namely a small channelled valley bottom wetland and weakly seasonal river system, associated with a planned upgrade of a culvert on the P230 Provincial road near Empangeni (KZN) was undertaken by Eco-Pulse Environmental Consulting Services in early spring (October 2016) to inform the environmental assessment and water use licensing requirements for the P230 road rehabilitation project.

Based on an initial aquatic screening exercise and desktop risk assessment, the proposed culvert upgrade stands to measurably impact only a channelled valley bottom wetland (W01) and weakly seasonal river system (R01), triggering water use and the need for impact assessment. Given the current moderately modified to largely modified habitat condition and low ecological importance and sensitivity (EIS) rating for the wetland and river, the minimum recommended management objective for watercourses assessed should be to '*maintain the current status quo of aquatic ecosystems without any further loss of integrity/condition or functioning*'.

Based on the nature of the project and the receiving aquatic environment at the site, key impacts were identified, namely the physical destruction and/or modification of aquatic habitat, flow modifications and erosion/sedimentation impacts and water quality impacts. With good environmental management and adequate mitigation of potential ecological impacts at the site, the overall impact of the proposed culvert upgrade on the ecological condition and functioning of the wetland and riverine habitat is unlikely to be of such an intensity and extent that the Present Ecological State (PES) will be significantly altered and it is therefore unlikely that the proposed development activities will compromise the ability to meet the water resource management objectives as defined by the Recommended Ecological Category (REC). Residual impacts in terms of meeting ecosystem conservation targets are likely to be negligible, as will the impact on potential species of conservation concern which were not flagged as being of importance for the habitats assessed. The expected disturbances associated with the proposed activities are also unlikely to result in the loss of important ecosystem services for local communities and wildlife. Nevertheless, managing impacts such as the direct disturbance of aquatic vegetation/habitat, pollution and erosion/sedimentation risks will be necessary to maintain the current level of integrity and functioning of aquatic ecosystems (i.e. the management objective set for watercourses assessed).

Most aquatic ecological impacts can probably be quite effectively mitigated through appropriate culvert design recommendations and supplemented by the application of on-site practical mitigation measures and management principles to control direct wetland/riverine habitat destruction, soil erosion & sedimentation, flow modification and pollution impacts and risks in conjunction with post-construction rehabilitation and ecological monitoring recommendations. Should the recommended mitigation and management guidelines be implemented timeously and to specification, impacts can be potentially reduced to acceptably Low/negligible significance levels. This should be sufficient to protect the aquatic environment from further deterioration and can then be considered to be generally acceptable as no loss of critical resources, habitats, services or threatened/endangered species is likely to be associated with the development project. Based on the outcomes of the study undertaken, no further specialist aquatic/ ecological studies are required and no fatal flaws have been identified.

Given that planned development activities will take place within a watercourse, a Water Use License Application (WULA) would generally apply for Section (c) and/or (i) at a minimum, however, the recent Government Notice (509 of 2016) pertaining to General Authorisation (GA) in terms of Section 39 of the National Water Act (No. 36 of 1998) for Section 21(c) and/or (i) water use, indicates that Low Risk Activities located within the regulated area of a watercourse will generally qualify for a GA. Based on the risk assessment undertaken using DWS Risk Based Matrix (DWS, 2015) whereby risk was determined after considering all listed control/mitigation measures (as defined in Section 6.2 of this report), the decommissioning and replacement of the existing road culvert is generally considered to be of Low-Moderate Risk. The risk scores for borderline low/moderate cases were manually reduced to give a Low risk level, which implies that **the proposed development can essentially be authorised under the provisions of the GA for Section 21 c and i water use.** This is based on the assumption that best-practice mitigation and impact management will be applied strictly, as per the recommendations made in Section 6 of this specialist report. Should these not be strictly enforced, the low risk ratings should not apply and a full Section 21 c and i WUL is likely to be required. The various conditions of the GA (including impact mitigation and monitoring requirements) will need to be complied with during construction and operational phases of the project.

It recommended that Section 6 of this report which deals with 'Impact Mitigation/Management' be referenced in the Environmental Authorisation (EA) for this project as a specific condition of the EA.

Should you have any queries regarding the findings and recommendations in this Specialist Freshwater Aquatic Habitat Assessment report, please contact Eco-Pulse Environmental Consulting Services directly.

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10. ANNEXURES

ANNEXURE A: Description of Assessment Methods.

A1 Wetland/Riparian areas delineation

- **Wetland delineation**

The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (*DWAF, 2005). Three specific wetland indicators were used in the detailed field delineation of wetlands, which include:

  - **Terrain unit indicator**

A practical index used for identifying those parts of the landscape where wetlands are likely to occur based on the general topography of the area.

  - **Wetland vegetation indicator**

Vegetation in an untransformed state is a useful guide in finding the boundary of a wetland as plant communities generally undergo distinct changes in species composition as one proceeds along the wetness gradient from the centre of a wetland towards adjacent terrestrial areas. An example of criteria used to classify wetland vegetation and inform the delineation of wetland zones is provided in Table 20.

Table 20. 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	

- **<u>Soil wetness indicator</u>**

According to the wetland definition used in the National Water Act (NWA, 1998), vegetation is the primary indicator which must be present under normal circumstances. However, in practice the soil wetness indicator (informed by investigating the top 50cm of wetland topsoil) tends to be the most important, and the other three indicators are used to refine the assessment. The reason for this is that vegetation responds relatively quickly to changes in soil moisture and may be transformed by local impacts; whereas the soil morphological indicators are far more permanent and will retain the signs of frequent saturation (wetland conditions) long after a wetland has been transformed/drained (DWAF, 2005a). Thus the on-site assessment of wetland indicators focused largely on using soil wetness indicators, determined through soil sampling with a soil auger, with vegetation and topography being a secondary indicator. A Munsell Soil Colour Chart was used to ascertain soil colour values including hue, colour value and matrix chroma as well as degree of mottling in order to inform the identification of wetland (hydric) soils. Soil sampling points were recorded using a GPS (Global Positioning System) and captured using Geographical Information Systems (GIS) for further processing. An example of soil criteria used to assess the presence of wetland soils is provided below in Table 21 while Figure 9 provides a conceptual overview of soil and vegetation characteristics across the different wetness zones.

Table 21. 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

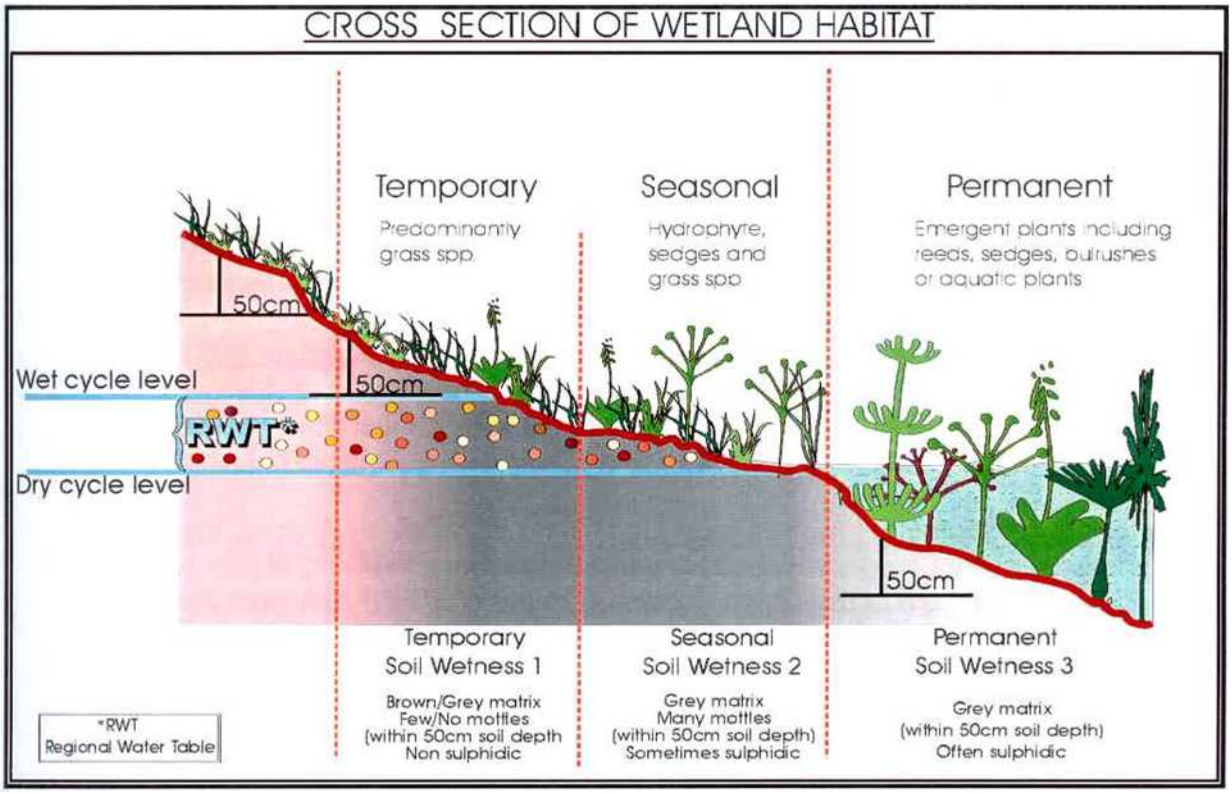


Figure 9 Diagram representing the different zones of wetness found within a wetland (DWAF, 2005).

- **Delineation of riparian areas**

The location of drainage features and boundary of any riparian areas (also known as the riparian zone) was 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, 2005*)*. According to the manual, this involves marking the outer edge of the macro-channel bank and associated vegetation. Like wetlands, riparian areas have their own unique set of indicators required in order to delineate these features. Delineation of riparian areas generally requires that the following be taken into account:

- **Topography associated with the watercourse**: the outer edge of the macro-channel bank associated with a river/stream provides a rough indication of the outer edge of a riparian area.
- **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.

A2 Classification of Wetlands, Rivers & Streams

The delineated wetland units were subdivided into distinct HGM units as per the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis *et al.,* 2013). The HGM types considered are defined as follows: (Ollis *et al.,* 2013):

1. **Seep (S)** – A wetland area located on gently to steeply sloping land and dominated by colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend onto a valley floor. The only exception are valley head seeps. A valley head seep is concave wetland area located within a defined valley head (side slopes and valley bottom) but which is still characterised by the colluvial processes.
2. **Valley bottom wetland** - A mostly flat wetland area located along a valley floor, often connected to an upstream or adjoining river channel. Valley bottom wetlands are either channelled or un-channelled.
   i. **Channelled valley bottom wetland (CVB)** - a valley bottom wetland with a river channel running through it. The valley bottom wetland is divided by and typically elevated above a stream channel, which makes that this wetland generally drains faster than an un-channelled valley bottom wetland. Water inputs to these areas are from adjacent valley side slopes and from the overtopping of the channel during floods.
   ii. **Un-channelled valley bottom wetland (UCVB)** - A valley bottom wetland without a river channel running through it. The valley bottom wetland is connected to a drainage network, but without a major channel running through it. It is characterized by the prevalence of diffuse flow, which is at or near the surface especially after rainfall events. Water mainly enters the wetland through an upstream channel, but sometimes also from adjacent slopes.
3. **Floodplain wetland (F)** - A wetland area on the mostly flat or gently-sloping land adjacent to and formed by an alluvial river channel under its present climate and sediment load, which is subject to periodic inundation by overtopping of the channel bank. Floodplain wetlands are characterised by typical floodplain features like levees, oxbow lakes and depressions where fine sediment is deposited.
4. **Flat (FL)** – A level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat. Their main input of water is from rainfall and/or the regional groundwater table as in the case of low lying coastal plain settings.
5. **Depression (D)** - A wetland or aquatic ecosystem with closed (or near-closed) elevation contours (within a closed basin), which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates.

Classification was achieved by observing the topographical and geomorphic setting, and the general hydrology of the wetland units during the site visit, as well as the review of relevant literature and desktop information.

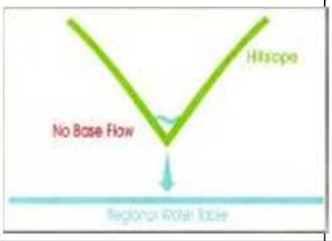
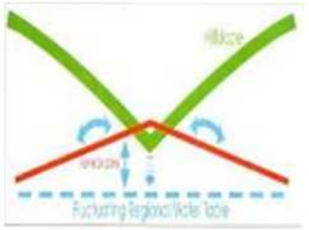
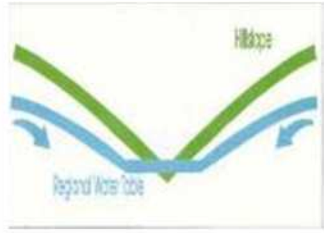
The classification of river/stream channels was based on the size of channels (Table 22) and the nature of flows through the channel (Table 23).

Table 22. Classification of channels according to channel size.

CHANNEL WIDTH	RESOURCE DESCRIPTION
>10 m	**Major Rivers**
2 – 10 m	**Rivers**
<2 m	**Streams**

Table 23. Classification of channels according to nature of flows.

	CHANNEL SECTION (CLASS)		
	"A" type	**"B" type**	**"C" type**
	Ephemeral systems	**Weakly ephemeral to seasonal systems**	**Perennial systems**
DESCRIPTION	A water-course that has no riparian habitat and no soil hydromorphy (i.e. strongly ephemeral systems). Signs of wetness rarely persist in the soil profile	A water-course with riparian vegetation/habitat and intermittent base flow (i.e. weakly ephemeral to non-perennial/seasonal systems). These channels show signs of wetness indicating the presence of water for significant periods of time.	A water-course with permanent-type riparian vegetation/habitat, permanent base flow and permanent inundation (i.e. perennial systems).
HYDROLOGY	A-section channels are situated well above the zone of saturation (no direct contact between surface water system and ground water system) and hence do not carry base-flows They do however carry storm water runoff following intense rainfall events (ephemeral), but this is generally short-lived.	Channel bed situated within the zone of the seasonally fluctuating regional water table (i.e. intermittent base flow depending on water table). Periods of no flow may be experienced during dry periods, with residual pools often remaining within the channel.	Water course is situated within the zone of the permanent saturation, meaning flow is all year round except in the case of extreme drought.
TOPOGRAPHICAL POSITION	Valley head (upper reaches of catchments). Channel type also linked to steep slopes which are responsible for water leaving the system rapidly.	Mid-section of valley (middle reaches of catchments).	Valley bottom areas (middle to lower reaches of catchments).

DIAGRAM			
PHOTO			

A3 Present Ecological State (PES) Assessment for wetlands: WET-Health

The qualitative/rapid wetland health assessment tool used in this assessment was adapted from the Level 1 WET-Health tool (Macfarlane *et al.*, 2008) which provides an appropriate framework for undertaking an assessment to indicate the functional importance of the wetland system that could be impacted by the proposed development. The assessment also helps to identify specific impacts thereby highlighting issues that should be addressed through mitigation and rehabilitation activities. While this is a rapid assessment, we regard it as adequate to inform an assessment of existing impacts on wetland condition. This approach relies on a combination of desktop and on-site indicators to assess various aspects of wetland condition, including:

- ***Hydrology*:** defined as the distribution and movement of water through a wetland and its soils.
- ***Geomorphology*:** defined as the distribution and retention patterns of sediment within the wetland.
- ***Vegetation*:** defined as the vegetation structural and compositional state.

Each of these modules follows a broadly similar approach and is used to evaluate the extent to which anthropogenic changes have impacted upon wetland functioning or condition. While the impacts considered vary considerably across each module, a standardized scoring system is applied to facilitate the interpretation of results (Table 24). Scores range from 0 indicating no impact to a maximum of 10 which would imply that impacts had totally destroyed the functioning of a particular component. The reader is encouraged to refer back to the tables below to help interpret the results presented in the site assessment.

Table 24. Guideline for interpreting the magnitude of impacts on wetland integrity (after Macfarlane *et al*., 2008).

IMPACT CATEGORY	DESCRIPTION	Score
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9

IMPACT CATEGORY	DESCRIPTION	Score
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table 25. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table 25. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

PES CATEGORY	DESCRIPTION	RANGE
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9
C	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9
D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9
E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9
F	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

A4 Wetland Ecosystem Services (Functional) Importance Assessment

The supply of ecosystem goods and services of the wetland was assessed using an approach based on the WET-EcoServices assessment tool Kotze *et al.* (2009). This approach relies on a combination of desktop and on-site indicators to assess the importance of a range of common wetland ecosystem services as described in Table 26, below.

Table 26. Descriptions of common wetland ecosystem goods and services (after Kotze *et al.*, 2009).

ECOSYSTEM SERVICE	Description
Flood Attenuation	*Refers to the effectiveness of wetlands at spreading out and slowing down storm flows and thereby reducing the severity of floods and associated impacts.*
Stream Flow Regulation	*Refers to the effectiveness of wetlands in sustaining flows in downstream areas during low-flow periods.*
Sediment Trapping	*Refers to the effectiveness of wetlands in trapping and retaining sediments from sources in the catchment.*
Nutrient & Toxicant Retention and Removal	*Refers to the effectiveness of wetlands in retaining, removing or destroying nutrients and toxicants such as nitrates, phosphates, salts, biocides and bacteria from inflowing sources, essentially providing a water purification benefit.*
Erosion Control	*Refers to the effectiveness of wetlands in controlling the loss of soil through erosion.*
Carbon Storage	*Refers to the ability of wetlands to act as carbon sinks by actively trapping and retaining carbon as soil organic matter.*
Biodiversity Maintenance	*Refers to the contribution of wetlands to maintaining biodiversity through providing natural habitat and maintaining natural ecological processes.*
Water Supply	*Refers to the ability of wetlands to provide a relatively clean supply of water for local people as well as animals.*
Harvestable Natural Resources	*Refers to the effectiveness of wetlands in providing a range of harvestable natural resources including firewood, material for construction, medicinal plants and grazing material for livestock.*
Cultivated Foods	*Refers to the ability of wetlands to provide suitable areas for cultivating crops and plants for use as food, fuel or building materials.*
Food for Livestock	*Refers to the ability of wetlands to provide suitable vegetation as food for livestock.*
Cultural significance	*Refers to the special cultural significance of wetlands for local communities.*
Tourism & Recreation	*Refers to the value placed on wetlands in terms of the tourism-related and recreational benefits provided.*
Education & Research	*Refers to the value of wetlands in terms of education and research opportunities, particularly concerning their strategic location in terms of catchment hydrology.*

A level 1 (rapid) assessment was conducted that assessed a suite of services/benefits by assigning a score to each service based on a rating system that rates a range of pre-defined variables affecting the importance of services provided by the wetland system. The results are captured in tabular form as a list of services/goods with the level of supply and demand rated on a scale of 0 - 4. The following rating shown in Table 27 was used to describe the level of supply, demand and importance (integration of supply and demand).

Table 27. Classes for determining the likely level to which a service is being supplied or demanded.

Score	Supply/Demand/Importance Scores	Importance Description
0.0 – 0.5	Very Low	Not important
0.6 – 1.0	Low	Low importance
1.1 – 1.5	Moderately-Low	Moderately-low importance
1.6 – 2.4	Moderate	Moderately important
2.5 – 2.9	Moderately-High	Important
3.0 – 3.4	High	Very/highly important

3.5 – 4.0	Very High	Critically important

Since the importance of wetland goods and services is dictated not only by the supply (service availability) of a particular good/benefit but also on the need or demand (user requirement) for such a benefit, the overall importance of the ecosystem service is ultimately derived from a combination of supply and demand scores. For example, a wetland may supply a particular service at a high level; however this service may not be in great demand, limiting the importance of the benefit to society. The results of the assessment were therefore interpreted to reflect the perceived importance of each of the ecosystem goods and services assessed.

A5 Wetland Ecological Importance and Sensitivity (EIS) Assessment

The outcomes of the WET-Health and WET-EcoServices functional assessment were used to inform an assessment of the importance and sensitivity of wetland and river ecosystems using a Wetland EIS (Ecological Importance and Sensitivity) assessment tool developed by Eco-Pulse Consulting (2015). The Eco-Pulse Wetland EIS tool includes an assessment of the following components:

- Biodiversity maintenance supply (informed by biodiversity noteworthiness, PES and ecological viability of the habitat);
- Biodiversity maintenance demand (at a regional/national scale); and
- Sensitivity of the water resource (i.e. Biota, floods, low flows, sediment, water quality, erosion risk and edge disturbances)

The maximum score for these components was taken as the importance rating for the wetland which is rated using Table 28, below.

Table 28. Rating table used to rate EIS (Eco-Pulse, 2015).

EIS Score	EIS Rating
>3.4	Very High
3.0 - 3.4	High
2.5 - 2.9	Moderately-High
1.6 - 2.4	Moderate
1.1 - 1.5	Moderately-Low
0.6 - 1.0	Low
<0.6	Very Low

A6 River Present Ecological State Assessment (IHI)

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "*maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region*" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

The IHI (Index of Habitat Integrity)1996, version 2 (Kleynhans, 2012) was used to assess habitat integrity and is based on an interpretation of the deviation from the reference condition for the river reach assessed and is approached from both an instream and riparian zone perspective. Specification of the reference state is followed by an impact-based approach, whereby the extent and intensity of anthropogenic impacts are interrogated to interpret the level of modification to the primary drivers of river health, namely hydrology, geomorphology and physic-chemical conditions. Naturally, the severity of impacts on habitat integrity will vary according to the natural characteristics of different rivers, with particular river types being inherently more sensitive to certain types of impacts than others. The IHI assessment involved the assessment and rating of a range of criteria for instream and riparian habitat (see Box 3) scored individually (using an impact magnitude rating scale from 0-10) using Table 29 as a guide. This assessment is informed by a site visit to a specific section or reach of the river but is refined based on a desktop review of reach and catchment-scale impacts based on available aerial photography and land cover information.

Table 29. Rating table used to assess impacts to riverine habitat.

Impact Class	Description	Score
A	Unmodified, natural.	90 – 100
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.	80 – 89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60 – 79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40 – 59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20 – 39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 – 19

Box 3. Criteria assessed in the Index of Habitat Integrity (after Kleynhans, 1996).

- ***Water abstraction:*** Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
- ***Flow modification*:** Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
- ***Inundation*:** Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al.*, 1992).
- ***Bed modification:*** This has a direct bearing on the amount and availability of substrate characteristics of available habitats. Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
- ***Bank erosion*:** Decrease in bank stability will cause sedimentation and possible collapse of the river

bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

- ***Channel modification:*** May be the result of a change in flow which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included. Any densification of woody exotic species would lead to channel shape change through increased sediment deposits. This has serious implications for more extensive bank over-topping during flood events with increased scouring along outer edges of the Dry Bank. It is the extremes, i.e. drought or very wet events, which are particularly crucial sensitive periods to be considered.
- ***Water quality:*** Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
- ***Inundation:*** Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al.*, 1992).
- ***Exotic macrophytes:*** Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
- ***Exotic fauna***: The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
- ***Solid waste disposal***: A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
- ***Vegetation removal:*** Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing. Includes both exotic and indigenous vegetation.
- ***Exotic vegetation:*** Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone.
- ***Connectivity:*** Relates to changes that influence the movement of aquatic biota, both laterally onto adjacent floodplain areas and longitudinal movement upstream and downstream. These modifications can affect the life-history stage requirements and recolonization options for instream biota.

A7 River Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) of riverine areas is an expression of the importance of the aquatic resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007). For the purposes of this assessment, the EIS assessment for riparian areas was based on rating the following criteria using the scheme in Table 30.

Table 30. Rating scheme used to rate EIS for riparian areas.

CRITERIA	RATING SCORE				
	0	1	2	3	4
Presence of rare/endangered species Presence of unique/endemic species Presence of species considered intolerant/sensitive to changes in flows/water quality	None	Low	Moderate	High	Very High
Diversity of habitat types Presence of refugia/Refuge value of habitat types Habitat sensitivity to changes in flow Habitat sensitivity to changes in water quality Importance in terms of migration routes/ecological corridors	Very Low	Low	Moderate	High	Very High
Conservation importance	None	Low (Local level)	Moderate (Provincial level)	High (National level)	Very High (National/ International)

The scores assigned to the criteria in Table 30 were used to rate the overall EIS of each mapped unit according to Table 31 which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane *et al*., 2008).

Table 31. EIS classes used to inform the assessment (after Kleynhans & Louw, 2007).

EIS Score	EIS Rating	General Description
0	None/ Negligible	Features that are highly transformed and have no ecological importance at any scale. Such features have a very low sensitivity to anthropogenic disturbances.
1	Very Low	Features are not ecologically important and sensitive at any scale. The biodiversity of these areas is typically ubiquitous with low sensitivity to anthropogenic disturbances and play an insignificant role in providing ecological services.
2	Low	Features regarded as somewhat ecologically important and sensitive at a local scale. The functioning and/or biodiversity features have a low-medium sensitivity to anthropogenic disturbances. They typically play a very small role in providing ecological services at the local scale.
3	Medium	Features that are considered to be ecologically important and sensitive at a local scale. The functioning and/or biodiversity of these features is not usually sensitive to anthropogenic disturbances. They typically play a small role in providing ecological services at the local scale.
4	High	Features that are considered to be ecologically important and sensitive at a regional scale. The functioning and/or biodiversity of these features are typically moderately sensitive to anthropogenic disturbances. They typically play an important role in providing ecological services at the local scale.
5	Very High	Features that are considered ecologically important and sensitive on a national or even international level. The functioning and/or biodiversity of these features are usually very sensitive to anthropogenic disturbances. This includes areas that play a major role in providing goods and services at a local or regional level.

A8 Impact Significance Assessment Method

For the purposes of this assessment, the assessment of potential impacts was undertaken using the "Impact Assessment Methodology for EIAs" designed by Eco-Pulse Consulting (2015). This assessment was informed by baseline aquatic information contained in this report relating to the importance and sensitivity of habitats, information on the proposed development activity provided by the client and experience with impacts resulting from similar development projects.

Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: (i) the measurable characteristics of the impact (e.g. intensity, extent and duration), (ii) the importance societies/communities place on the impact (or resource being affected), and (iii) the probability / likelihood of the impact occurring.

In light of this understanding, significance can only be assessed if one knows the importance or value of the environmental change/impact. Thus, end point or eventual / ultimate impacts that can be valued like impacts to water resources, ecosystem services and biodiversity conservation are the only impacts that can be assessed in terms of significance and are referred to as ultimate consequences of an activity. Put another way, the significance of an impact to the environment or ecosystem can only be assessed in terms of the measurable changes to ecosystem services, resources and biodiversity associated with that system or component being assessed.

The approach adopted is to identify and describe all potential primary and secondary (indirect) impacts resulting from the proposed construction and operational activities. As a starting point the extent of the impact is defined upfront. Thereafter, remaining impact rating criteria are scored based on the predefined extent of impacts. Intensity is rated as the realistic consequence (end-point) of an activity under the various mitigation scenarios. The rating of intensity has been specifically defined for specialist terrestrial and aquatic impacts so as to reduce ambiguity that could arise in the assessment process. Probability rates the likelihood of the impact(s) being assessed occurring across the predefined extent of the anticipated impacts and has been specifically linked to expected probabilities of occurrence. Finally, impact duration rates the time period or lifecycle of a specific impact. Table 32 summarises the rating criteria and scoring system applied in rating the significance of project-related impacts.

The assessment of impact significance is based on the basic risk formula: **Risk = consequence x probability** but has been customised to accommodate the rating criteria included in the assessment process:

Impact significance = consequence (impact intensity + impact extent + impact duration)[5] x impact probability

Table 32. Criteria and numerical values for rating environmental impacts.

Score	Rating	Description
Extent (E) – relates to the expected extent of the impact in spatial and population terms		
10	**National**	***The effects of an impact are experienced over a very large geographic area. Given the extent of impacts, they are likely to be relevant at a national scale.*** ***Water resource impacts:*** • Water resources are affected across a very extensive geographic area (e.g. spanning a number of water management areas / crossing international boundaries); and / or • Indirect impacts continue to affect water resources far from the development site (e.g. impacts continue to be experienced > 100km downstream). ***Habitat impacts:*** • The extent of direct impacts results in extensive impacts to water resources relative to the remaining extent (e.g. affecting >100ha wetlands / >10km watercourses); and / or • The extent of direct impacts is high relative to the extent of affected habitat types (e.g. affecting >10% of a remaining ecosystem type); and / or • The proposed development affects large areas (e.g. > 1000 ha) across a broad geographic area and affecting a range of habitat types. ***Species Impacts:*** • Impacts affect a large proportion of the population of an important species at a national level (e.g. >10% of species population affected); and / or • The proposed development will affect a wide range of important species populations across a very large geographic area. ***Social impacts***: • Impacts will affect a society at a national scale (e.g. large number of stakeholders

[5] Note: Whilst this describes the basic formula used to calculate impact significance, additional weightings and rules have been introduced to train the model to better align with scores based on expert-opinion. This essentially reduces the significance scores in situations where (i) low intensity impacts occur over a broad extent or (ii) where high intensity scores at a localised scale.

Score	Rating	Description
		across multiple district municipalities / provinces).
8	**Regional**	***The effects of an impact are experienced over a large geographic area. Given the extent of impacts, they are likely to be relevant at a regional scale.*** ***Water resource impacts:*** • Water resources are affected across a broad geographic area (e.g. extending across a large number of quaternary catchments); and / or • Indirect impacts continue to affect water resources a considerable distance from the development site (e.g. 10 - 100km downstream). ***Habitat impacts:*** • The extent of direct impacts results in large-scale impacts to water resources relative to the remaining extent, (10-100ha wetlands / 1-10km watercourses); and / or • The extent of direct impacts is notable relative to the extent of affected habitat types (e.g. affecting 1 - 10% of a remaining ecosystem type); and / or • The proposed development affects *a large area (100 – 1000ha) and typically extends across a range of habitat types.* ***Species Impacts:*** • Impacts affect a large proportion of the population of an important species at a regional level (e.g. 1 - 10% of species population affected); and / or • The proposed development will affect a wide range of important species populations across a large geographic area. ***Social impacts***: • Impacts will affect a society at a regional scale (e.g. large number of communities and stakeholders across a number of local municipalities).
4	**Local**	***The effects of an impact are experienced over a limited geographic area. Given the extent of impacts, they are likely to be relevant at a local scale.*** ***Water resource impacts:*** • Water resources are affected within a localised geographic area (e.g. single quaternary catchment); and / or • Indirect impacts continue to affect water resources some distance from the development site (e.g. 1 - 10km downstream). ***Habitat impacts:*** • The extent of direct impacts results in localised impacts to water resources relative to the remaining extent, (1 - <10ha wetlands / 100m - <1km watercourses); and / or • The extent of direct impacts is limited relative to the extent of affected habitat types (e.g. affecting <1% of a remaining ecosystem type); and / or • The proposed development affects *a moderately large area (10 – 100ha) but may extend across a wide range of habitat types.* ***Species Impacts:*** • Impacts affect species populations that are important at a local scale (e.g. < 1% of population affected); and / or • The proposed development will affect a number of important species across a local geographic area. ***Societal impacts***: • Impacts will affect society at a local scale (e.g. a number of communities across a single local municipality).
2	**Surrounding Area**	***The effects of an impact are experienced over a very small area. Given the extent of impacts, they are likely to be relevant at a very localised scale.*** ***Water resource impacts:*** • Water resources are affected within a small geographic area (e.g. single quinery catchment); and / or • Indirect impacts affect water resources a limited distance downstream of the development site (e.g. <1km downstream). ***Habitat impacts:*** • Direct impacts affects a small area proportion of water resources (e.g. 0.1-1ha wetlands / 10 – <100m watercourses); and / or • The proposed development affects a small localised area (1 – 10ha) and is often

<table>
<tr><th>Score</th><th>Rating</th><th>Description</th></tr>
<tr><td></td><td></td><td>confined to a very few habitat types.

Species Impacts:
• Impacts affect populations of important species beyond the site level;

Social impacts:
• Impacts will affect society at a very local scale (e.g. a number of households within a single community).</td></tr>
<tr><td>0</td><td>Site</td><td>The effects of an impact are confined to a very small footprint. Given the extent of impacts, they are likely to be relevant at a site scale.

Water resource impacts:
• Impacts are largely confined to the development footprint with limited downstream impact (<100m downstream effect).

Habitat impacts:
• Direct impacts are typically confined to a single water resource or few water resources within a small focal area (typically <0.1ha wetlands / 10m watercourses); and / or
• The proposed development affects a small area (<1ha) and is typically confined to very few habitat types.

Species Impacts:
• Impacts are very localised and are unlikely to affect important species beyond the site level;

Social impacts:
• Impacts will affect society at a very local scale (single or few households within a single local community)</td></tr>
<tr><td colspan="3">Intensity (I) – defines the severity and importance of the impact to water resources / habitats / species or human populations within defined impact extent</td></tr>
<tr><td>10</td><td>High</td><td>Water resource impacts:
• Loss of regulating and supporting services critical to support effective water resource management (as defined by management objectives / sustainability thresholds / RQOs); and / or
• Loss will compromise the ability to meet water resource management objectives.

Habitat impacts:
• Loss of largely intact critically endangered habitat; and / or
• Loss of particularly unique / especially important special habitat features.

Species impacts:
• Loss of or seriously compromises persistence of viable populations of critically endangered species; and / or
• Loss of or seriously compromises viable landscape-level corridors.

Social Impacts:
• Loss of human life; and / or
• Marked deterioration in human health; and / or
• Loss of ecosystem services that are critical to support / protect livelihoods of dependant vulnerable communities; and / or</td></tr>
<tr><td>8</td><td>Moderately-High</td><td>Water resource impacts:
• Loss of regulating and supporting services important to support effective water resource management (as defined by management objectives / sustainability thresholds / RQOs) ; and / or
• Loss is very likely to compromise the ability to meet water resource management objectives.

Habitat impacts:
• Serious modification (2 or more classes) of critically endangered habitat; and / or
• Loss of largely intact endangered habitat types; and / or
• Loss of moderately modified critically endangered habitat types (and with reasonable rehabilitation potential) ; and / or
• Loss of habitat that has special habitat attributes (e.g. high habitat diversity / species richness).

Species impacts:
• Loss of or seriously compromises persistence of viable populations of endangered</td></tr>
</table>

Score	Rating	Description
		species; and / or • Loss of regionally important species populations (e.g. at municipal scale). ***Social Impacts:*** • Loss of human livelihoods; and / or • Some deterioration in human health; and / or • Loss of ecosystem services that are important (highly valued but not critical to) supporting / protecting vulnerable communities. Alternative options / resources are not available to meet community needs without incurring significant costs.
4	**Moderate**	***Water resource impacts:*** • Loss of regulating and supporting services important to support effective water resource management (as defined by management objectives / sustainability thresholds / RQOs); and / or • Loss could compromise the ability to meet water resource management objectives. ***Habitat impacts:*** • Moderate modification (1 classes) of critically endangered habitat / serious modification (2 classes) of endangered habitat; and / or • Loss of largely intact vulnerable habitat types; and / or • Loss of moderately modified endangered habitat types (and with reasonable rehabilitation potential). ***Species impacts:*** • Loss of or seriously compromises persistence of viable populations of vulnerable / endemic / specially protected species; and / or • Loss of or seriously compromises viable corridors that are locally important for species movement. ***Social Impacts:*** • Notable impact on human livelihoods; and / or • Moderate reduction in the availability of ecosystem services that are important for supporting / protecting vulnerable communities; and / or • Loss of ecosystem services that are moderately valued by local communities. Alternative options / resources are available but limited.
2	**Moderately-Low**	***Water resource impacts:*** • Loss of regulating and supporting services which are not particularly important for water resource management (as defined by management objectives / sustainability thresholds / RQOs); and / or • Loss is unlikely to compromise the ability to meet water resource management objectives. ***Habitat impacts:*** • Moderate modification (1 classes) of endangered habitat / serious modification (2 classes) of vulnerable habitat; and / or • Loss of largely intact least-threatened habitat types; and / or • Loss of moderately modified vulnerable habitat types (and with reasonable rehabilitation potential). ***Species impacts:*** • Reduction in populations of vulnerable / endemic / specially protected species (without compromising viability of locally occurring populations) ; and / or • Loss of populations of locally important species. ***Social Impacts:*** • Limited but identifiable impact on human livelihoods; and / or • Moderate reduction in the availability of ecosystem services with a noticeable but limited impact to livelihoods.
0	**Low**	***Water resource impacts:*** • Loss of regulating and supporting services which are not particularly important for water resource management (as defined by management objectives / sustainability thresholds / RQOs); and / or • Loss will not compromise the ability to meet water resource management objectives. ***Habitat impacts:*** • Loss of highly degraded threatened vegetation types (and with low rehabilitation potential); and / or

Score	Rating	Description
		• Moderate modification (1 classes) of vulnerable habitat; and / or • Loss of moderately modified least threatened habitat types. ***Species impacts:*** • Limited impact to any locally important species populations. ***Social Impacts:*** • None / very limited impact on human livelihoods; and / or • None / limited reduction in the availability of ecosystem services with very limited impact to livelihoods.
Duration (D) – relates to the duration of the impact in time (consideration should be given to reversibility which may reduce the duration of impact)		
5	**Permanent**	The impact will continue indefinitely (>30 years) and is essentially regarded as irreversible.
4	**Long-term**	The impact and its effects will continue over the long-term (10 - 30 years).
3	**Medium-term**	The impact and its effects will persist for a number of years (1 – 10).
2	**Short-term**	The impact and its effects will persist for a number of months after the impact has occurred (2 -12 months) but is unlikely to persist for more than a year.
1	**Immediate**	The impact and its effects will cease within days or weeks after the impact has occurred (0 – 2 months).
Probability (P) – relates to the expected likelihood and frequency of the impact causing event occurring		
1	**Definite**	More than 80% likelihood of occurrence. The impact is typically recorded under similar conditions and settings.
0.9	**Highly Probable**	The impact has a 50-80% chance of occurring and thus expected to occur. The impact is known to occur regularly in similar conditions and settings.
0.8	**Probable**	The impact has a 20-50% chance of occurring and thus is quite likely to occur. The impact is known to occur quite frequently in similar conditions and settings (less than once in 10 years).
0.7	**Possible**	The impact has a 5-20% chance of occurring. This impact could occur and is known to occur irregularly under the similar conditions and settings (less than once in 20 years).
0.6	**Unlikely**	The possibility of the impact occurring is low with less than 5% chance of occurring. The impact has little chance of materialising (less than once in 50 years).

Table 33. Impact significance categories and definitions.

Impact Significance	Score Range	Definition
High	**18 - 25**	Totally unacceptable and fatally flawed. Impact should be avoided and limited opportunity for offset/compensatory mitigation. The proposed activity should only be approved under special circumstances.
Moderately High	**15 - 17**	Generally unacceptable and should ideally be avoided. If authorised, residual impacts must be adequately compensated through appropriate offset mechanisms. Strict conditions and high levels of compliance and enforcement will be required. The potential impact will affect a decision regarding the proposed activity and require that the need and desirability for the project be clearly substantiated to justify the associated ecological risks.
Moderate	**11 - 14**	Impact may be acceptable under special circumstances but should ideally be reduced to moderately low significance levels. If authorised, offsets should be considered to compensate for residual impacts. Strict conditions and high levels of compliance and enforcement are generally required. The potential impact should influence the decision regarding the proposed activity and requires a clear and substantiated need and desirability for the project to justify the risks.
Moderately Low	**8 - 10**	Acceptable with moderately-low to moderate risks provided that specific/generic mitigation applied and routine inspections undertaken. The potential impact may not have any meaningful influence on the decision regarding the proposed activity.
Low	**0 - 7**	The potential impact is very small or insignificant and should not have any meaningful influence on the decision regarding the proposed activity. Basic duty of care must be ensured.

A confidence rating was also given to the impacts rated in accordance with the table below:

Table 34. Confidence ratings used when assigning impact significance ratings.

Level of confidence	Contributing factors affecting confidence
Low	A low confidence level is attributed to a low-moderate level of available project information and somewhat limited data and/or understanding of the receiving environment.
Medium	The confidence level is medium, being based on specialist understanding and previous experience of the likelihood of impacts in the context of the development project with a relatively large amount of available project information and data related to the receiving environment.
High	The confidence level is high, being based on a sound understanding of the state, functioning and sensitivity of the receiving environment, high availability of project-related data and good understanding of similar impact scenarios.

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ANNEXURE B: Impact Significance Assessment Results.

B1. Construction Phase Impact Significance Assessment:

IMPACT SIGNIFICANCE: With Poor Mitigation								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Destruction, loss and physical modification of freshwater habitat and aquatic biota**	Negative	Surrounding Area	Moderate	Medium-term	Definite	**Moderately-Low**	High
2	**Flow modification & associated impacts (erosion and sedimentation)**	Negative	Surrounding Area	Moderately-Low	Medium-term	Highly Probable	**Low**	Medium
3	**Pollution impacts**	Negative	Surrounding Area	Moderately-Low	Medium-term	Highly Probable	**Low**	Medium
IMPACT SIGNIFICANCE: With Good Mitigation								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Destruction, loss and physical modification of freshwater habitat and aquatic biota**	Negative	Site	Moderately-Low	Short-term	Definite	**Low**	High
2	**Flow modification & associated impacts (erosion and sedimentation)**	Negative	Site	Moderately-Low	Short-term	Possible	**Negligible**	Medium
3	**Pollution impacts**	Negative	Site	Moderately-Low	Short-term	Unlikely	**Negligible**	Medium

B2. Operational Phase Impact Significance Assessment:

IMPACT SIGNIFICANCE: With Poor Mitigation								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Destruction, loss and physical modification of freshwater habitat and aquatic biota**	Negative	Surrounding Area	Moderately-Low	Permanent	Definite	**Low**	Medium
2	**Flow modification & associated impacts (erosion and sedimentation)**	Negative	Surrounding Area	Moderately-Low	Long-term	Highly Probable	**Low**	Medium
3	**Pollution impacts**	Negative	Surrounding Area	Low	Long-term	Definite	**Low**	Medium
IMPACT SIGNIFICANCE: With Good Mitigation								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Destruction, loss and physical modification of freshwater habitat and aquatic biota**	Negative	Site	Low	Permanent	Highly Probable	**Negligible**	Medium
2	**Flow modification & associated impacts (erosion and sedimentation)**	Negative	Site	Low	Long-term	Highly Probable	**Negligible**	Medium
3	**Pollution impacts**	Negative	Surrounding Area	Low	Long-term	Highly Probable	**Low**	Medium

ANNEXURE C: DWS Risk-based Matrix Assessment Results.

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

Assessment Date:	17-Nov-16		
Name of Assessor:	Mr. Brian Mafela (Cand.Sci.Nat.)	SACNASP Registration No.	100214/15
Name of Reviewer:	Mr. Adam Teixeira-Leite (Pr.Sci.Nat.)	SACNASP Registration No.	400332/13

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

No.	Phase	Activity	Aspect (Stressor)	Impact	SEVERITY: Flow Regime	Physico & chemical (water Quality)	Habitat (Geomorph & Vegetation)	Biota	Severity (average)	Spatial Scale	Duration	Consequence	Frequency of Activity	Frequency of Impact	Legal Issues	Detection	Likelihood	Significance (score)	Risk Rating	Confidence Level (%)	Control measures	Revised Risk Score (manually adjusted)	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
1	Construction	Replacement of existing culvert with a new portal culvert at one crossing site	**1. Site clearing and disturbance of soil and vegetation, stripping and stockpiling**	Destruction of aquatic vegetation, disturbance of soils and habitat.	2	2	3	1	**2**	1	1	**4**	1	5	5	1	12	**48**	Low	80	i. Identify 'No-go' areas and limit vegetation clearing to the construction footprint. ii. Retain excavated soils and vegetation for use in rehabilitation. iii. Rehabilitate the construction site with indigenous plant species (*refer to Section 6.4 of specialist report for further details*).	48	Low	Wetland Unit W01 (PES "D", Low EIS)
			2. Temporary flow diversion to create a "dry" working area	Temporarily impeding/diverting the flow of water during construction, alteration of natural flow patterns and soil saturation rates, scouring and erosion due to redirection of flows.	3	1	2	2	**2**	2	2	**6**	1	5	5	2	13	**78**	Moderate	80	iv. Undertake all temporary flow diversions during dry winter months when flows are low/zero. v. Flows must be diverted using only best-practice suitable methods (*refer to Section 6.2 of specialist report for further details)*: a. Full isolation gravity / flume pipe. b. Full isolation over pumping / siphon. vi. The flow diversion structure (berm & flume piers) must be designed such flows are piped through the construction site effectively and efficiently; and very little water is impounded behind the berm. vii. Flows coming out of the flume pipes must be attenuated such that no erosion takes place and not directed towards any erosion-prone areas such as channel banks.	55	Low	Wetland Unit W01 (PES "D", Low EIS) & River Unit R01 (PES "B", Low EIS)
			3. Excavation and removal of the existing culvert	Disturbance of soils, channel bed material and banks, sedimentation of watercourses downstream, potential for water pollution.	2	2	3	1	**2**	2	1	**5**	1	4	5	2	12	**60**	Moderate	70	viii. Undertake excavations during dry winter months when flows are minimal/zero. ix. Excavations must be limited to the construction footprint only. x. No machines must be allowed to work in highly saturated soils or within standing or flowing water.	55	Low	Wetland Unit W01 (PES "D", Low EIS)

			4. Replacement of old culvert with a new portal culvert to be constructed	Disturbance of soils, channel bed material and banks, sedimentation of watercourses downstream, potential for water pollution.	2	2	2	1	**1.75**	2	2	**5.75**	2	4	5	2	13	**74.75**	**Moderate**	70	xi. Undertake excavations/construction during dry winter months when flows are minimal/zero. xi. Cement slurry must be efficiently contained so as not to pollute the water column. xii. All disturbed areas to be properly back-filled, compacted and rehabilitated/re-vegetated according to the rehabilitation guidelines *(refer to Section 6.4 of specialist report for further details).*	50	**Low**	Wetland Unit W01 (PES "D", Low EIS)
2	**Operation**	**Operation of culvert upgrade**	**1. Post-construction disturbance of habitat where not properly addressed, inadequate culvert design and construction**	Alteration of natural flow patterns, channel bank instability, increased levels of Invasive Alien Plants (IAPs) and weeds, scouring/erosion and associated sedimentation of downstream areas.	3	1	3	1	**2**	1	2	**5**	1	4	5	3	13	**65**	**Moderate**	70	i. Culvert to be appropriately designed and constructed (including storm water and erosion control) in accordance with the environmental design guidelines *(as provided in Section 6.1 of the specialist report).* ii. All disturbed areas to be properly compacted and rehabilitated/re-vegetated according to the rehabilitation guidelines *(refer to Section 6.4 of specialist report for further details).*	50	**Low**	Wetland Unit W01 (PES "D", Low EIS)