Proposed Bhudlu Access Bridge over the uMtamvuna River and Link Road in the uMuziwabantu Municipality, KwaZulu-Natal

Freshwater Habitat Impact Assessment Report

Revision No. 2.0

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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.

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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.

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I, Ross van Deventer, 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: 19 October 2015

EXECUTIVE SUMMARY

This report sets out the findings of a specialist freshwater habitat assessment, including wetlands and river ecosystems, associated with the proposed Bhudlu bridge and link road in the uMuziwabantu Municipality, KwaZulu-Natal. The uMuziwabantu Municipality (KZN) and Mbizana Municipality (EC) intend to provide direct link between the municipalities and link up the communities of Nyandeni (KZN) and Nomganya (EC) over the uMtamvuna River. The proposed developments includes the construction of link road to access the river crossing and the construction of a bridge over the uMtamvuna River.

The main findings of this specialist report have been summarized as follows:

- The proposed activities stand to negative impact four perennial riverine units and one permanent un-channelled valley bottom wetland unit;
- The tributary watercourses are all spring-fed indicating strong groundwater-surface linkages;
- The catchment soils comprises structured clays that appear to be highly erodible;
- The uMtamvuna River is a national freshwater ecosystem conservation priority and is one of the last remaining free flowing rivers in the country.
- Given the largely undeveloped nature of the catchment areas associated with water resources and the relatively low levels of physical disturbance to freshwater habitat, the freshwater habitat assessed remains in relatively good condition.
- According the South Africa Scoring System (SASS) Data Interpretation Guidelines (Dallas, 2007) for the South Eastern Uplands – Lower biological band, the Mtamvuna River reach assessed can be classified as Largely Natural (B PES Class).
- The Present Ecological State (PES) for rivers shows that instream and riparian habitat associated with rivers was in Natural/ Largely Natural (A/B PES Class) to largely Natural (B PES Class) state.
- Based on the direct and indirect impacts to the wetland unit assessed, wetland condition (PES) can be regarded as Largely Natural ("B" PES Category) characterised by a small shift from perceived reference state.
- The most significant ecosystem services provided are regulating and supporting services in the form of flood attenuation, streamflow regulation, sediment trapping, water quality enhancement (nutrients and toxicants), erosion control, carbon storage and biodiversity maintenance services. These services were on average assessed as being of moderate importance with the exception of erosion control which scored as high.
- Provisioning services are generally of low importance largely due to the permanent saturation of this system, fed largely by groundwater expressing itself directly upstream.
- Cultural services are of low to very low importance overall.
- EIS results indicate that the smaller tributary river units draining into the uMtamvuna River are of low EIS (D EIS Class) whereas the Mtamvuna River (R-01) is of High EIS (B EIS Class).
- The wetland unit was assessed as being of Moderate EIS (D EIS Class). This was driven largely by the sensitivity of the habitat to floodpeaks and edge disturbances.
- It is acceptable to maintain the current status quo (B PES Class) without any further loss of integrity should mitigation measure proposed be implemented to specification.

- Due to the sensitivity and importance of the freshwater habitats assessed and erodibility of the catchment soils, the proposed activities stand to have serious measurable impacts (of moderate significance) on the onsite and local/regional freshwater ecosystems if the link road and bridge are poorly designed, poorly constructed and the construction disturbances are poorly rehabilitated.
- The most significant risk is the long-term impacts of the bridge crossing on the uMtamvuna River, particularly if the proposed box culvert bridge results in reach fragmentation.
- The proposed bridge design, using instream box culverts, has the potential to alter local habitat, interfere with river hydrology and geomorphology and impede or restrict the movement of aquatic biota.
- As such it is recommended that a spanned bridge structure with support structures outside the river channel and its banks be established. This structure must allow flows to access the floodplain under peak flows and cater for lateral movement of the channel as it would under natural geomorphic process.
- In addition a number of onsite construction and operation phase mitigation measures as well as rehabilitation guidelines have been recommended.
- With poor mitigation, the potential construction impacts under this scenario stand to be moderately significant and generally unacceptable. This is largely due to the sensitivity of the freshwater habitats assessed and the importance of the uMtamvuna River. Should the recommended mitigation measures be implemented to specification (good mitigation scenario), all of the impacts can be reduced and as such the significance can be reduced to a moderately-low level.
- With poor mitigation, the potential operational impacts were assessed as being of moderate significance and generally unacceptable. This is linked to the sensitivity of the receiving freshwater environment and the potential fragmentation effects of the proposed box culvert system. The stormwater management related impacts can be reduced to moderately-low significance and more acceptable levels should mitigation measures recommended in this report be implemented to specification. However, even with good mitigation, the flow modification impacts of the box culvert crossing will remain moderately significant and generally unacceptable as long as the box culvert crossing design is retained.
- In response to these planning and design recommendations, the applicant has revised the Mtamvuna River bridge proposal to be a spanned bridge rather than culvert bridge, which has reduced the significance of the operational impacts to more acceptable levels. It is strongly recommended that only this revised proposal be taken forward as part of the environmental authorisation and water use license applications.
- Furthermore it is strongly recommended that alignment option 2 be considered only.

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DEFINITION OF TERMS

Catchment	A catchment is an area where water is collected by the natural landscape. In a catchment, all rain and run-off water eventually flows to a river, wetland, lake or ocean, or into the groundwater system.
Conservation	The safeguarding of biodiversity and its processes (often referred to as Biodiversity Conservation).
Delineation	Refers to the technique of establishing the boundary of a resource such as a wetland or riparian area.
Ecosystem	An ecosystem is essentially a working natural system, maintained by internal ecological processes, relationships and interactions between the biotic (plants & animals) and the non-living or abiotic environment (e.g. soil, atmosphere). Ecosystems can operate at different scales, from very small (e.g. a small wetland pan) to large landscapes (e.g. an entire water catchment area).
Ecosystem Goods and Services	The goods and benefits people obtain from natural ecosystems. Various different types of ecosystems provide a range of ecosystem goods and services. Aquatic ecosystems such as rivers and wetlands provide goods such as forage for livestock grazing or sedges for craft production and services such as pollutant trapping and flood attenuation. They also provide habitat for a range of aquatic biota.
Ezemvelo KZN Wildlife	Ezemvelo KwaZulu-Natal Wildlife, the local conservation authority for the Province of KwaZulu-Natal.
Endemic	Refers to a plant, animal species or a specific vegetation type which is naturally restricted to a particular defined region (not to be confused with indigenous). A species of animal may, for example, be endemic to South Africa in which case it occurs naturally anywhere in the country, or endemic only to a specific geographical area within the country, which means it is restricted to this area and grows naturally nowhere else in the country.
Function/function-ing/functional	Used here to describe natural systems working or operating in a healthy way, opposed to dysfunctional, which means working poorly or in an unhealthy way.
Habitat	The general features of an area inhabited by animal or plant which are essential to its survival (i.e. the natural "home" of a plant or animal species).
Indigenous	Naturally occurring or "native" to a broad area, such as South Africa in this context.
Intact ecosystems/ environments	Used here to describe natural environment that is not badly damaged, and is still functioning in a largely natural manner.
Invasive alien species	Invasive alien species means any non-indigenous plant or animal species whose establishment and spread outside of its natural range threatens natural ecosystems, habitats or other species or has the potential to threaten ecosystems, habitats or other species.
Mitigate/Mitiga-tion	Mitigating impacts refers to reactive practical actions that minimize or reduce in situ impacts. Examples of mitigation include "changes to the scale, design, location, siting, process, sequencing, phasing, and management and/or monitoring of the proposed activity, as well as restoration or rehabilitation of sites". Mitigation actions can take place anywhere, as long as their effect is to reduce the effect on the site where change in ecological character is likely, or the values of the site are affected by those changes (Ramsar Convention, 2012).
Systematic conservation plan	An approach to conservation that prioritises actions by setting quantitative targets for biodiversity features such as broad habitat units or vegetation types. It is premised on conserving a representative sample of biodiversity pattern, including species and habitats (the principle of representation), as well as the ecological and evolutionary processes that maintain biodiversity over time (the principle of persistence).
Threatened ecosystem	In the context of this document, refers to Critically Endangered, Endangered and Vulnerable ecosystems.

Threat Status	Threat status (of a species or community type) is a simple but highly integrated indicator of vulnerability. It contains information about past loss (of numbers and / or habitat), the number and intensity of threats, and current prospects as indicated by recent population growth or decline. Any one of these metrics could be used to measure vulnerability. One much used example of a threat status classification system is the IUCN Red List of Threatened Species (BBOP, 2009).
Transformation (habitat loss)	Refers to the destruction and clearing an area of its indigenous vegetation, resulting in loss of natural habitat. In many instances, this can and has led to the partial or complete breakdown of natural ecological processes.
Water course	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).
Wetland	Refers to land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (National Water Act, 1998).

1. INTRODUCTION

1.1 Project Background and Locality

Eco-Pulse Environmental Consulting Services was appointed to undertake a specialist freshwater habitat impact assessment for the proposed Bhudlu Access Bridge and Link Road within the uMuziwabantu Municipality, KwaZulu-Natal. The proposed development includes the construction of a bridge structure across the uMtamvuna River and a link road to the bridge from the D1100 road, on the KZN side. Currently, three alternative link roads are proposed as shown in Figure 1. The 'red' alignment is currently the preferred option.

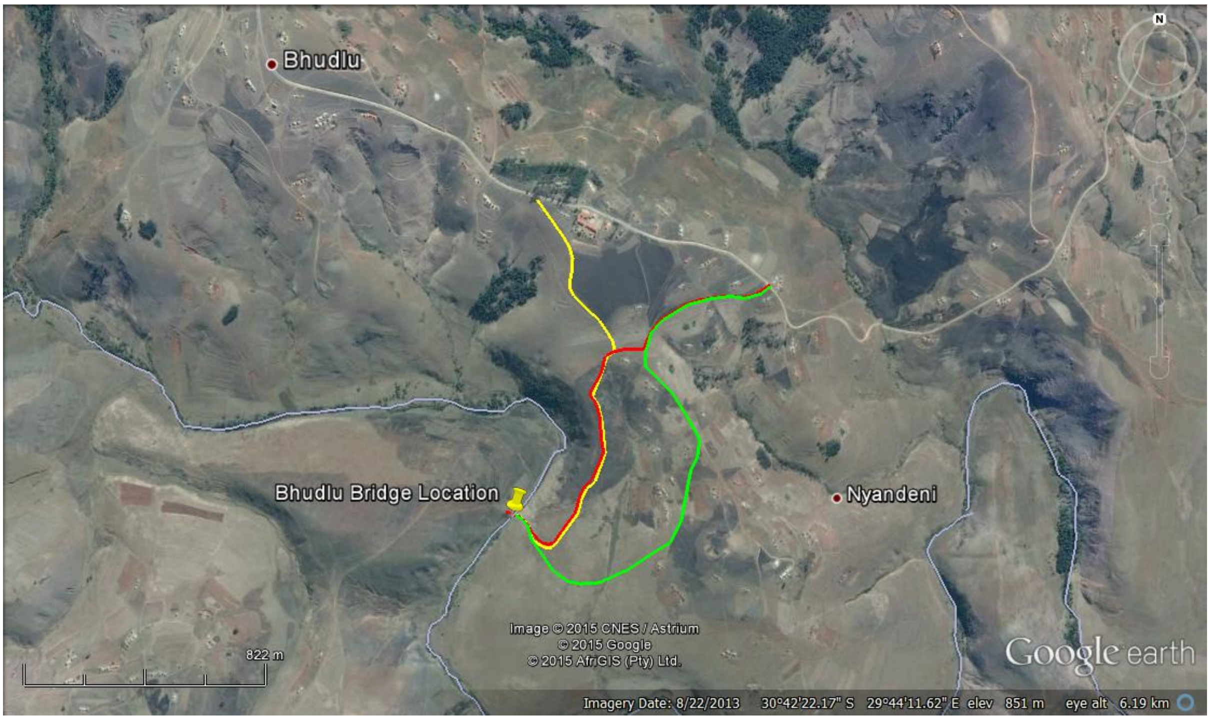


Figure 1 The location of the proposed Bhudlu bridge site as well as link road alternatives to be assessed.

1.2 Description of Proposed Activity

The uMuziwabantu Municipality (KZN) and Mbizana Municipality (EC) intend to provide direct link between the municipalities and link up the communities of Nyandeni (KZN) and Nomganya (EC) over the uMtamvuna River. The proposed developments includes the construction of link road to access the river and the construction of a bridge over the uMtamvuna River. The uMuziwabantu Municipality will construct the bridge, the KZN portion of the Access Road and a 100m approach road on the EC side of the bridge. The remainder of the access road on the EC side will be constructed by Mbizana Municipality.

It is proposed that the access road bed is prepared to 90% modified AASHTO density using the in-situ material. A 150mm gravel wearing course will be constructed on top of this.

All existing accesses/driveways will be re-graded to suit the proposed alignment. Extent of works for the upgrading can be summarised as follows:

- Clear and grub;
- Construct bridge;
- Construct earthworks and bridge approaches;
- Construct side and cross drainage;
- Construct pavement layer;
- Tie in to driveways/accesses; and
- Landscaping.

Originally, a box culvert bridge was proposed that comprised a class 5 road with width of 3.9m and able to accommodate the 5 year design flood of 268 m^3/s in accordance with SARAL's Drainage Manual. The following culvert types were proposed:

- 3 No. 4.8m x 4.8m *Insitu* Box Culvert.
- 4 No. 4.2m x 4.2m *Insitu* Box Culvert.
- 6 No. 3.6m x 3.6m *Insitu* Box Culvert.

A conceptual schematic of the original bridge proposed is shown in Figure 2 below.

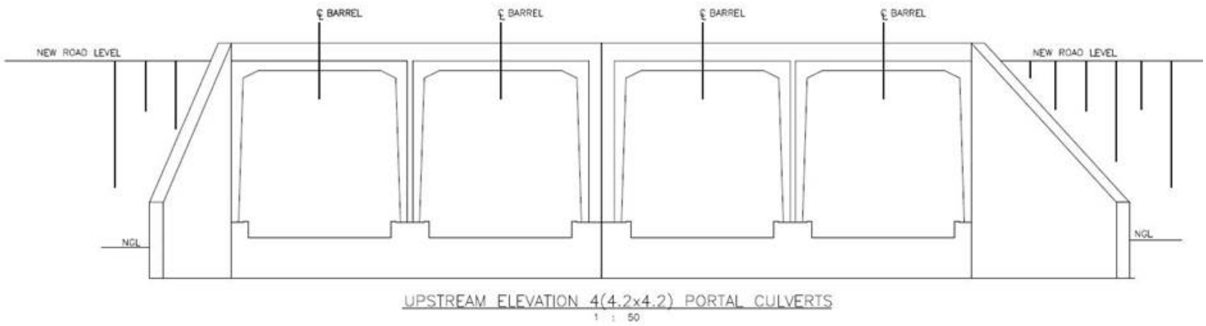


Figure 2 Conceptual culvert bridge design that was originally proposed.

However, following the completion of the draft version of this freshwater habitat impact assessment, it was found that the proposed bridge had the potential to alter local habitat, interfere with river hydrology and geomorphology and impede or restrict the movement of aquatic biota, ultimately resulting in reach fragmentation in the long-term. For one of the last remaining free-flowing rivers in South Africa, this potential risk was considered undesirable and unacceptable and as such, the authors recommended that that the design of the bridge be revised and that the proposed bridge be spanned using piers.

Consequently the bridge design has been revised and the bridge is now proposed to be a **simply supported, 76m long and 6.5m wide six span continuous voided slab-deck bridge** structure designed to accommodate the 1:10year flood event (referred to as Bridge Option 2). The proposed bridge sections and elevation plan is included in Annexure A.

1.3 Scope of Work

The appointed scope of work of the proposed assessment is as follows:

- Contextualization of the study area in terms of important biophysical characteristics and conservation planning;
- Desktop mapping of all watercourses/freshwater habitats (rivers, streams, wetlands, springs) occurring within 500m of the proposed activity;
- Desktop risk screening assessment of wetland and riverine areas likely to be affected by the proposed activity to guide detailed infield assessments;
- Detailed infield delineation of wetland, in-stream and riparian habitat to be measurably affected (i.e. occurring within 32m and 100m downstream of the proposed development) according to the methods contained in the manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005).
- The splitting up of the delineated wetland and river/riparian areas into distinct resource units and the classification of these units according to accepted, published classification systems;
- Description of the key biotic and abiotic characteristics of the delineated freshwater habitats;
- Assessment of in-stream habitat integrity (and indirectly water quality) using the SASS5 macro-invertebrate bio-monitoring protocol (Dickens and Graham, 2002);
- Determination of the Present Ecological State (PES) of the delineated riverine and wetland units;
- Determination of the Ecological Importance and Sensitivity (EIS) of the delineated riverine and wetland units;
- Assessment of the direct and indirect functional (ecosystem goods and services) importance of the delineated wetland units;
- The identification, description and assessment of the potential impacts of the proposed development on the delineated freshwater habitats. Please note that the predicted change in the state and level of ecosystem services provided by the delineated freshwater habitats will qualitatively described based on professional opinion (and not using formal post-development assessment tools; and
- Provision of mitigation and management recommendations including rehabilitation measures and a monitoring protocol.

2. APPROACH AND METHODS

The approach to the assessment involved the following four phases:

1. Desktop assessment, including:

- Desktop mapping of all wetland and riparian habitat within 500m of the proposed development using aerial imagery and available spatial datasets (see Table 1, on the next page) in a Geographical Information System (GIS).
- Rapid desktop risk assessment to determine which of the desktop mapped watercourses is likely to be measurably affected by the proposed activity/water use. This will be used to guide field efforts and further details assessment.

2. Collection and refinement of baseline information pertaining to the potentially affected freshwater environment, including field verification of:

- The extent of wetlands, active and macro channels and riparian habitat (wetland & riparian zone delineation);
- Condition (PES) of wetland and riverine units potentially affected by the proposed development;
- Ecological importance and sensitivity (EIS) of wetland and riverine units potentially affected by the proposed development; and
- Functional importance of the delineated wetland units potentially affected by the proposed development.

3. The identification and assessment of potential freshwater habitat impacts was undertaken based on the development information provided, experience in similar development projects and informed by an understanding of the sensitivity of the receiving environment.

4. Recommendations for mitigation: Management and mitigation recommendations were compiled to assist with addressing the range of impacts identified and other ecological concerns related to project activities, including:

- Planning and design measures;
- Site specific and generic construction and operation mitigation measures; and
- Rehabilitation and monitoring requirements.

2.1 Data Sources Consulted

The following data sources and GIS spatial information provided in Table 1 below was consulted to inform the assessment. The data type, relevance to the project and source of the information has been provided.

Table 1. Information and data coverages used to inform the assessment.

DATA/COVERAGE TYPE	RELEVANCE	SOURCE
Biophysical Context		
2009 Colour aerial photography	*Desktop mapping of drainage network and freshwater habitats*	Surveyor General
Latest Google Earth ™ imagery	*To supplement available aerial photography where needed*	Google Earth™ On-line
5m Elevation Contours (GIS Coverage)	*Desktop mapping of drainage network and freshwater habitats*	Surveyor General
DWA Eco-regions (GIS Coverage)	*Classification of local ecoregions*	DWA (2005)
Geology of RSA (GIS Coverage)	*Assessment of underlying geology controlling soil formation and aspects of wetland/river geomorphology*	1: 1000 000 Geological Map of South Africa (Council for Geosciences)
Geomorphological Provinces of South Africa	*Understand regional geomorphology controlling the distribution and occurrence of rivers and wetlands*	Partridge *et al.* (2010)
South African Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation*	Mucina & Rutherford (2006)

DATA/COVERAGE TYPE	RELEVANCE	SOURCE
KwaZulu-Natal Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation*	EKZNW (2011)
NFEPA: NFEPA river and wetland inventories (GIS Coverage)	*Highlight potential onsite and local rivers and wetlands*	CSIR (2011)
Desktop PES/EIS (DWA 2013)	*Desktop rating of PES and EIS to be refined during onsite investigations.*	DWA 2014
Conservation Context		
NFEPA: River, wetland and estuarine FEPAs (GIS Coverage)	*Shows location of national aquatic ecosystems conservation priorities*	CSIR (2011)
National Biodiversity Assessment - Threatened Ecosystems (GIS Coverage)	*Determination of national threat status of local vegetation types*	SANBI (2011)
KwaZulu-Natal Vegetation Map (GIS Coverage)	*Determination of provincial threat status of local vegetation types*	EKZNW (2011)
KZN Freshwater Systematic Conservation Plan (GIS Coverage)	*Location and extent of conservation planning units*	EKZNW (2007)
KZN Terrestrial Systematic Conservation Plan (GIS Coverage)	*Location and extent of conservation planning units*	EKZNW (2010)
NFEPA: Strategic Water Source Areas (GIS Coverage)	*Location and extent of strategic water source areas*	(Nel *et al.*, 2013)

2.2 Methods Used

Table 2 (below) summarises the methods that were used as part of this assessment. The reader is referred to **Annexure A** for further details on the assessment methods used.

Table 2. Information and data coverage's used to inform the aquatic assessment.

METHOD/TECHNIQUE		REFERENCE FOR METHODS/TOOLS USED	ANNEXURE
Wetland and riparian delineation		➢ *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005)*	A1
Classification of water resources		➢ National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (SANBI, 2014) ➢ Classification system for channelled watercourses (Eco-Pulse, 2013)	A2
Rivers	**SASS5 derived water quality**	➢ SASS5 - South African Scoring System, Version 5 (Dickens and Graham, 2002)	A3
	River condition/Present Ecological State (PES)	➢ Rapid Index of Habitat Integrity (IHI) tool for rivers (Kleynhans, 1996)	A4
	River Ecological Importance & Sensitivity (EIS)	➢ DWAF Riverine EIS tool (Kleynhans, 1999)	A5
Wetlands	**Wetland condition/Present Ecological State (PES)**	➢ Level 1 WET-Health tool (Macfarlane et al., 2009).	A6
	Wetland Functional / Ecosystem Services Assessment	➢ Level 2 WET-EcoServices assessment tool (Kotze et al., 2009). ➢	A7
	Wetland Ecological Importance & Sensitivity (EIS)	➢ EIS tool developed by Eco-Pulse adapted from the DWAF Wetland EIS tool (Duthie, 1999)	A8
Assessment of Ecological Impacts		➢ Impact assessment methodology for EIAs (Eco-Pulse, 2015)	A9

2.3 Assumptions and Limitations

The following limitations and assumptions apply to the assessment:

- The wetland and riparian boundaries must be identified and classified along a transitional gradient which makes it difficult to identify the exact boundary of the wetland. The boundaries mapped in this specialist report therefore represent the approximate boundary of these wetlands as evaluated by an assessor familiar and well-practiced in the delineation technique.
- Wetland and riparian boundaries are based largely on the GPS locations of soil sampling points or specific terrain/morphological features (e.g. break in slope). GPS accuracy will therefore affect the accuracy rating of mapped sampling points and therefore wetland and riparian boundaries. Soil sampling points were recorded using a Garmin Oregon™ Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- Infield soil and vegetation sampling was focused around potentially affected watercourses only. Therefore, the rest of the larger resource units were assessed at a desktop level only.
- 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 vegetation information provided for wetland and riparian areas is based on observations and no formal vegetation sampling/plots were undertaken.

- The PES, EIS and Ecosystem Services Assessments undertaken utilised rapid and qualitative assessment tools and thus the results are open to professional opinion and interpretation. We have made an effort to substantiate all claims where applicable and necessary.
- The EIS assessments of rivers and wetlands were informed by a once off field investigation and does not account for seasonal or temporal variability.
- The assessment of impacts and provision of mitigation measures was informed by the site-specific ecological concerns arising from the field survey, the nature of the proposed activity and the assessor's working knowledge and experience with similar development projects.
- Evaluation of the significance was undertaken for 'realistic worst case poor mitigation' and a 'realistic best case good mitigation' scenarios. The 'realistic best case good mitigation scenario takes into account all mitigation measures recommended in this report and generic best practice mitigation measures to be included in the Environmental Management Programme (EMPr). If any of these recommended mitigation measures cannot be adhered to, the good mitigation (post-mitigation) scenario will need to be redone based on what mitigation the client agrees to.

3. BACKGROUND INFORMATION

3.1 Regional / Local Biophysical Setting

The proposed activity is planned within the upper reaches of the uMtamvuna River and catchment, within quaternary catchment T40C and the uMvoti to uMzimkhulu water management area (Figure 3). The uMtamvuna River is a free flowing perennial, main steam river that flows into the Indian Ocean at Port Edward. The uMtamvuna River estuary, located approximately 60km downstream (straight line distance) of the project activity, is a permanently open estuary. Local drainage density is moderate and valleys are generally steep and incised, particularly the uMtamvuna River valley.

The key biophysical setting details of the project site and surrounds are summarised in Table 3 below.

Table 3. Key biophysical details.

Biophysical Aspects	Desktop Biophysical Details	Source
Elevation a.m.s.l	Approx. 758m - 920 a.m.s.l.	Google Earth™ & Surveyor General
Mean annual precipitation (MAP)	828.9mm	Schultz, 1998
Rainfall seasonality	Early Summer – late summer	DWAF, 2007
Mean annual temperature	10 - 22°C	DWAF, 2007
Mean annual potential evaporation (MAPE)	1577.0 mm	Schultz, 1998
Median annual simulated runoff (mm) for quaternary catchment	119.8mm	Schultz, 1998
Geomorphic Province	Southeastern Coastal Hinterland	Partridge et.al., 2010
Geology	Shale with sandstone present towards basin margins / dolerite sills and dykes	SA Geological Society
Soils	Structured clays, highly erodible	Onsite observations
Water management area	Mvoti to Umzimkhulu	DWA
Quaternary catchment	T40C	DWA
Main collecting river in the catchment	uMtamvuna	CSIR, 2011
Location in the catchment	Upper reaches of the catchment	CSIR, 2011, Surveyor General
Noteworthy downstream watercourses/water resources	uMtamvuna Estuary (60km SE)	CSIR, 2011, DWA
DWA Ecoregion	South Eastern Uplands (No. 16)	DWA, 2005
National vegetation types	Ngongoni Veld	Mucina & Rutherford, 2006
Provincial vegetation types	Moist Coast Hinterland Grassland	EKZNW, 2010
Wetland vegetation group	Sub-Escarpment Savanna	CSIR, 2011

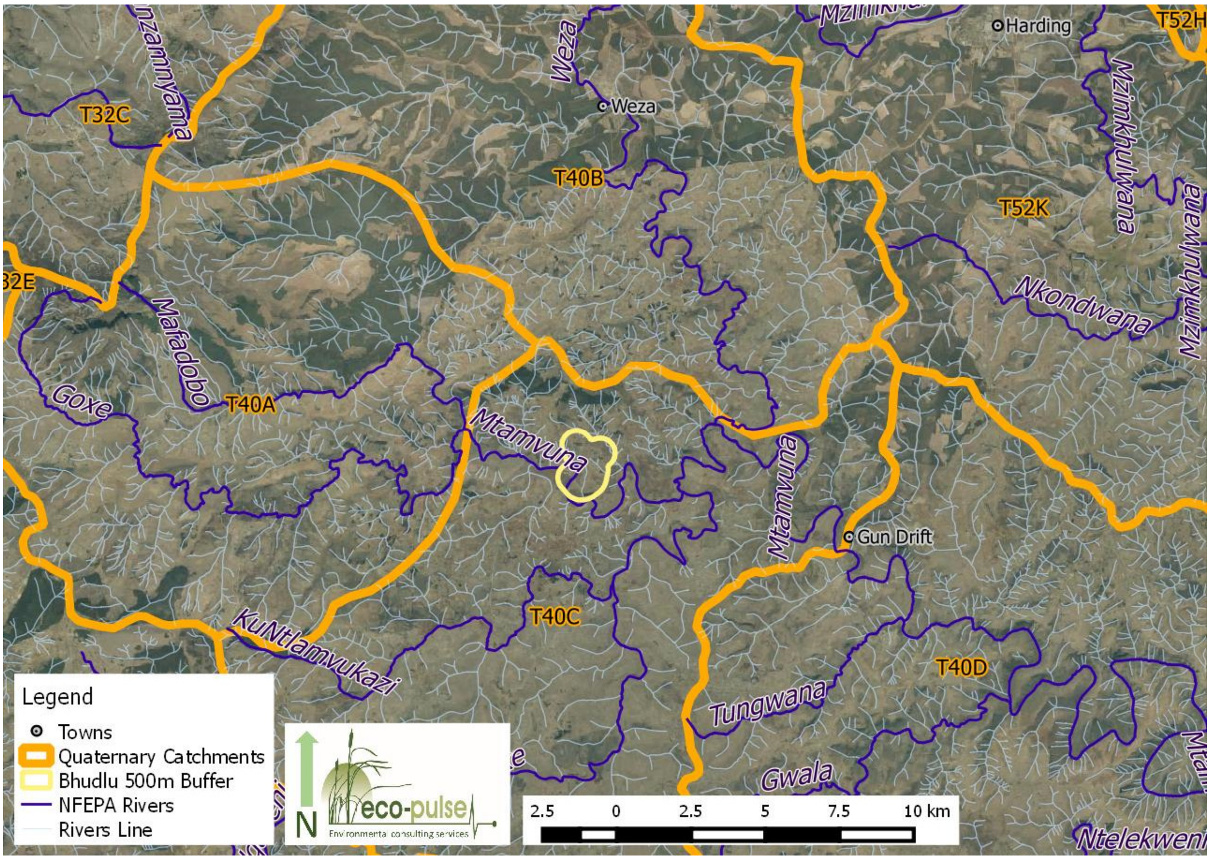


Figure 3 Map showing the local drainage network and key downstream water resources.

3.2 Conservation Context

The affected reach of the uMtamvuna River and its associated sub-quaternary catchments have been classified as a River FEPA (Freshwater Ecosystem Priority Area). The classification of a sub-quaternary catchment as a FEPA indicates that the surrounding land and smaller stream networks need to be managed in a way that maintains the present good condition (A or B ecological category) of the river reach (Driver et al., 2011). FEPAs need to remain in a good condition in order to achieve biodiversity goals and protect water resources from human use (Driver et al., 2011).

The uMtamvuna River has also been classified as a "Flagship Free-flowing river". A free-flowing river is a long stretch of a relatively large river that has not been dammed or does not experience major flow alteration and which flows undisturbed from its source to the confluence with a larger river or to the sea (Driver et al., 2011). A "Flagship free-flowing river" is deemed the most suited for representing the last remaining free-flowing rivers in South Africa and should receive top priority for retaining their free-flowing character (Driver et al., 2011).

Furthermore, the uMtamvuna River has been classified as a and a fish sanctuary and a fish FEPA (CSIR, 2011). "Fish sanctuaries" represent sub-quaternary catchments required to meet fish population targets i.e. that are essential for protecting threatened and near threatened freshwater fish that are indigenous to South Africa. A goal of NFEPA is to keep further freshwater species from becoming threatened and to prevent those fish species that are already threatened from becoming extinct. In order to achieve this, there should be no further deterioration in river condition in fish sanctuaries (Driver et al., 2011). Fish FEPAs are fish sanctuaries in a good condition (A or B ecological category).

The key conservation context details of the project site and surrounds are summarised in Table 4 below.

Table 4. Key conservation context details.

Relevant Conservation Plan	Relevant Conservation Feature	Location in Relation to Project Site	Conservation Planning Status
National			
National Freshwater Ecosystem Priority Area (NFEPA) Assessment	uMtamvuna River and sub-quaternary catchment	Crossed/traversed by the proposed development	• River FEPA • Fish FEPA • Fish Sanctuary • Flagship Free Flowing River
National Biodiversity Assessment (NBA) & National Vegetation Map	Ngongoni Veld	Untransformed terrestrial areas	Vulnerable
	Subtropical Freshwater Wetland Vegetation	Primary and secondary herbaceous wetland habitat	Not rated. Refer to NFEPA
Provincial			
Provincial Vegetation Map	Moist Coast Hinterland Grassland	Untransformed terrestrial areas	Endangered
	Subtropical Freshwater Wetland Vegetation	Primary and secondary herbaceous wetland habitat	Least Threatened
KZN Freshwater Systematic Conservation Plan	All catchments within the study area	Entire site and greater tributary catchment	Available

Relevant Conservation Plan	Relevant Conservation Feature	Location in Relation to Project Site	Conservation Planning Status
KZN Terrestrial Systematic Conservation Plan	Midlands Mistbelt Grassland	Untransformed terrestrial areas	Endangered
	Moist Ngongoni Veld	Untransformed terrestrial areas	Unknown
	Euonyma lymneaeformis (Mollusc)	Terrestrial habitat	Unknown
	Sheldonia burnupi (Mollusc)	Terrestrial habitat	Unknown
	Doratogonus infragilis (Millipede)	Terrestrial habitat	Unknown

3.3 Desktop PES & EIS Information (DWS 2014)

According to the desktop PES/EIS assessment undertaken by the Department of Water and Sanitation (DWS, 2014) for major rivers, the uMtamvuna River reach (Figure 3) potentially affected by the proposed development is **Largely Natural (B PES class)** and is of **High Ecological Importance & Sensitivity (B Class).** Evident from the EI and ES classes is that ES (ecological sensitivity) drives the importance of this system, influenced largely by the presence of sensitive aquatic biota such as fish and macro-invertebrates. Table 5 below summarises the desktop assessment, Table 7 summarises fish species likely to be present based on the desktop assessment and Figure 4 shows the extent of the sub-quaternary river reach of the uMtamvuna in relation to the proposed development.

Table 5. Summary of desktop PES/EIS (DWS, 2014) results.

General	SQ reach	T40C-05510
	SQ reach name	uMtamvuna
	SQ reach length	13.65 km
	SQ reach assessed	Yes
Ecological Importance (EI) & Ecological Sensitivity (ES)	EI class	Moderate
	ES class	High
	ECOLOGICAL CATEGORY (EI & ES)	**B: HIGH**
Present Ecological State (PES)	Instream habitat continuity modification	Small
	Riparian/wetland continuity modification	Small
	Potential instream habitat modification	Small
	Potential riparian/wetland habitat modification	Small
	Potential flow modification	Small
	Potential physico-chemical modification	Small
	PES CATEGORY	**B: LARGELY NATURAL**

Table 6. Summary of desktop fish presence (DWS, 2014) and migratory requirements according to (Kleynhans, 2008).

Species Scientific Name	Threat status	Migration Score	Migration Comment
ANGUILLA MOSSAMBICA	Least Concern	5 -Species with requirement for catchment scale migrations	Up to watershed, >100km
BARBUS NATALENSIS	Not Classified	3 - Species with requirement for movement between reaches / fish habitat segments	20-100
BARBUS PALUDINOSUS	Least Concern	3 - Species with requirement for movement between reaches / fish habitat segments	8km reported / specialist speculate much further (50km)
CLARIAS GARIEPINUS	Least Concern	3 - Species with requirement for movement between reaches / fish habitat segments	Long distances

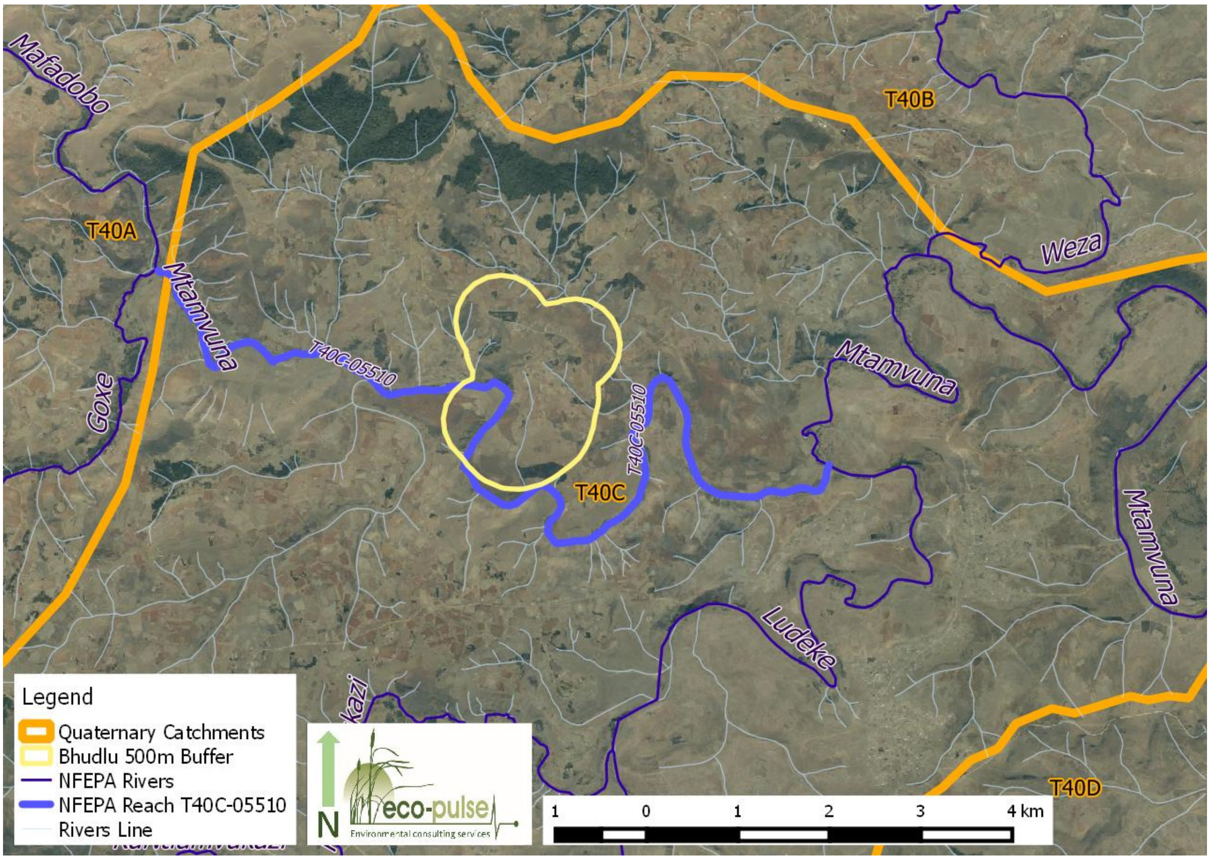


Figure 4 Focal river reach of the uMtamvuna River.

4. BASELINE ASSESSMENT FINDINGS

The findings of the baseline freshwater habitat assessment are presented in this section of the report. This includes the following:

i. *Desktop delineation and risk screening (Section 4.1);*
ii. *Infield delineation and classification (Section 4.2);*
iii. *Description of habitat features and human impacts (Section 4.3);*
iv. *Present Ecological State (PES) assessment (section 4.4); and*
v. *Importance and Sensitivity assessment (Section 4.5).*

4.1 Desktop Delineation and Risk Screening

All watercourses within 500m of the proposed development activity are shown in Figure 5 below. Each of the watercourses was assigned a qualitative risk rating according to desktop analysis and verification during the site assessment. Only those watercourses at a moderate to high risk of impact as shown in Figure 4 and summarised in Table 7 below were taken forward for further assessment.

The desktop delineation and risk assessment of all water resources (wetlands and rivers/riparian areas) with 500m of the proposed bridge and link road development indicated that five broadly defined water resource areas could potentially be negatively affected. This included the following water resource units that would require field delineation and further assessment (as shown in Figure 5 below):

1. **R-01 - Perennial uMtamvuna River** to be crossed by the proposed bridge;
2. **R-02 - Perennial tributary stream** directly downstream of link road option 1 crossing;
3. **W-01 - Unchannelled valley bottom to be** crossed in lower reaches by link road option 1;
4. **R-03 - Perennial spring fed stream** directly downslope of link road option 2; and
5. **R-04 - Perennial spring fed stream** directly downslope of link road option 2.

Measurable potential direct impacts to the **R-01, R-02 and W-01** are expected whereas **R-03 and R-04** may be affected by indirect impacts related to the construction and/or operation of the link road and road crossings. Therefore, these units were identified for further detailed assessment. All remaining water resources are at low risk to change and will not form the basis any further investigations. Table 7 below summarises the rationale for the risk assessment used to screen water resources for further assessment.

Table 7. Preliminary risk of delineated water resources within 500m of the proposed development.

Water Resources	Risk (potential impact)	Rationale	Selection for filed verification and further assessment
R-01 R-02 W-01	High	To be crossed by, or directly downstream of, the proposed access/link road. Freshwater habitat will be directly impacted along the construction corridor and downstream habitat may experience indirect impacts during construction and operation.	Field delineate and detailed impact assessment
R-03 R-04	Moderate	Directly downslope of link road option 2 and may be indirect impacted by the construction and/or operation of the link road, particularly stormwater runoff impacts.	Field delineate and detailed impact assessment
Remaining water resources within 500m	Low	Remaining low risk areas are either upstream, upslope, within separate sub-catchments or a large distance away from activity.	Desktop delineate with no further assessments required.

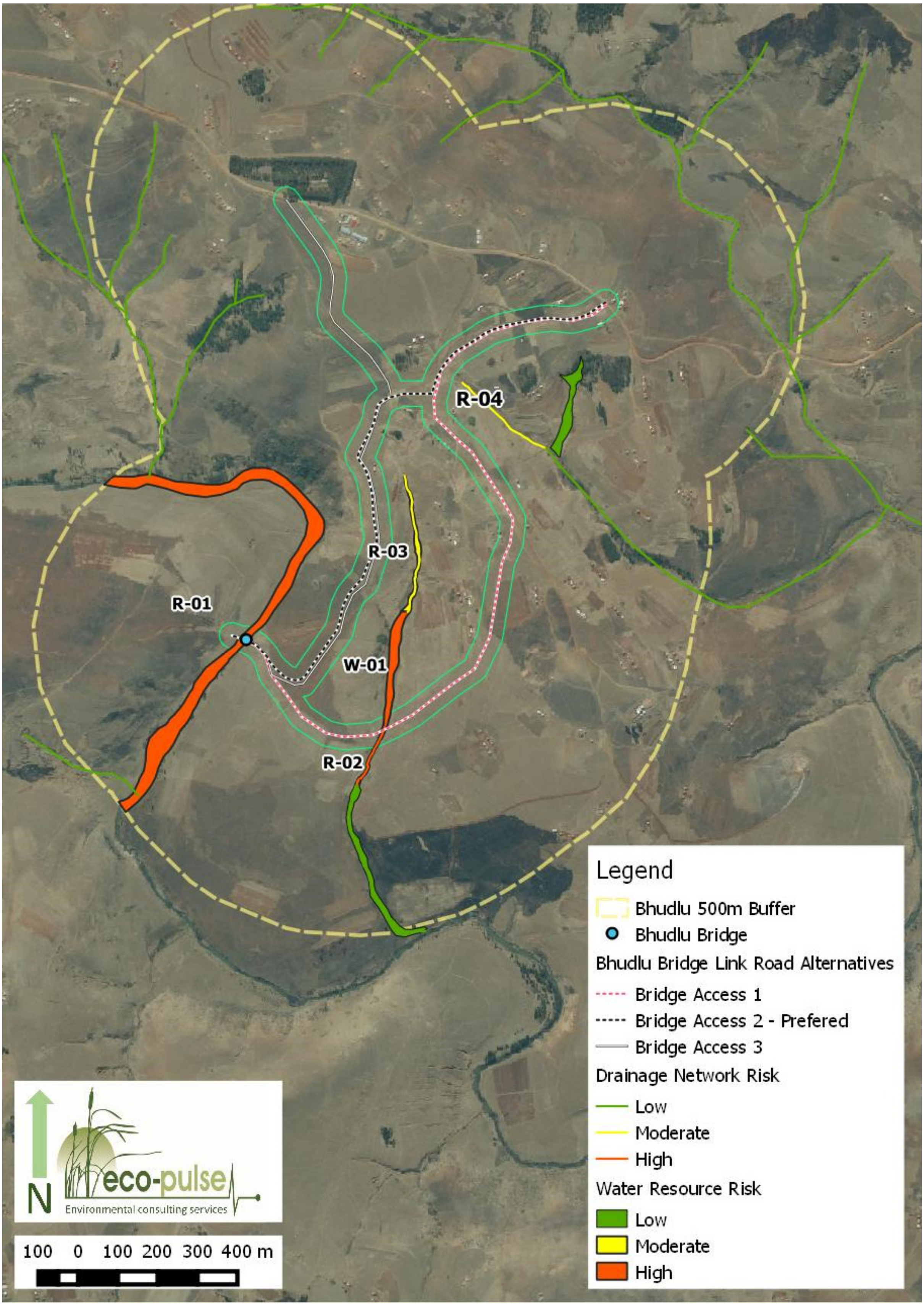


Figure 5 Delineated wetland and riparian units.

4.2 Delineation and Classification

Soil and vegetation sampling in conjunction with the recording of topographical features enabled the infield delineation of the outer boundaries of potentially affected water resource units identified during the desktop analysis. The extent and classification of the water resource units were used to guide detailed impact assessments (Table 8).

Table 8. Summary of delineation details for potentially affected water resource units.

Water Resource Unit	Classification	Relevant Details	Selection for detailed assessment
Riverine Units			
R-01	Perennial River	Large active channel ranging from 8 - 10m width and 0.5 – 2m depth. In places, left bank of active channel bordered by a flood bench and higher lying macro channel bank. River generally bordered by a flat terrace, the inundation frequency of which is unknown and has not been included in the riparian area as habitat foes not exhibit characteristics distinct from upland habitat. Bank profiles are steep (near vertical) characterised by stratified alluvial soils. Herbaceous and grass dominated riparian vegetation is generally confined to the marginal banks and flood bench environments with upland grassland vegetation occurring outside of these areas i.e. terraces and beyond. Dominant riparian species included *Arundinella nepalensis* and *Miscanthus junceus* along the active channel banks. Typical terrestrial species such as *Aristida junciformis* and *Eragrostis curvula* characterise higher elevations.	Yes
R-02	Perennial stream	Very narrow, confined valley floor setting with channelled flow and low channel sinuosity. Some typical wetland species such as *Cyperus latifolius* and *M. junceus* occur within and along the marginal of the active channel with no typical wetland or riparian species occurring outside the active channel.	Yes
R-03	Perennial spring fed stream	Confined valley floor characterised by channelled flow with no wetland or riparian vegetation outside of the active channel. Groundwater daylights within eroded channel to form a perennial stream. Wetland species such as *Fimbristylis spp., Cyperus digitatus* and *Juncus exertus only* occur within the active channel.	Yes
R-04	Perennial spring fed stream	Very narrow, confined valley floor characterised by channelled flow with no wetland or riparian vegetation outside the active channel. Groundwater daylights within eroded channel to form a perennial stream. Wetland species such as *Fimbristylis spp., C. digitatus* and *Juncus exertus only* occur within the active channel.	Yes
Wetland units			
W-01	Unchannelled valley-bottom	Very narrow, confined valley floor setting characterised by diffuse surface and subsurface flows and dense marsh habitat dominated by *M. junceus, C. latifolius, Fimbristylis spp., C. digitatus* and *Juncus lomatophyllus.* Very narrow seasonal/ temporary margin adjoins steep terrestrial slopes were *Aristida junciformis* dominates. Soils were organic rich, dark gray and highly saturated with limited mottling, indicative of permanent saturation.	Yes

4.3 Description of Habitat Features and Human Impacts

The landscape is characterised by a diversity of drainage types, all of which have unique habitat features and vegetation characteristics. Given the largely undeveloped nature of the catchment areas associated with water resources and the relatively low levels of physical disturbance to freshwater habitat, freshwater habitat remains in relatively good condition. However, due to the steep nature of the topography and the high erodibility of the upland soils (highly structured clay soils), the upland slopes and smaller steeply sloping wetlands and streams (tributaries to the Mtamvuna River) are highly sensitive to surface runoff alteration impacts, particularly increased flow concentration and runoff velocities. This is evident by the occurrence of intensive localised gully erosion in some of the watercourses as a result of flow concentration along informal vehicular tracks and cattle tracks. Even at relatively low densities, these tracks have had a measurable localised effect. Scour and depositional features (alluvial fans/plumes) were particularly evident within the upper reaches of Unit R-03, caused by erosion along the informal track along 'bridge access option 3'.

Direct imapcts observed include vegetation and soil trampling by people, livestock and vehicles as well as the excavation of wells within the springs for water use.

Other indirect impacts within the study area include alien invasive and ruderal plant invasion along areas of disturbance, namely those areas affected be erosion and deposition and those areas that are regularly grazed i.e. the flood bench of the uMtamvuna River downstream of the proposed bridge crossing. Table 9 below provides a brief description of the habitat associated with each water resource unit as well as a list of the dominant existing impacts.

Table 9. Brief Description of potentially affected water resource units and existing impacts.

Water Resources	Description of habitat	Existing impacts
R-01	Large active channel with a moderate diversity of instream habitats. These include large stretches of bedrock/boulder and stone run and riffle habitat as well as pool habitat characterised by slower flows, alluvial substrates (gravel, sand, mud) and herbaceous marginal vegetation. Channel depth varies from 1-3m with average widths of 8-10m. Flows were moderate and water clarity was good to very good based on visual observations.	• Localised bed and bank modification from existing informal road crossing. The banks have been re-graded and have little vegetation cover and in-steam rocks have re-ordered/stacked in rows for vehicles. • Cattle trampling and over grazing on the bench features resulting in plant species compositional changes and invasion by invasive species. • *Acacia mearnsii* (black wattle) invasion along large stretches of the riparian zone, particularly the flood benches and macro channel.

Water Resources	Description of habitat	Existing impacts
		
	Photo 1: View of uMtamvuna River from upstream of the proposed crossing looking downstream.	**Photo 2:** View of the uMtamvuna River from downstream of proposed crossing looking downstream.
R-02	Small perennial channel (0.5m deep by 1m wide) showing signs of incision. Vegetation outside the channel is typically characterised by herbaceous dryland species while typical wetland species are limited to the instream habitat.	• Localised bed and bank modification from human and cattle accessing the channel. • Abstraction upstream. • Signs of channel incision. • Channel margins are invaded by Rubus cuneifolius (American bramble) in places.
		
	Photo 3: View downstream of narrow valley with confined channel R-02.	**Photo 4:** View of localised bank erosion from cattle activity in the channel.
R-03	Small bedrock stream channel fed by a perennial spring. Stream bed is stepped with a number of bedrock knickpoints along the longitudinal profile. Typical wetland vegetation is limited to the active channel with dryland species on macro channel banks. Head of stream and spring associated with incised bit apparently stable headcut.	• Localised bed and bank modification from local communities accessing the channel. • Channel incision and erosion as a result of upstream catchment impacts – upslope gulley erosion and flow concentration associated with informal vehicular tracks. • Excavation around the spring source and abstraction of water. • Abstraction upstream.

Water Resources	Description of habitat	Existing impacts
		
	Photo 5: View of small spring fed channel within confined macro-channel banks.	**Photo 6:** View downstream showing the bedrock controlled lower reaches of R-03.
R-04	Very narrow bedrock stream channel fed by a perennial spring. Stream bed is stepped with a number of bedrock knickpoints along the longitudinal profile. Typical wetland vegetation is limited to the active channel with dryland species on macro channel banks. Head of stream and spring associated with incised bit apparently stable headcut.	• Localised bed and bank modification from local communities accessing the channel. • Excavation around the spring source and abstraction of water. • Abstraction upstream.
		
	Photo 7: View downstream of narrow valley line in which R-04 flows.	**Photo 8:** View of groundwater spring source feeding R-04.
W-01	Narrow, permanently saturated herbaceous marsh habitat characterised by obligate and facultative wetland plant species. Narrow seasonal/ temporary wetland fringe adjoins steep valley sides. Flo is un-channelled and predominantly diffuse surface flows. The wetland is fed predominantly from diffuse incoming flows from upstream and lateral subsurface inputs are present to a lesser extent.	• Increased sediment delivery to the HGM unit from erosion upstream. • Abstraction upstream. • Wetland margins are invaded by *Rubus cuneifolius* (American bramble) in places.

Water Resources	Description of habitat	Existing impacts
		
	Photo 9: View of largely intact herbaceous wetland W-01 looking upstream.	**Photo 10:** View lower reaches of W-01 where the crossing is proposed looking downstream.

4.4 Present Ecological State (PES)

Present ecological state (PES) refers to the health or integrity of an ecosystem defined as a measure of deviation from the reference state (Macfarlane et al., 2007). The Present Ecological state for rivers/riparian and wetland units are presented below separately.

4.4.1 *River PES*

A. SASS5 Derived Environmental Water Quality:

According the South Africa Scoring System (SASS) Data Interpretation Guidelines (Dallas, 2007) for the South Eastern Uplands – Lower biological band, the uMtamvuna River reach assessed can be classified as **Largely Natural (B PES Class).**

Invertebrates have evolved to survive in a particular suite of habitat conditions/ preferences and SASS results are a reflection of in-stream water quality as well as habitat quality, diversity and availability. In-stream biotope diversity was found to be moderate within the boulder/bedrock dominated reach of the uMtamvuna River. Despite the moderate SASS habitat availability, the results of the SASS5 assessment show that good quality water is present for sufficient periods to meet the life cycle requirements of sensitive aquatic biota that are intolerant to poor or fluctuating local water quality conditions. This is indicated largely by the Average Score Per Taxa (ASPT) which is a direct expression of the average sensitivity of taxa present to water quality. While this will vary seasonally, it does indicate longer term health or integrity within the instream environment. Table 10 below summarises the SASS5 results.

Table 10. Results from the SASS5 sampling within the uMtamvuna River (R-01).

Determinand	Rating/Score
Stones In Current (SIC)	4
Stones Out Of Current (SOOC)	2
Bedrock	4
Aquatic Vegetation	1
Marginal Vegetation In Current	2
Marginal Vegetation Out Of Current	3
Gravel	3
Sand	2
Mud	3
Biotope Score (%)	**53**
SASS Score	153
No. of Taxa	23
ASPT	6.7
Ecological Category (PES)	**B: largely Natural**

B. Index of Habitat Integrity (IHI)

The Present Ecological State (PES) for rivers includes both in-stream habitat as well as riparian habitat adjacent to the main channel. A summary of the results of the IHI assessment river health or PES is presented in Table 11, below, and shows that instream and riparian habitat associated with rivers was in **Natural/ Largely Natural (A/B PES Class) to largely Natural (B PES Class)** state.

Overall impacts to rivers are limited, largely due to the relatively untransformed nature of the associated catchments. Direct impacts were generally localised and include bed and bank erosion associated with cattle and human trampling as well as excavations around springs for abstraction purposes. Indirect impacts are limited to localised erosion and increased rates of sedimentation resulting from catchment surface runoff alteration, particularly the concentration of runoff along cattle and vehicular tracks. Alien vegetation has invaded river banks and wetland edges in places as a result of localised disturbances and historical alien seed sources (Black wattle), although this impact is limited in extent.

Table 11. Summary results of the river IHI (Index of habitat Integrity) assessment.

REF	Instream Habitat		Riparian Habitat	
	Integrity Score (% intact)	PES Category	Integrity Score (% intact)	PES Category
R -01	91	A/B	88	B
R -02	82	B	82	B
R -03	82	B	82	B
R -04	87	B	83	B

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

4.4.2 *Wetland PES*

Present ecological state (PES) is defined as a measure of deviation from the reference state (Macfarlane et al., 2009). Therefore, it is important to define the perceived hypothetical reference state of the HGM unit before undertaking the PES assessment. The unchannelled valley-bottom wetland (W-01) was likely characterised by hygrophilous grass and sedge dominated communities comprising predominately of obligate and facultative wetland species.

Based on the direct and indirect impacts to the wetland unit assessed, wetland condition (PES) can be regarded as **Largely Natural ("B" PES Category)** characterised by a small shift from perceived reference state. Table12 summaries the result of the WET-Health assessment as per the three components driving wetland condition.

Table 12. Summary of PES results for wetlands.

REF	Hydrology	Geomorphology	Vegetation	OVERALL PES
W-01	B	A	B	B: Largely Natural

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

Impacts driving the current hydrological integrity of the wetlands include low intensity catchment alterations to land cover affecting surface runoff and floodpeaks, and small water abstraction impacts upstream. Impacts affecting water distribution and retention within the wetland are limited. Some alien vegetation is present along the edges of the wetland but the impact on through flows is negligible.

While geomorphology remains the least impacted component of wetland integrity, anthropogenic impacts are identifiable and have led to a slight increase in sediment inputs to the system as a result of increased erosion within the catchment and increased deposition within the drainage network associated with informal vehicular and cattle tracks and footpaths.

Overall, impacts to the core of the wetland vegetation community is very limited and ruderal and alien invasive plant invasion of the permanent wetland habitat is also limited. However, the temporary and seasonal edges of the wetland have been disturbed by cattle access and grazing as well as by intense fires and, as a result, there is some incidence of alien vegetation within these areas, particularly *Rubus cuneifolius.*

4.5 Importance and Sensitivity of Water Resources

The importance and sensitivity of water resources is an expression of the hydrological/functional importance, social importance, ecological importance and ecological sensitivity. Generally, the maximum score/rating for each of these three components is considered the overall importance and sensitivity score.

4.5.1 *Functional and Social Importance (Wetland Ecosystem Services)*

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

The most significant ecosystem services provided are regulating and supporting services in the form of flood attenuation, streamflow regulation, sediment trapping, water quality enhancement (nutrients and toxicants), erosion control, carbon storage and biodiversity maintenance services. These services were on average assessed as being of **moderate importance** with the exception of erosion control which scored as **high**. Key determinants of moderate to high functional importance were:

- Diffuse un-channelled nature of flow (low energy).
- Dense and intact vegetation cover and high surface roughness.
- Predominance of permanent soil saturation.
- Limited physical disturbance.
- Presence of erosion in catchment.
- Presence of important aquatic ecosystems downstream, namely the uMtamvuna River.

Provisioning services are generally of **low importance** due to the fact that useful subsistence or other resources provided by the wetland are limited and the community do not currently utilise the wetland. Cultural services are of low to very low importance overall.

Figure 6, below shows the level of service provision for wetland W-01 and Table 13 below summarises the result of the ecosystem services assessment.

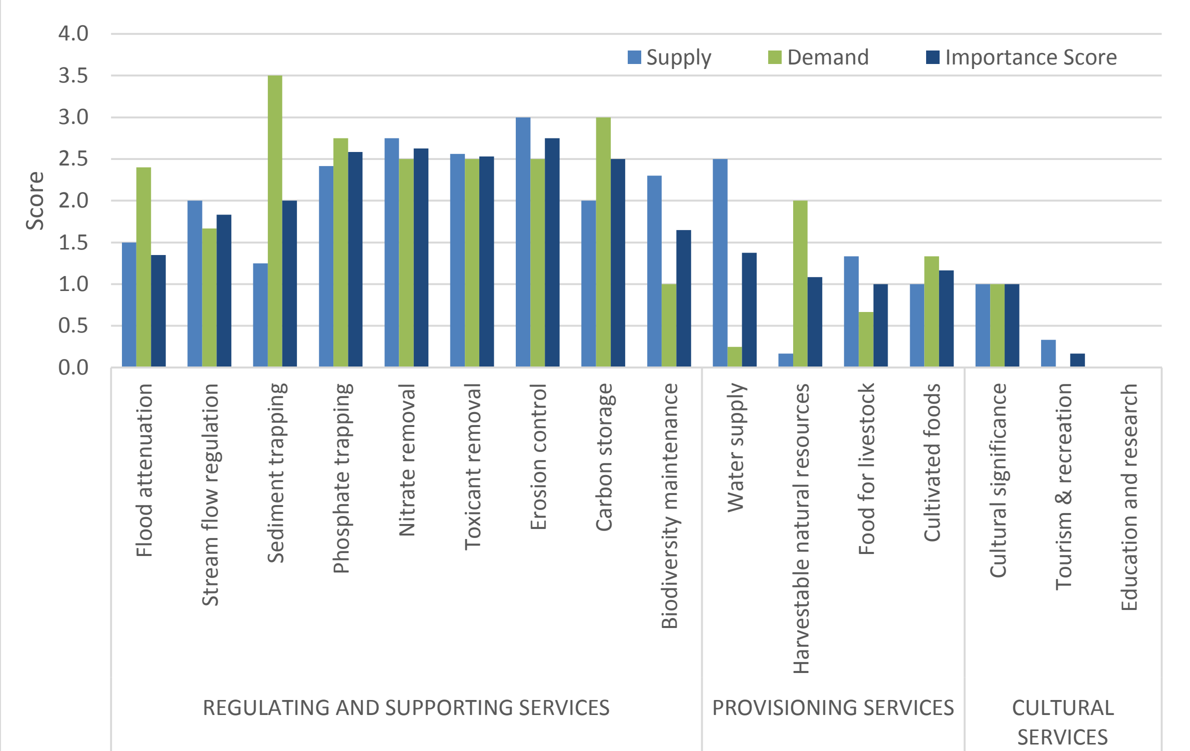


Figure 6 Graph showing the importance of wetland W-01 in providing ecosystem services.

Table 13. Summary of wetland importance for ecosystem service delivery.

ECOSYSTEM SERVICE		Importance Score	Importance	Comments
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.4	Low	Demand driven due to catchment slope, run-off potential and rainfall intensity.
	Stream flow regulation	1.8	Moderate	Due to hydrological zonation, strong surface-groundwater linkage and link to an important water resource downstream.
	Sediment trapping	2.0	Moderate	Demand driven due to presence of important aquatic ecosystems downstream but limited supply.
	Phosphate trapping	2.6	Moderate	Due to diffuse flows, extent of vegetation cover and important downstream ecosystems.
	Nitrate removal	2.6	Moderate	Supply driven but limited demand for these services due to low anthropogenic nutrient inputs.
	Toxicant removal	2.5	Moderate	Due to diffuse flows, extent of vegetation cover and important downstream ecosystems.
	Erosion control	2.8	High	Driven by the largely undisturbed nature of the system with good vegetation cover and limited evidence or active erosion, as well as important downstream ecosystems.
	Carbon storage	2.5	Moderate	Due to hydrological zonation, limited soil disturbance and the demand for carbon storage.
	Biodiversity maintenance	1.7	Moderate	Due to the relatively intact nature of this system and basic ecological factors like ecological connectivity and ecological buffers.
PROVISIONING SERVICES	Water supply	1.4	Low	As a result of stream flow augmentation and water need being met upstream of the wetland at the spring.
	Harvestable natural resources	1.1	Low	Limited grasses and sedges for use by communities
	Food for livestock	1.0	Low	Small narrow system with better alternatives for grazing nearby.
	Cultivated foods	1.2	Low	Not suitable due to narrow nature and wetness regimes.

ECOSYSTEM SERVICE		Importance Score	Importance	Comments
CULTURAL SERVICES	Cultural significance	1.0	Low	Driven by the presence of the wetland in a communal areas although no perceived cultural importance.
	Tourism & recreation	0.2	Very Low	Very limited to no importance.
	Education and research	0.0	Very Low	Very limited to no importance.

Note that individual assessment ExcelTM spreadsheets can be made available by Eco-Pulse upon request.

4.5.2 *Ecological Importance and Sensitivity (EIS)*

The Ecological Importance and Sensitivity (EIS) of riverine/wetland is an expression of the importance of the wetland/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 et al., 2007).

A. Riverine Units:

For the purposes of this assessment, the EIS assessment for rivers was based on rating the importance and sensitivity of riparian & in-stream biota (including fauna & flora) and habitat, using both desktop and on-site indicators. The results indicate that the smaller tributary river units (R-02 to R-04) draining into the uMtamvuna are of **low EIS (D EIS Class)** whereas the **Mtamvuna river (R-01) is of High EIS (B EIS Class)**.

The low EIS attained by the smaller rivers can be attributed to low flows and the lack of a habitat diversity to support important and sensitive biota. The high EIS attained by the uMtamvuna is largely driven by the intact nature of the system, with a range of suitable habitats for a variety of sensitive biota such as fish and macro-invertebrates. Furthermore the uMtamvuna river system represents one of the few remaining examples of free flowing rivers in KZN and thus presents good opportunities for instream migration as well as aquatic conservation. The river systems is also of high importance in terms of national freshwater ecosystem conservation planning. The results of the river EIS assessment have been summarised below in Table 14.

B. Wetland Units:

The wetland unit was assessed as being of **Moderate EIS (D EIS Class).** This was driven largely by the sensitivity of the habitat to floodpeaks and edge disturbances due to the narrow confined nature of the system. A summary of the EIS scores are shown in Table 14 below.

Table 14. Summarised EIS scores for the wetland unit.

Unit	EIS Score (out of 4)	Comments	Comments
Riverine Units			
R-01	3	B: High	• Diverse and sensitive aquatic biota (informed by SASS5). • Diverse and sensitive instream habitats. • Migration corridor for fish and macro-invertebrates. • Largely intact example of a free flowing river. • Refugia opportunities during low flows in large pools.
R-02	1	D: Low	• Low diversity of instream habitats. • Low flows will result in marginal habitat suitability for important and sensitive aquatic biota. • Limited refugia opportunities.
R-03	1	D: Low	
R-04	1	D: Low	
Wetland Units			
W-01	2	C: Moderate	• Low ecological importance due to low habitat diversity and lack of important species. • EIS driven by sensitivity of the HGM unit to changes in floodpeaks and its vulnerability to edge disturbance due to the narrow confined nature of the system.

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

5. ECOSYSTEM MANAGEMENT OBJECTIVES

Future management of the freshwater ecosystems identified for the project area should be informed by recommended management objectives for the water resource which, in the absence of classification, is generally based on the current ecological state or PES (Present Ecological State) and the EIS (Ecological Importance and Sensitivity) of water resources (DWAF, 2007 – see Table 15, below). This suggests that that the general management objective for river unit R-01 should be to be to improve the current state of the river within its current 'B' class or up to an 'A' PES class (as guided in Table 15). **It is acceptable to maintain the current status quo (B PES Class) without any further loss of integrity should mitigation measure proposed be implemented to specification.**

Table 15. Management measures for water resources.

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

6. IMPACT ASSESSMENT AND MITIGATION MEASURES

6.1 Identification and Description of Potential Impacts

Freshwater ecosystems, including wetlands & rivers, are particularly vulnerable to human activities and these activities can often lead to irreversible damage or longer term, gradual/cumulative changes to these ecosystems. When making inferences/predictions on the impact of development activities on aquatic ecosystems it is important to understand that these impacts speak specifically to their effect on the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) or functional importance/value of aquatic ecosystems. All of these are linked to the physical components and processes of aquatic ecosystems, including hydrology, geomorphology and vegetation as well as the biota that inhabit these ecosystems. Anthropogenic activities can generally impact either directly (e.g. physical change to habitat) or indirectly (e.g. changes to water quantity & quality).

For the purposes of this assessment, all of the potentially significant direct/primary and indirect/secondary impacts of the proposed development on the onsite and downstream freshwater ecosystems have been grouped within four broad impact categories:

1. Freshwater habitat destruction and modification impacts;
2. Catchment land cover and surface runoff modification impacts;
3. Direct flow modification impacts; and
4. Pollution impacts.

All of the impacts ultimately combine to impact on the ecological state and functionality (ecosystem services provision) of the onsite and downstream freshwater ecosystems. The ultimate consequences (ultimate / endpoint impacts) that are assessed can be summarised into the following four impacts as shown in Figure 7:

1. Deterioration in freshwater ecosystem integrity;
2. Reduction in the supply of ecosystem goods and services;
3. Reduction in the extent and conservation of freshwater habitat types; and
4. Reduction in the populations of threatened aquatic and wetland flora and fauna.

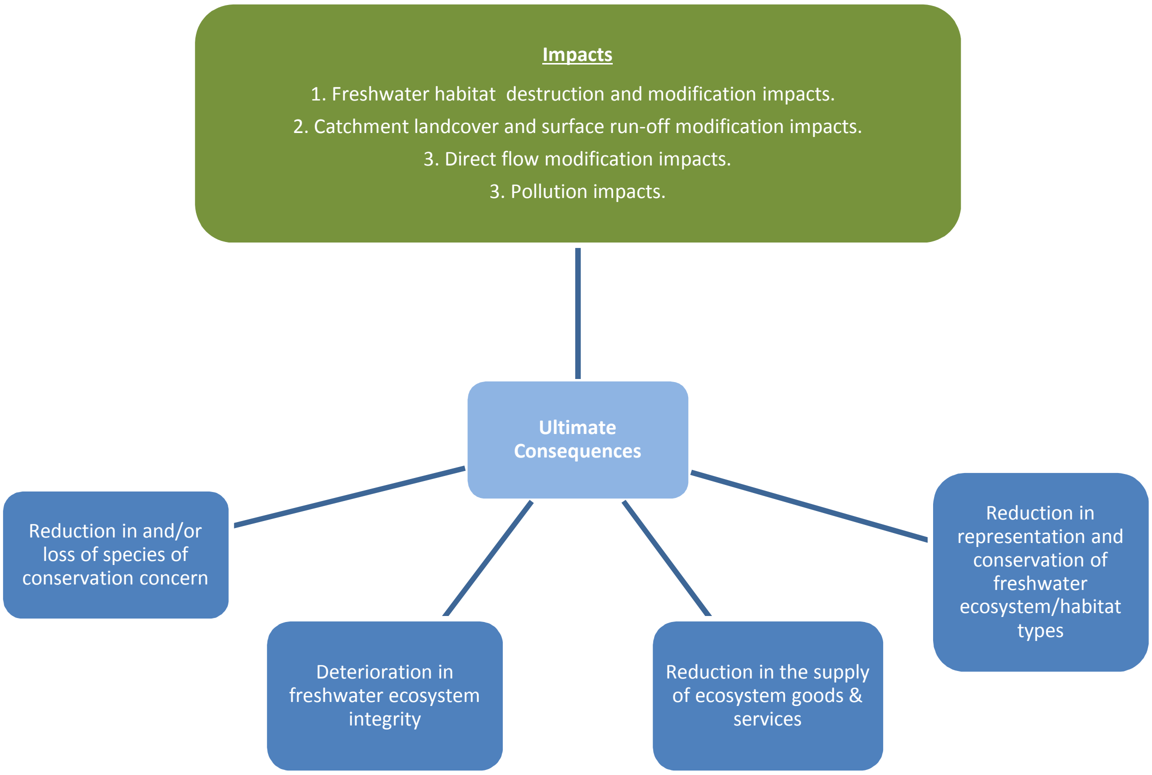


Figure 7 Diagram showing the range of negative ecological consequences of anthropogenic impacts to aquatic resources.

Impacts are discussed separately for the construction and operational phases of the proposed activity. While an attempt has been made to separate impacts into categories there is inevitable overlap due to the interrelatedness of impacts.

Please note that the impact descriptions and later assessment is based on the proposed activity description provided in Section 1.2 earlier.

6.1.1 Construction Phase Impacts

C1. Freshwater habitat destruction and modification impacts

This impact category refers to the direct physical destruction or disturbance of freshwater habitat caused by vegetation clearing, habitat infilling and/or excavation and all associated unintended indirect/secondary disturbances.

uMtamvuna River crossing:

The proposed development will likely result clearing of the uMtumvuna River riparian vegetation, the physical modification and re-shaping of the bed and banks disturbed by the bridge piers, and the infilling of such riverine habitat within the bridge footprint for the establishment of the embankments of the bridge. Presently, the banks have already been modified along the existing informal vehicular track and are largely bare and re-shaped. In addition, the river bed has been modified slightly by the re-ordering of instream rocks. Thus, the impacts of the crossing in terms of habitat destruction will be slightly reduced, particularly for the loss of riparian habitat.

Likely secondary consequences of such direct physical disturbance impacts include a reduction in bank stability, exposed bank erosion and in-stream and riparian habitat sedimentation downslope and downstream, aquatic habitat burying, increased water turbidity (increased suspended solid load) and aquatic fauna fatalities. Ultimately, the potential direct and indirect impacts of freshwater habitat will result in a deterioration in local freshwater ecosystem ecological condition downstream, particularly increased turbidity and sedimentation within the downstream pool habitats. This will result in a local reduction in the availability of intact natural habitat, particularly if mitigation measures are not implemented effectively.

Other associated impacts of working within freshwater habitats include direct faunal fatalities for those sedentary and immobile fauna inhabiting the areas to be transformed as well as a result of onsite poaching or killing during the construction phase.

Other indirect impacts that could affect the ecological condition of the freshwater habitat during working within the freshwater habitat are dust and noise pollution and vibration impacts during the construction phase that could contribute to increased water column turbidity and short-term disturbance impacts for fauna utilising the local freshwater habitat.

Further, the physical disturbance of the wetland and river/riparian habitat (soils and vegetation) around the construction footprint will open up the riparian habitat to invasion by locally occurring indigenous and alien invasive, pioneer and ruderal plant species, particularly if rehabilitation of the disturbed areas is not undertaken effectively. Alien plants and weeds have the ability to out-compete and replace indigenous flora, which will in turn impact on natural biodiversity. Such an impact could result in the gradual invasion of the local riparian habitat by these undesirable species and the alteration of the current composition of the freshwater vegetation communities. Such vegetation changes could lead to negative changes in aquatic instream habitat through decreased bank stability and soil cover that could lead to increased rates of erosion and sedimentation, and changes to the composition and structure of wetland and riparian/in-stream habitat that could alter microhabitats in terms of degree of shading, temperature and marginal vegetation biotopes. If rehabilitation is undertaken effectively and is signed off after successful indigenous vegetation re-establishment, the risks of these impacts should be minimised.

Wetland Crossing:

Similar impacts as described above can be expected for any proposed wetland crossings. In this case, the crossing would likely result in a small loss of wetland habitat under the crossing, as well as clearing of wetland vegetation within the construction servitude. The wetland is a lot more sensitive to onsite erosion and excessive erosion could result in headcut and gully formation that could threaten the integrity of the entire wetland unit. Burying of wetland habitat with eroded sediment is also a serious issue as this could also alter through flow dynamics and result in localised erosion. Ultimately, erosion impacts would result in a change from diffuse to channelled flows and decreased soil saturation rates adjacent to gullies leading to habitat transformation. Ultimate consequences would be habitat deterioration and decreased levels of indirect ecosystem service delivery.

C2. Catchment land cover and surface run-off modification impacts

This impact category refers to the alterations in hydrological and geomorphological inputs and ecological processes as a result of catchment transformation, as well as all associated secondary impacts.

Vegetation clearing and exposure of bare soils within and upslope of the freshwater habitats during construction will decrease the soil binding capacity and cohesion of the upslope soils and thus increase the risk of erosion and sedimentation downslope. If runoff and erosion control measure are not effectively implemented by the contractors, erosion rills and gullies may form along the cleared and exposed slopes upslope within the construction footprint and lead to increased rates of erosion and sedimentation within the riparian, in-stream and wetland habitat in the vicinity of the construction zone. Any erosion within the construction footprint will likely result in the sedimentation of the watercourses immediately below the construction servitude and the partial to complete burying of instream habitat depending on the severity of erosion.

Similarly such disturbances to catchment landcover and topography may also lead to increased surface runoff velocities entering the river due to soil compaction, reduced infiltration and the creation of preferential flow paths by machinery and labourers accessing the site. These impacts will be more pronounced during rainfall events and/windy conditions. In particular, due to the absence of access roads to the bridge site, the construction of temporary access roads is required to which will also pose a serious erosion risk, particularly if surface runoff is not managed and if the access road is aligned perpendicular to the slopes where it can act as a preferential flow route. The high erodobility of the catchment soils also needs to borne in mind.

Such impacts during will likely result in increased sediment loads, increased bed sedimentation and increased turbidity that will likely contribute to decreased local water quality and degradation in local aquatic habitat integrity.

The steep slopes and shallow erodible topsoil's within the study area will increase the intensity of this impact. If construction is undertaken in a poor manner with little consideration of minimising erosion and sedimentation impacts, there could be significant impacts in and around the construction zone that will contribute to deterioration in local wetland and riverine wetland habitat, onsite and downstream.

Some of the key aquatic biological effects related to the elevated levels of deposition and suspended sediment within the water column of rivers/wetlands may include:

- Habitat alteration downstream of crossing points due to increased sediment deposition;

- The creation of low light conditions reducing photosynthetic activity and the visual abilities of foraging aquatic biota;
- Increased downstream drift by benthic invertebrates causing localised reductions in population densities;
- Reduced density and diversity in benthic invertebrate and fish communities as a result of reduced water quality (suspended solids impacting intolerance taxa), habitat degradation caused by smothering of aquatic habitat, changes in streambed and biotope composition (i.e. reduced habitat suitability through the destruction of pool and/or riffle habitat).

Ultimately, the potential erosion and sedimentation impacts will result in a deterioration in local freshwater ecosystem ecological condition and a reduction in the availability of intact natural habitat, particularly if mitigation measures are not implemented effectively.

Under a poor mitigation scenario, indirect erosion/sedimentation impacts as a result of the disturbance of catchment land will likely be medium term and locally intense. Under a good mitigation scenario, the impacts will likely be short term, with recovery of aquatic ecosystems expected post construction should mitigation and rehabilitation measures be implemented to specification – see recommendations provided in Section 6.2 below.

C3. Direct flow modification impacts

This impact category refers to the physical alteration of throughflow through the establishment of impoundments, diversions and in-stream piers and/or as a result of water abstraction or water discharges, as well as all associated secondary impacts.

The establishment of in-stream piers for bridge crossings and culverted crossings for wetlands often requires temporary flow diversion to prepare the channel bed / wetland floor prior to culvert placement. A temporary change in local flow regime is the likely result of in-channel construction activities including coffer dams, diversions, dewatering activities around work areas and the installation of instream culverts. This will alter the low regime of the affected watercourse, particularly the impoundment of flows upstream of the construction area and concentrated flow releases downstream with temporary flow reductions also experienced downstream due to flow impoundment. Resultant impacts include increased sedimentation upstream of construction site crossing, increased bed and bank scour downstream, increased sedimentation downstream, and temporary discharge reductions downstream. The consequences of such impacts include habitat smothering / burying, increased turbidity, and temporary alteration of flow volume and variability, which all ultimately affect local aquatic habitat. See the description of erosion and sedimentation impact described above.

Lowering of a watercourse bed caused by excavations and culvert installations will also increase the velocity of flows to downstream habitat due to a localised increase in gradient, this can result in scouring downstream of the crossing and headward erosion if the base level is not maintained. Conversely if the bed of a watercourse is raised, upstream habitat will be inundated and sediment will be retained within the system. The downstream effect of this would be increased erosive energy of flows through an increased local gradient and a disruption of the water-sediment balance resulting in scouring - sediment free water is more erosive than sediment laden water.

Abstraction of water for construction purposes within the uMtamvuna River will result in a reduction of flows reaching downstream habitat, more so if undertaken during the dry season. Ultimately this will have an effect on instream habitat suitability to aquatic biota. Given the scale of the proposed bridge it is unlikely that direct impacts from reduced flows will have a significant impact on the availability of instream habitat.

C4. Pollution impacts

This impact category refers to the alteration or deterioration in the physical, chemical and biological characteristics of water with the channel and downstream. The term 'water quality' must be viewed in terms of the fitness or suitability of 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.

Potential construction phase contaminants and their relevant source 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).

These contaminants may enter the channel during construction activities and have the capacity to negatively affect the aquatic habitat within the vicinity of the construction corridor and downstream, particularly aquatic flora and fauna sensitive to changes in turbidity levels, nutrient levels, chemical oxygen demand and toxicants. Where significant changes in water quality occur, this will ultimately result in a shift in aquatic species composition, favouring more 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 leading to localised extinctions. Measurable negative water quality impacts are of significance within this system due to the largely intact nature of the instream environments and the sensitivity of habitats such as pools and riffles.

6.1.2 Operational Phase Impacts

O1. Catchment land cover and surface run-off modification impacts

Roads will increase the extent of hardened surfaces in the catchments of the assessed watercourses as well as result in the increased occurrence of point source surface water discharges associated with the stormwater management system of the new link road. Road networks intercept, direct and concentrate flows that changes (increases) volume and velocity of surface flows entering the watercourses. Increased hardened surfaces within the catchment will result in a small increase in surface water runoff but more importantly it will result in increased runoff velocities at discharge points that will become areas at risk from erosion (Photo 11). Stormwater discharges from formal rural roads in steep and erodible settings are known to pose serious gulley erosion risks and such impacts are already evident within the local catchment as a result of poor road alignment and stormwater management. If road stormwater is collected and discharged at few outlet points at low points in the road and limited erosion protection is installed (as would be expected in a rural setting), it is highly likely that erosion will occur below the stormwater discharge points which could lead to further erosion downslope and ultimately the sedimentation and/or erosion of riverine and wetland habitat, particularly the tributary systems, and ultimately increased transportation of sediment to the uMtamvuna River.

Photo 11: Example of erosion from road run-off entering a water courcse.

O2. Direct flow modification impacts

Mtamvuna River:

Although the proposed spanned bridge crossing will maintain free flowing conditions and have less of an impact that culvert structures, the proposed bridge will still have some negative impacts. The proposed piers and encroaching embankments of the spanned bridge will alter river flows through the creation of turbulence and eddies around the in-stream pier structures and the confinement of large floods by embankments (>1:10 year). Localised scouring and sedimentation will likely occur around the piers leading to local alteration of instream habitat. The crossing will also fix the channel banks at the crossing and the raised road embankment will likely impede large floods. Rivers in particular are highly dynamic systems and are continually reshaping their bed and banks through erosional and depositional processes in order to maintain a dynamic equilibrium. As the bed of the uMtamvuna reach assessed is comprises largely of bedrock and boulders that is resistant to scouring erosion, the river banks and floodplain terrace would therefore be key energy dissipaters under high / flood flows. Thus, fixing the bank will lead to increased erosional forces being exerted along other areas of the river bank that will result in increased bank scour immediately upstream and downstream of the crossing, and the resultant increase channel cross sectional area. The ultimate result would be a shift in the structure and composition of the river habitat including biotope types and overall habitat diversity.

Revising the proposed bridge design from a culvert crossing to a spanned bridge crossing will substantially reduce potential river fragmentation impacts as long as the number of pier structures within the channel are minimised and the piers do not cause substantial scouring and sedimentation. Rivers by nature are largely linear features often providing key linkages between important habitats including feeding and breeding habitat. This is of particular importance for migrating fish species that rely on habitat connectivity to complete their life-cycle. River crossings that use culverts may present more of a barrier by creating higher velocities, shallow flow depths, length of run with no resting areas, or excessive jump height for aquatic species. This is compounded by noise and light disturbances which will limit to some degree the natural patterns of species movement within water courses at various spatial scales, depending on species life stage, feeding and breeding requirements. The NFEPA status as a well as free flowing nature of the Mtamvuna River considerably increases the significance of this impact due to the lack of free flowing, largely intact (B PES Class) rivers in South Africa as a whole. Hence the necessity of changing the design of the river crossing to a bridge crossing.

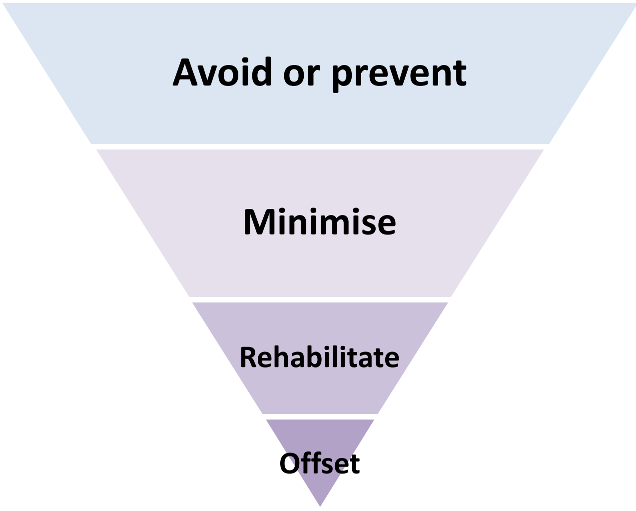
Other watercourses:

Similarly intensive operational impacts are expected for culverted wetland crossings, especially if the culverts are poorly sized or do not extent across the entire width of the wetland. W-01 is also highly sensitive to flow concentration and the establishment of a new base level and such a disturbance could result in adjustments in wetland longitudinal profiles ultimately resulting in the loss of wetland habitat associated with gully erosion.

6.2 Impact Mitigation and Management

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. 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 resource and the social systems that depend on it. Ultimately, the risk of water resource degradation must drive sustainability in development design. The protection of water resources (wetlands & rivers in this instance) 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 impacts. Driver *et al.* (2011) recommend 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). Mitigation requires proactive planning that is enabled by following the mitigation hierarchy (see Figure 8, below). Examples of mitigation can include changes to the scale, design, location, siting, process, sequencing, phasing, and management and/or monitoring of the proposed development activities, as well as the restoration or rehabilitation of disturbed sites. Where environmental impacts can be severe, the guiding principle should be "anticipate and prevent" rather than "assess and repair". A stepped approach should therefore be followed in trying to minimize development impacts which include:

1. Firstly, attempting to avoid/prevent impacts through project design and location;
2. Secondly, employing mitigation aimed at minimizing the magnitude/significance of impacts where these are unavoidable; and
3. Lastly, compensating for any remaining/residual impacts through on-site rehabilitation or through the application of offsets where deemed relevant.



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

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

6.2.1 Planning and Design Phase Mitigation (Pre-construction)

A. Mtamvuna River Bridge Design Recommendations

The following best practice alignment measures should be incorporated into the design of the proposed project:

- In light of the ecological importance of the Mtamvuna River, the river crossing should make use of a spanned bridge structure with minimal instream piers rather than a box culvert crossing to avoid the risks/impacts identified in Section 6.1 above. The use of box culverts to cross the river is not recommended due to the perceived impact on flows, habitat and biota. **<u>The motivation for this recommendation is linked to the current health and importance of this river (B PES Class and High EIS) as well as its FEPA status as a flagship free flowing river. Any alteration natural flow regimes and habitat condition for sensitive/migratory aquatic biota is undesirable and significant in this context.</u>**
- The height of the bridge should accommodate the 1:100yr flood events.
- Bridge abutments should not be located within 10m of the edge of the delineated riparian zone to allow for natural channel migration/adjustments over time.
- Where necessary, box culverts should be installed within abutments/embankments to allow for the natural spreading out of flood flows, and minimise the blocking of flood flows and the deactivation of flood terraces.

B. Link Road Alignment Recommendations

- Of the three link road alternatives, option 2 (Figure 9) should be used as this aligns largely with existing informal dirt tracks and avoids the crossing of additional water resources currently not impacted. The unnecessary crossing of Unit W-01 should be avoided.
- Notwithstanding the above, the road alignment must avoid long stretches that run perpendicular to steep slopes and should be re-aligned to run as close to parallel to contours as possible.
- The bridge crossing must be aligned along the existing corridor of disturbance i.e. where river bed and banks have already been modified. Under no circumstances must the bridge cross at unimpacted sections of the river.

C. Construction Access Alignment Recommendations

- Should temporary access routes be required outside of route option 2, the following is design/alignment recommendations apply:
  - The temporary access routes must avoid all water resources not being crossed by the preferred route 2. In addition, the access routes must not be located within 32m of unaffected watercourses <u>(i.e. Wetland and river habitat not being crossed by option 2 must be considered 'No Go' areas. This includes R-02, R-03, R-04 and W-04).</u>
  - The temporary access roads must not be aligned perpendicular to the slopes for long stretches to avoid the road acting as a preferential flow path for runoff.
  - Stormwater runoff and erosion control measures must be installed as part of the temporary access road and should include the establishment of many small shallow chute type drains and/or berms/cut-off drains at regular intervals along slopes that direct surface run-off from the road into adjacent grassland to avoid rill erosion and gully formation. Many small must be favoured over few large and these outlets must be armoured against erosion using dump rock/riprap.
  - Wherever possible, the temporary chutes/berms must not be aligned perpendicular to the slope.
  - The access roads must be one-way and adequate turning areas outside of the sensitive areas will need to be identified and demarcated in conjunction with the ECO.
- Access routes must be agreed upon prior to construction commencing and should be signed off by the ECO appointed.

D. Link Road Stormwater Management

The following design measures should be incorporated into the design of the road stormwater management system:

- Many small shallow chute/mitre type drains and/or berms/cut-off drains must be installed at regular intervals along the road to direct surface run-off from the road into adjacent grassland. Many small must be favoured over few large and these outlets must be armoured against erosion using gabion Reno-mattresses or riprap.

- Stormwater drainage should be via open drains/swales adjacent to the road with energy check structures rather than concrete drains. Under no circumstances must drop inlets and concrete pipes be utilised.
- Wherever possible, the temporary chutes/berms must not be aligned perpendicular to the slope.
- Outlet erosion protection structures must be designed to reduce outflows to energy levels that do not pose an erosion risk to downslope soils.
- Outlet erosion structures must be properly installed along the grade and elevation of the slope. Under no circumstances must the structures be placed higher than the ground surface thereby creating a drop off that may cause erosion.

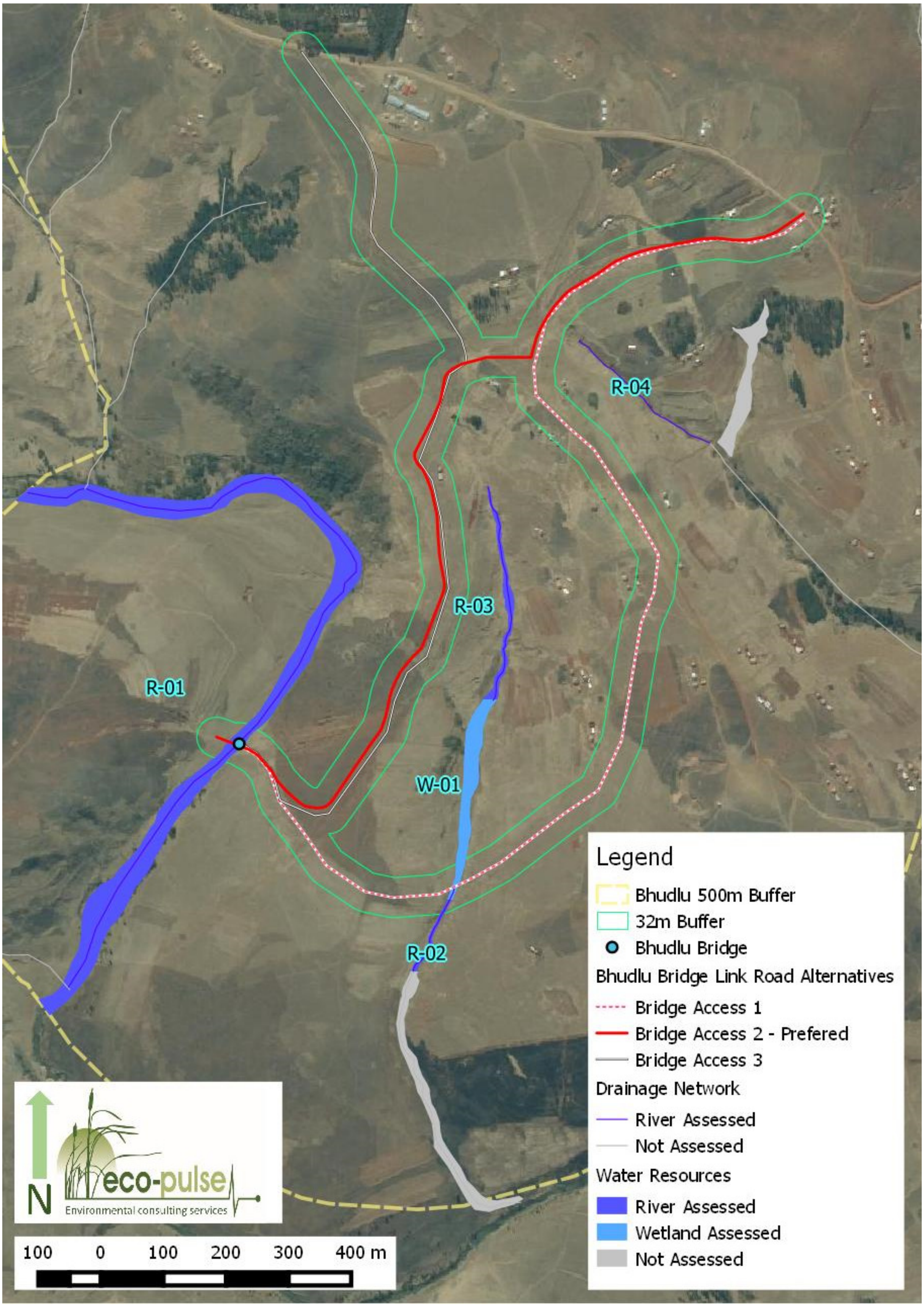


Figure 9 Access route option including the recommended (preferred route option 2).

6.2.2 Construction Impact Mitigation

A. Finalisation of Method Statements

A method statement for each finalised bridge crossing must be compiled by the ECO in line with the mitigation measures proposed below and in conjunction with the appointed contractor to confirm all methods of watercourse crossing/ encroachment include effective steps to minimise the impacts to freshwater habitat. An aquatic specialist will also need to provide input and comment on the method statement before finalisation.

B. Phasing

It is recommended that construction take place in the winter/dry months to reduce erosion and sedimentation risks associated with high summer rainfall in this region.

C. Site Setup and establishment

i. Defining the construction servitude/working area:

- The construction servitude/working area will comprise the following:
  - Bridge footprint and working area.
  - Selected access road option (option 2 preferred)
  - Soil stockpile area.
  - Equipment laydown and storage area.
  - Vehicle turning area.
- At watercourse crossings, a maximum construction working servitude of 4m should be allowed within the riparian, instream and/or wetland habitat.
- The temporary access roads must be strictly one-way and be a maximum width of 3m.
- No vehicle turning areas must be located within 32m of any watercourse.
- No equipment laydown or storage areas must be located within 50m of any watercourse and/or within the 1:100 year floodline.
- No soil stockpile areas must be located within 20m of any watercourse.

ii. Demarcations and No-go Areas:

- The outer edge of the construction servitude/working area as defined above must be clearly demarcated for the entire construction phase using plastic orange bonnox fencing.
- Once the temporary access route has been agreed to by the ECO, the outer edge of the access route must be staked out by the contractor using brightly coloured stakes prior to the access route being used by machinery.
- All demarcation work must be signed off by the Environmental Control Officer (ECO) before any work commences.
- Any contractors found working inside the 'no-go' areas (areas outside the working servitude) should be fined as per fining schedule/system setup for the project.

iii. <u>In-stream sediment control measures:</u>

- Before any work commences in the river channel, sediment control/silt capture measures (e.g. bidim/silt curtains) must be installed downstream of the working areas within the river. Quantities of silt fences/curtains shall be decided on site with the engineer, contractor and ECO. The ECO should be present during the location and installation of the silt curtains.
- During works within the channel, the downstream silt fences/curtains must be regularly checked and maintained (de-silted to ensure continued capacity to trap silt), and repaired where necessary.

D. Contractor induction and staff education

- Staff environmental induction must take place prior to construction commencing and any sub-contractors utilised must be inducted before starting work onsite. All contractor employees must receive basic environmental awareness training and shall be educated on the requirements of the EMPr. The environmental induction training is the responsibility of the project manager and the contractor and should be undertaken by the EO or a suitably qualified person. The Environmental Control Officer (ECO) must oversee and monitor the induction training to ensure that the training is sufficient and that adequate training is provided prior to construction commencing.
- All staff involved in work within the freshwater habitats must receive specific inductions related to the detailed methods statements.
- All managers, contractors, labourers and personnel involved during the project are to be familiarized with the method statement.
- It is vital that all personnel are adequately trained to perform their designated tasks to the accepted standards.
- The ECO must monitor the compliance of the Contractors and instruct the Contractors where necessary. The ECO may request that the Project Manager suspend part or all the works if the Contractors repeatedly cause damage to the environment. The suspension should be enforced until such time as the offending actions, procedure or equipment is corrected and the environmental damage repaired.
- A copy of the method statement will need to be made available at the construction site offices/site camp at all times.

E. Construction area clearing

- Indigenous vegetation and topsoil cleared for the construction servitude/working area should be rescued and stored at the designated vegetation and soil stockpile area outside of the wetland/aquatic zone for use later in rehabilitation. In this regard, vegetation will need to be cleared in-situ (with sods/topsoil).

F. Soil Management (Stockpile areas)

- Erosion/sediment control measures such as silt fences, low soil berms or wooden shutter boards must be placed around the stockpiles to limit sediment runoff from stockpiles.
- Subsoil and topsoil is to be stockpiled separately. Stockpiled soil must be replaced in the reverse order as 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, which must fall within the demarcated construction area. The contractor shall, where possible, avoid stockpiling materials in vegetated areas that will not be cleared.
- Stockpiled soils are to be kept free of weeds and are not to be compacted. The stockpiled soil must be kept moist using some form of spray irrigation on a regular basis as appropriate and according to weather conditions.
- The slope and height of stockpiles must be limited to 2m to avoid collapse.

G. Flow and erosion/sedimentation control measures:

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

- The natural flow of rivers or streams shall not be permanently diverted or blocked.
- Maintain adequate through flows to downstream aquatic ecosystems to protect aquatic life, and prevent the interruption of existing downstream uses.
- Clearing activities must only be undertaken during agreed working times and permitted weather conditions. If heavy rains are expected, clearing activities should be put on hold. In this regard, the contractor must be aware of weather forecasts.
- Construction activities should be scheduled to minimise the duration of exposure to bare soils on site, especially on steep slopes.
- Run-off generated from cleared and disturbed areas/slopes that drains into rivers, streams or wetlands must be controlled using erosion control and sediment trapping measures like silt fences, sandbags, earthen berms and synthetic logs, particularly where slopes are exposed. These control measures must be established at regular intervals perpendicular to the slope to break surface flow energy and reduce erosion as well as trap sediment.
- Sediment barriers (e.g. silt fences, sandbags, hay bales, earthen filter berms, retaining walls and check dams) must be established to protect water resources from erosion and sedimentation impacts from upslope. Sediment barriers should be regularly maintained and cleared so as to ensure effective drainage.
- The berms, sandbags and/or silt fences must be maintained and monitored for the duration of the construction phase and repaired immediately when damaged. The berms, sandbags and silt fences must only be removed once vegetation cover has successfully re-colonised the disturbed areas post-rehabilitation.
- During construction, the contractor must check the site for erosion damage after every rainfall event, and rehabilitate this damage immediately.

It is important that all of the above-listed 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.

H. Pollution prevention measures:

The following measures should be implemented in conjunction with the generic pollution prevention measures provided in the Construction Environmental Management Programme (EMPr):

- Hazardous storage and refueling areas must be bunded prior to their use on site during the construction period following the appropriate SANS codes.
- The bund wall should be high enough to contain at least 110% of any stored volume.
- The surface of the bunded surface should be graded to the centre so that spillage may be collected and satisfactorily disposed of.
- 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 so as to prevent leaks.
- Mixing and/or decanting of all chemicals and hazardous substances must take place on a tray, shutter boards or on an impermeable surface and must be protected from the ingress and egress of stormwater.
- Drip trays should be utilised at all dispensing areas.
- No refueling, servicing nor chemical storage should occur within 50m of the delineated wetland/aquatic habitat or within the 100-year flood line, whichever is applicable.
- No vehicles transporting concrete, asphalt or any other bituminous product may be washed on site.
- Vehicle maintenance should not take place on site unless a specific bunded area is constructed for such a purpose.
- Ensure that transport, storage, handling and disposal of hazardous substances is adequately controlled and managed. Correct emergency procedures and cleaning up operations should be implemented in the event of accidental spillage.
- If a water pump is required, the water pump must operate inside or on top of a drip tray to prevent any spillage of fuel and limit the risk of soil/water contamination. The drip tray will need to be lined with absorbent pads and checked daily while in use.
- All equipment to be used within the sensitive working areas (within the channel) must be checked daily for oil and diesel leaks before gaining access to these working areas.
- An emergency spill response procedure must be formulated and staff are to be trained in spill response. All necessary equipment for dealing with spills of fuels/chemicals must be available at the site. Spills must be cleaned up immediately and contaminated soil/material disposed of appropriately at a registered site.
- 44-gallon drums must be kept on site to collect contaminated soil. These should be disposed of at a registered hazardous waste site.
- Fire prevention facilities must be present at all hazardous storage facilities.

- Sanitation - portable toilets (1 toilet per 10 users) to be provided where construction is occurring. Workers need to be encouraged to use these facilities and not the natural environment. Toilets must not be located within the 1:100yr flood line of a watercourse or closer than 50m or from any natural water bodies including rivers, streams, riparian areas and wetlands. Waste from chemical toilets must be disposed of regularly (at least once a week) and in a responsible manner by a registered waste contractor. Toilet facilities must be serviced weekly and in a responsible manner by a registered waste contractor to prevent pollution and improper hygiene conditions.

I. Solid waste pollution control:

- Eating areas must not be located within 15m of the wetland/riparian habitats.
- Provide adequate rubbish bins and waste disposal facilities on-site and educate/encourage workers not to litter or dispose of solid waste in the natural environment but to use available facilities for waste disposal.
- Clear and completely remove from site all general waste, constructional plant, equipment, surplus rock and other foreign materials once construction has been completed.
- Recycling/re-use of waste is to be encouraged.
- Litter generated by the construction crew must be collected in rubbish bins and disposed of weekly at registered sites by a registered waste management company.
- No litter, refuse, wastes, rubbish, rubble, debris and builders wastes generated on the premises be placed, dumped or deposited on adjacent/surrounding properties during or after the construction period, but disposed of at an approved dumping site. The construction site must be kept clean and tidy and free from rubbish.

J. Alien plant control:

- All alien invasive vegetation that has colonised the construction site must be removed, preferably by uprooting. The contactor should consult the ECO regarding the method of removal.
- All bare surfaces across the construction site must be checked for alien invasive plants at the end of every month and alien pants 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 to be used. The ECO must be consulted in this regard.

K. Freshwater habitat rehabilitation

Refer to Section 6.2.3 below.

L. General rehabilitation

- Immediately after construction disturbed areas must be re-vegetated using the rescued plant sods and supplemented with transplants from adjoining like habitats if required. Alternatively, re-seeding via broadcasting using an indigenous seed mix reflecting the general species composition of the area should also be used where necessary. If such seed mixes are not available, seed will need to be harvested from the area and grown nearby for later re-vegetation using plugs/sprigs.

- A biodegradable geofabric mat (or vegetation blanket) must be utilized to protect the topsoil on steep slopes from water and wind erosion during re-vegetation. Alternatively, the plants can be secured using a coarse mesh (steel wire or plastic). The mesh or mat is placed over the vegetation securing it until it can fully establish. The plants must be able to grow unhindered through the mesh or matting. Mats can be staked down.
- Alien and weedy vegetation that colonize the disturbed areas must be removed and eradicated as per measure J above.
- The soils must be adequately prepared prior to planting by a contractor with experience in re-vegetation and under no circumstances must fertiliser be applied.
- Once the initial transplants / plugs are planted, the contractor to conduct weekly site visits to monitor re-establishment and remove alien plants (in accordance with the latest revised NEM:BA requirements) and address any re-vegetation concerns until re-vegetation is considered successful (i.e. >90% indigenous cover). Thereafter, the rehabilitation must be signed off by the ECO.

M. Accidental Incursions into No-Go Areas

- Should wetland and riparian areas outside of the construction corridor 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 relevant re-vegetation/re-planting plan.
- Where stream channels have been disturbed, the channels should be re-graded, stabilised using erosion control measures and re-vegetated as per the relevant re-vegetation/re-planting plan.

6.2.3 Construction Rehabilitation Guidelines

Note: rehabilitation guidelines pertain to wetland, river/riparian areas and their associated buffer zones. Rehabilitation refers to all disturbed areas affected by constriction activities. The key objective of rehabilitation in this context is as follows:

- Stabilise erodible soils/material.
- Ensure continued hydrological functioning.
- Ensure all disturbed areas are well vegetated.
- Ensure alien plant do not colonise disturbed areas.

Rehabilitation will aid the recovery of the ecosystems and can be seen as critical in preventing further impacts to these systems including those associated with alien plant infestations, soil erosion and sedimentation. The following rehabilitation guidelines (step 1 to 5 in Table 16 below) have been recommended:

Table 16. Freshwater habitat rehabilitation guidelines

STEP	GUIDELINE
STEP 1: Stabilise unstable/eroding channel banks	• Any erosion features need to be stabilised. This may include the need to deactivate any erosion headcuts/rills/gullies that may have developed. Compacted soil infill, rock plugs, gabions or any other suitable measures can be used for this purpose. • All foreign sediment washed into the buffer zone and wetland from upslope erosion must be removed taking care not to remove or disturb the natural soil profile.
STEP 2: Remove any waste products	• All foreign materials and waste products (spoil, construction materials, hazardous substances and general litter) need to be removed from wetland/riparian areas and disposed of in proper local waste facilities. • Minimise additional disturbance by limiting the use of heavy vehicles and personnel during clean-up operations.
STEP 3: Remove alien plants from water resources	• All exotic/alien plants and weeds to be removed and properly disposed of prior to the implementation of rehabilitation measures.

STEP 4: Restore natural topography and prepare soils	• The natural topography is to be re-instated as close as practically possible to pre-construction dimensions to ensure natural drainage patterns.
	• The channel bed type (e.g. alluvium, rocks, pool, riffle etc.) is to be reinstated.
	• For unstable of steep banks it is acceptable to reshape to a stable angle of repose to avoid stumping.
	• 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.
	• Where good topsoil exists, no specific preparation is required.
	• Where re-vegetation on its own is not sufficient to stabilize the banks (as determined by a rehabilitation specialist), 'soft' stabilization (bioengineering applications) (e.g. fascine work, brush mattresses etc.) interventions should be installed where necessary and applicable (to be determined in the detailed rehabilitation plan). As a principle, 'soft' stabilsation interventions should be favored over 'hard' interventions wherever possible to ensure that the channel retains some dynamism and habitat.
	• The following soft interventions (in addition to re-vegetation) should be investigated (Russell, 2009):
	  o Fibre mats / blankets/ mattresses / nets.
	  o Fibre rolls.
	  o Fibre bags.
	  o Brush or vegetation mattresses (mats).
	  o Terracing.
	  o Live or inert fascines.
	  o Live staking.
	• For re-planting/re-seeding, the soil needs to be prepared to optimise germination. Such preparation is undertaken by hand hoeing. The soil in the seedbed should be loosened but firmed to facilitate good contact between the seeds and the soil.
	•

STEP 4: Reinstate riparian/riverine vegetation	• A trained rehabilitation expert should be contracted to oversee the rehabilitation of areas. • Once alien vegetation and waste products have been removed and soils are prepared for planting, vegetation is to be reinstated as soon as weather conditions allow for plant growth. • The disturbed and bare areas must be re-vegetated using indigenous plants rescued during initial clearing and plugs of naturally occurring indigenous riparian vegetation including the dominant occurring clump grasses: e.g. *A. nepalensis*, *M. junceus* and *Aristida junciformis* as well as *C. dactylon*, a naturally occurring rhizomatous grass suitable for soil stabilisation. • Although not recommended – if wetland habitat is disturbed, these areas will also need to re-vegetated with plugs of locally occurring clump grasses like *M. junceus*. • Locally occurring, indigenous runner grasses are typically most useful for rehabilitation of disturbed areas. These should ideally be sourced locally (areas within a 50 km radius). If this is <u>not</u> feasible, then a sterile variety of Couch Grass (*Cynodon dactylon*) can be commercially sourced and planted. • Do not use fertilizer, lime, or mulch unless required. • Mono-specific planting should be avoided as diversity is the key to robustness, which will assist in retaining sediment and preventing erosion. • It is important to note that bioengineering interventions are vulnerable to failure immediately following construction should a drought or large flood take place. Thus, the timing of construction to avoid peak flow conditions is very important to the rehabilitation success. This will, however, result in the need to irrigate the re-vegetated area to aid establishment. • If using fibre mats, avoid 3D 'tangle' type mats and fibre mats with a scrim section for ecological reasons.

	• Alien plant species are not to be used for re-vegetation, particularly those with invasive potential (Category 3 and above – National Environmental Management: Biodiversity Act or NEMBA). • When sourcing plants from nurseries, it is important to consider the genetic origin of the plants. It is considered best to use small regional nurseries that breed plants from the region, instead of large commercial nurseries that are likely to obtain stock from large regional suppliers. • Temporary erosion protection measures must only be removed once good vegetation cover has established. • Should the replanting area be invaded by weeds prior to planting, these must be hand pulled, hoed or killed with an appropriate environmentally friendly herbicide. Care must be taken, however, of not clearing all weeds indiscriminately as the weeds may be performing a useful soil covering and binding function.
STEP 5: Monitor re-vegetation progress and administer alien plant control	• A basic framework for rehabilitation monitoring is provided in Table 17 below. • Recovery of disturbed areas should be assessed for the first 6 months to assess the success of rehabilitation actions. Any areas that are not progressing satisfactorily must be identified (e.g. on a map) 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 12 months and include any recommendations for further action to the relevant environmental authority (EDTEA). • The use of herbicides in IAP control will require an investigation into the necessity, type to be used, effectiveness and impacts of the agent on aquatic biota. • Any soil erosion in rehabilitated areas must also be addressed through appropriate actions.

Table 17. A basic framework for rehabilitation monitoring.

Phasing	Frequency	Assessment	Duration
Pre-Construction Phase	Before construction commences	Baseline fixed-point photography of freshwater habitat to be cleared	Before construction commences
Remediation Phase	Bi-monthly (every 2 weeks) site visit and monthly report	Compliance with detailed rehabilitation plan and method statements, intervention/bank stability, success of re-vegetation, alien/weed encroachment	±3 months
Recovery phase	Bi-annual site visit and ad-hoc site visits following large storm events	Intervention stability / bank stability, success of re-vegetation, alien/weed encroachment	±12 months

6.2.4 Operational Phase Impact Mitigation

A. Stormwater Management

Adhere to the stormwater design recommendations provided in Section 6.2.1(D) above.

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 link road and bridge structure, in perpetuity. 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;

- 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 negligible.

6.3 Implementation and Monitoring

In dealing with significant impacts to aquatic resources during both the construction and operation phases, mitigation would be best achieved through the incorporation of the mitigation measures recommended in this report into an Environmental Management Programme (EMPr) for the project. This EMPr should define the responsibilities, budgets and necessary training required for implementing the recommendations made in this report. This will need to include impact management and the provision for regular auditing to verify environmental compliance. The EMPr should be enforced and monitored for compliance by a suitably qualified/trained ECO (Environmental Control Officer) with any additional supporting EO's (Environmental Officers) having the required competency skills and experience to ensure that environmental mitigation measures are being implemented and appropriate action is taken where potentially adverse environmental impacts are highlighted through monitoring and surveillance. The ECO will need to be responsible for conducting regular site-inspections of the construction, rehabilitation and operation processes, reporting back to the relevant environmental authorities with findings of these investigations. The ECO will need to prepare a training programme to educate machine operators about the sensitivity of constructing within aquatic environments associated with wetlands/rivers and also be responsible for preparing a monitoring programme to evaluate construction compliance with the conditions of the EMP.

6.3.1 Monitoring Recommendations

Monitoring is required In order to ensure that wetlands and rivers affected by the proposed development are maintained in their current ecological state or improved but incurring no net loss to ecosystem integrity and functionality as a result of construction. It is recommended that a Monitoring Programme be developed and implemented in accordance with the following guidelines.

A. Construction monitoring objectives:

Key monitoring objectives during the construction-phase should include:

- o Ensuring that management and mitigation measure (included in Method Statements and EMPr) are adequately implemented to limit the potential impact on aquatic resources; and
- o Ensuring that disturbed areas have been adequately stabilised and rehabilitated to minimise residual impacts to affected resources.

B. Construction phase monitoring requirements (ECO):

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 the bed and banks of water resources.
- Signs of intense or excessive erosion (gullies, rills, scouring and headcuts) and/or sedimentation within, along the edge and/or immediately downstream of the construction zone.
- 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 habitat during construction across rivers/streams/wetlands.
- Pollution of water resources (with a particular focus on water turbidity and 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.
- Evidence of unsafe working conditions (e.g. evidence of flow overtopping the bund wall/running tracks).

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 of the effectiveness of rehabilitation activities. The ECO and construction staff would need to perform routine checks of rehabilitation effectiveness with the initial focus on stabilising and vegetating disturbed soils and the restoration of natural topography. This can also be achieved through basic visual inspections documenting inadequacies in the rehabilitation outcomes for remediation. Once complete it is recommended that an independent aquatic specialist is consulted to ensure the success of rehabilitation and to identify shortcomings that will need to be addressed.

C. Operation phase monitoring requirements:

This involves annual monitoring of water resources (rivers/wetlands) crossed by the development in order to ensure that operational impacts identified for each crossing are being effectively managed. This can also be achieved through basic visual inspections by the ECO and support staff, documenting issues such as:

- Alien Invasive Plant colonisation;
- Scouring around or infrastructure at crossings (including bridge and culvert structures); and
- Channel bank erosion and collapse (bank instability concerns).

D. Responsibilities for monitoring:

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

6.4 Additional Requirements

6.4.1 *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.

The following Section 21 water use activities may be to be triggered by the proposed development and associated activities and would require a water use license from the DWS:

NWA Section 21 Water Use	Relevance to Project
21 (a): ***Taking water from a watercourse***	Abstraction for construction purposes. May fall under General Authorisation depending on quantity abstracted.
21(c): ***Impeding[1] or diverting[2] the flow of water in a watercourse***	During instream works
21(i): ***Altering the bed, banks, course or characteristics of a water course[3]***	Bridge abutments on river banks or instream construction.

6.5 Impact Significance Assessment

The impact significance assessment was undertaken for the original proposal (Alignment Option 2 with a culvert bridge crossing) and the revised proposal (Alignment Option 2 with a spanned bridge crossing). It is assumed that the latter option if the developer's preferred option and as such the original proposal is included for comparative purposes.

The significance of the identified potential impacts of the proposed development proposals on freshwater ecosystems was assessed for the following realistically possible scenarios:

[1] ***Impeding the flow*** - refers to the temporary or permanent obstruction or hindrance to water flow in a water course by a structure built either fully or partially in or across a watercourse (DWAF, 2009).

[2] ***Diverting the flow*** - refers to a temporary or permanent structure causing glow of water to be rerouted (DWAF, 2009)

1. **Realistic poor mitigation scenario** – this is a realistic worst case scenario involving the poor implementation of construction mitigation, bare minimum incorporation of recommended design mitigation, poor operational maintenance, and poor onsite rehabilitation.
2. **Realistic good mitigation scenario** – this is a realistic best case scenario involving the effective implementation of mitigation recommended in this report i.e. effective implementation of construction mitigation, incorporation of the majority of design mitigation, good operational maintenance and successful rehabilitation.

An attempt has been made to quantify the relative significance of the range of potential freshwater ecosystem impacts identified in **Section 6.1** with the summary of the results shown in Table 13, below.

Please note that where recommended planning and design mitigation measures have not been incorporated into the design of the development proposals, these measures have not been included in the 'good mitigation' (post-mitigation) scenarios.

6.5.1 Original Proposal (Culvert Bridge)

Construction Phase Impacts:

With poor mitigation, Impacts C1 and C3 were assessed as being of **moderate significance and generally unacceptable**. This is largely due to the ecological importance and sensitivity of the freshwater habitats assessed, particularly the uMtamvuna River, and the high impact intensity of the proposed activities i.e. direct physical modification of sensitive riverine and wetland habitats.

Should the recommended mitigation measures be implemented to specification (good mitigation scenario), all of the impacts can be reduced and as such the significance can be reduced to a **moderately-low level**.

It is important to note however that such scenario assumes the very strict adoption and implementation of the recommended mitigation measures. Should any of these recommendations not be accepted, especially the design recommendations, these impact significance would remain moderate and generally unacceptable.

Operational Phase Impacts:

With poor mitigation, both operational impacts were assessed as being of **moderate significance and generally unacceptable**. This is linked to the sensitivity of the receiving freshwater environment (particularly to erosion) and the potential fragmentation effects of the proposed box culvert system. With realistic mitigation (but assuming the box culvert crossing is retained), the significance of Impact O1 can be reduced to a **moderately-low significance** and more acceptable levels. However, even with good mitigation, the significance of Impact O2 will remain **moderate and generally unacceptable** as long as the box culvert system is retained.

Table 18. Assessment of the significance of the freshwater ecosystem impacts for the original proposal.

CONSTRUCTION-PHASE IMPACTS		IMPACT SIGNIFICANCE	
		Poor mitigation	Good mitigation
C1	Freshwater habitat destruction and modification impacts	Moderate	Moderately Low
C2	Catchment land cover and surface runoff modification impacts	Moderately Low	Moderately Low
C3	Direct flow modification impacts	Moderate	Moderately Low
C4	Pollution impacts	Moderately Low	Moderately Low
OPERATION-PHASE IMPACTS		IMPACT SIGNIFICANCE	
		Poor mitigation	Good mitigation
O1	Catchment land cover and surface runoff modification impacts	Moderate	Moderately Low
O2	Direct flow modification impacts	Moderate	Moderate

6.5.2 Revised Proposal (Spanned Bridge)

Construction Phase Impacts:

The significance of the potential construction impacts is similar to that assessed for the original proposal. See Section 2.5.1 above.

Operational Phase Impacts:

With poor mitigation, operational impact O1 was assessed as being of **moderate significance and generally unacceptable** for similar reasons to that described for the original proposal. However, the significance of Impact O2 has been reduced to moderately low due to the spanned bridge maitaing the free flowing nature of the Mtamvuna River. With the implementation of good mitigation, all operational impacts can be reduced to **moderately-low significance** and acceptable levels should mitigation measures recommended in this report be implemented to specification.

Table 19. Assessment of the significance of the freshwater ecosystem impacts for the revised proposal.

CONSTRUCTION-PHASE IMPACTS		IMPACT SIGNIFICANCE	
		Poor mitigation	Good mitigation
C1	Freshwater habitat destruction and modification impacts	Moderate	Moderately Low
C2	Catchment land cover and surface runoff modification impacts	Moderately Low	Moderately Low
C3	Direct flow modification impacts	Moderate	Moderately Low
C4	Pollution impacts	Moderately Low	Moderately Low
OPERATION-PHASE IMPACTS		IMPACT SIGNIFICANCE	
		Poor mitigation	Good mitigation
O1	Catchment land cover and surface runoff modification impacts	Moderate	Moderately Low
O2	Direct flow modification impacts	Moderately Low	Moderately Low

7. CONCLUSION

The uMuziwabantu Municipality (KZN) and Mbizana Municipality (EC) intend to provide direct link between the municipalities and link up the communities of Nyandeni (KZN) and Nomganya (EC) over the uMtamvuna River. The proposed developments includes the construction of link road to provide access the river crossing and the construction of a bridge over the uMtamvuna River. The main findings of this specialist report have been summarized below.

The landscape is characterised by a diversity of drainage types, all of which have unique habitat features and vegetation characteristics. Given the largely undeveloped nature of the catchment areas associated with water resources and the relatively low levels of physical disturbance to freshwater habitat, freshwater habitat remains in relatively good condition. Overall, the water resources assessed are in a largely natural (B PES Class) state with a small shift from reference state expected. The ecological importance and sensitivity (EIS) of water resources is more variable. Small tributary streams of the uMtamvuna are classified as of low EIS (D EIS Class) whereas the uMtamvuna River itself is of high EIS (B EIS Class). The wetland unit assessed does provide some key regulating and supporting services such as flood attenuation, streamflow regulation, sediment trapping, water quality enhancement (nutrients and toxicants), erosion control, carbon storage and biodiversity maintenance whereas provisioning and cultural services are low to very low.

Due to the sensitivity and importance of the freshwater habitats assessed and erodibility of the catchment soils, the proposed activities stand to have serious measurable impacts (of moderate significance) on the onsite and local/regional freshwater ecosystems if the link road and bridge are poorly designed, poorly constructed and the construction disturbances are poorly rehabilitated. As a result, a detailed suite of design/planning, construction phase and operational phase mitigation measures have been provided with the aim of reducing the intensity and significance of the potential impacts.

If the recommended design and alignment measures and construction measures are adopted and adhered to, the potential impacts can be reduced to more acceptable levels (moderately-low significance). However, this would involve the total re-designing of the bridge crossing to be a spanned structure. The most significant risks are the long-term impacts of the bridge crossing on the uMtamvuna River, particularly if the proposed box culvert bridge results in reach fragmentation. This system represents one of the last remaining large free flowing rivers is the province of KZN and provides habitat and a migration corridor for a number of sensitive aquatic biota. The proposed bridge design, using instream box culverts, has the potential to alter local habitat, interfere with river hydrology and geomorphology and impede or restrict the movement of aquatic biota using the river at various scales for breeding, feeding and habitat colonisation. As such it is recommended that a spanned bridge structure with support structures outside the river channel and its banks be established. This structure must allow flows to access the floodplain under peak flows and cater for lateral movement of the channel as it would under natural geomorphic process.

In response to these planning and design recommendations, the applicant has revised the Mtamvuna River bridge proposal to be a spanned bridge rather than culvert bridge, which has reduced the significance of the operational impacts to more acceptable levels. It is strongly recommended that only this revised proposal be taken forward as part of the environmental authorisation and water use license applications. Furthermore it is strongly recommended that alignment option 2 be considered only.

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9. ANNEXURES

ANNEXURE A: Assessment Methods

A1 Wetland/Riparian 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, 2005a). 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., 2007 and DWAF, 2005a)

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	

- **Soil wetness indicator**

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 10 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, 2005a)

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

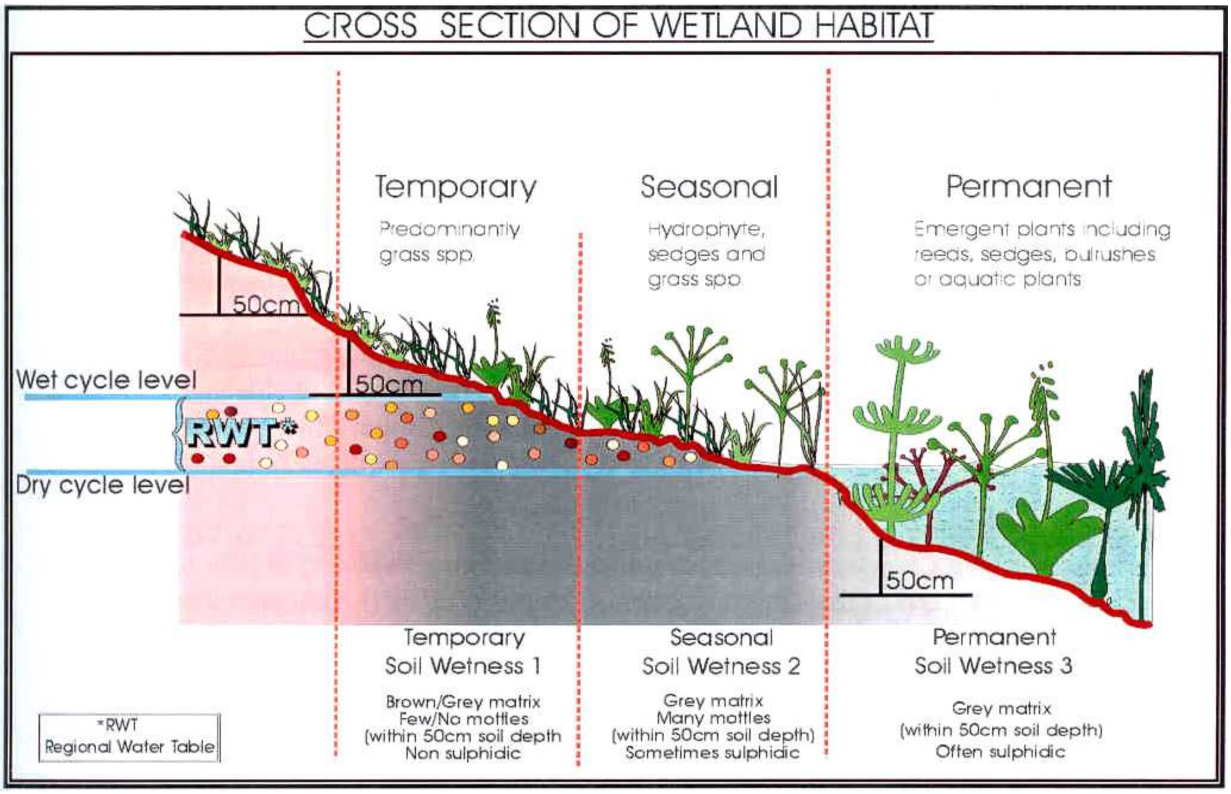


Figure 10 Diagram representing the different zones of wetness found within a wetland (DWAF, 2005a).

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*a).* 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 water resources

For the purposes of this study, water resources were classified according to HGM (hydro geomorphic) type (Level 4A classification level) using the National Wetland Classification System which was developed for the South African National Biodiversity Institute (SANBI, 2009) as outlined in Table 22, below.

Table 22. Wetland classification (after SANBI, 2009)

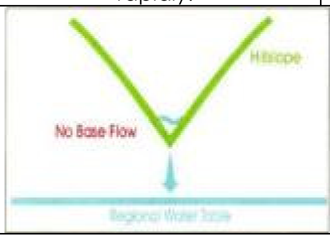
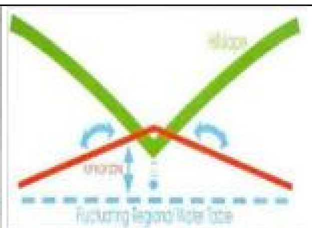
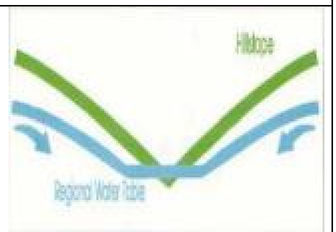
LEVEL 3	LEVEL 4A	
Landscape Setting	**HGM Type**	**Description**
SLOPE	Channel (river)	*Areas of channelled flow including rivers and streams where water is largely confined to a main channel during low flows. Flood waters may over top the banks of the channel and spread onto an adjacent floodplain*
	Hillslope seep	*Wetlands on slopes formed mainly by the discharge of sub-surface water.*
VALLEY FLOOR	Channel (river)	*River channels in a valley floor setting.*
	Channelled valley-bottom wetland	*Valley floors with one or more well-defined stream channels, but lacking characteristic floodplain features.*
	Unchannelled valley-bottom wetland	*Valley floors with no clearly defined stream channel.*
	Floodplain wetland	*Valley floors with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbows and natural levees.*
	Depression	*Basin-shaped areas that allow for the accumulation of surface water, an outlet may be absent (e.g. pans).*
	Valleyhead seep	*Seeps located at the head of a valley, often the source of streams.*
PLAIN	Channel (river)	*River channels in a plain landscape setting.*
	Floodplain wetland	*Floodplain wetlands as above but in a plain landscape setting.*
	Unchannelled valley-bottom wetland	*Unchannelled valley bottom type wetlands as above but in a plain landscape setting.*
	Depression	*Depression type wetlands as above but in a plain landscape setting.*
	Flat	*Extensive areas characterised by level, gently undulating or uniformly sloping land with a very gentle gradient.*
BENCH (HILLTOP / SADDLE / SHELF)	Depression	*Depression wetlands located on a bench.*
	Flat	*Flat wetlands located on a bench.*

Channels were further classidifed classification based on the size of channels (Table 23) and the nature of flows through the channel (Table 24).

Table 23. Classification of channels according to channel size

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

Table 24. 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 (ie. strongly ephemeral systems). Signs of wetness rarely persist in the soil profile	A water-course with riparian vegetation/habitat and intermittent base flow (ie. 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 (ie. 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 (ie. 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			

A3 South African Scoring System, Version 5 (SASS5)

The composition and structure of aquatic invertebrate communities provides a useful indication of the ecological condition of rivers. A variety of invertebrate organisms (e.g. insect larvae, snails, crabs, worms) require specific aquatic habitat types and water quality conditions for at least part of their life cycle. As most invertebrates are relatively short-lived and remain in one area during their aquatic life phase, they are particularly good indicators of localised conditions in a river over the short term (months). The South African Scoring System or SASS 5 (Dickens & Graham, 2002) accredited to ISO 17025 was the approach used to quantify the current condition of aquatic invertebrates. The SASS is a relatively simple index that is based on the families of aquatic invertebrates present at the site. Generally depending on the occurrence of different aquatic taxa, which have different pollution tolerance ratings, each bio-indicator assessment provides an indication of the state of health of the river. Generally the higher the index (e.g.

SASS score or ASPT) the better the health, or condition, of a river. Interpretation of the results obtained was done using the Ecological Categories or "Biological Bands" of Dallas (2007). The bands are region-specific aggregations of SASS score and ASPT Values into categories which indicate the condition or health of a reference site in that region. Higher numbers place the site into categories of better condition or health. The descriptions of the various bands are shown in Table 25 below.

Table 25. Biological bands or ecological categories used to define stream condition (Dallas, 2007).

Biological Band / Ecological Category	Ecological Category Name	Description
A	Natural	No or negligible modification of in-stream and riparian habitats and biota.
B	Good	Ecosystems essentially in good state; biodiversity largely intact
C	Fair	A few sensitive species may be lost; lower abundances of biological populations may occur.
D	Poor	Habitat diversity and availability have declined; mostly only tolerant species present; species present are often diseased; population dynamics have been disrupted (e.g. biota can no longer breed or alien species have invaded the ecosystem).
E	Seriously modified	Loss of habitat availability and high levels of pollution, result in few families being present due to the loss on most intolerant forms.

A4 River Present Ecological State – IHI Assessment

The index of habitat integrity, 1996, version 2 (Kleynhans, 2012) was used to obtain a habitat integrity class for the instream habitat and riparian zone. The Index of Habitat Integrity (IHI) was applied to channels/riparian areas in order to inform the rating of the condition or PES of river systems. This tool compares the current state of the in-stream and riparian habitats (with existing impacts) relative to the estimated reference state (in the absence of anthropogenic impacts). This involved the assessment and rating of a range of criteria for instream and riparian habitat (see Box 1, below) scored individually (from 0-25) using Table 26 as a guide. This assessment is informed by a site visit to the section of the river that will be impacted by the proposed development but is refined based on a desktop review of reach and catchment-scale impacts based on available aerial photography and land cover information.

Table 26. Rating table used to assess impacts to major river systems.

Impact Class	Description	Score
A: Natural	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
B: Good	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1-5
C: Fair	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6-10
D: Poor	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
E: Seriously modified	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area is affected. Only small areas are not influenced.	16-20
F: Critically modified	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Box 1. *Criteria assessed in the Index of Habitat Integrity (after* Kleynhans, 2012)

In-stream habitat criteria:

- ***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.
- ***Bed modification:*** 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.
- ***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.
- ***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.

Riparian zone criteria:

- ***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.
- ***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 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.
- ***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).
- ***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.
- ***Water quality modification*:** 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.

A5 River Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) of riparian 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 27:

- **Riparian & in-stream biota**: referring to the presence and status of biota (*including fauna & flora)*. This includes aspects of species richness/diversity, the presence of rare/endangered species, unique species/endemics, species that are sensitive to changes in flows/water quality.
- **Riparian & in-stream habitat:** including the diversity of habitat types within the in-stream and riparian zones, the sensitivity of habitats to changes in flow/water quality and the importance of riparian areas as migration routes/ecological corridors as well as the conservation importance of areas.

Table 27. Rating scheme used to rate EIS for riparian areas.

CRITERIA	RATING SCORE				
	0	1	2	3	4
Presence of rare/endangered species	None	Low	Moderate	High	Very High
Presence of unique/endemic species					
Presence of species considered intolerant/sensitive to changes in flows/water quality					
Diversity of habitat types	Very Low	Low	Moderate	High	Very High
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					
Conservation importance	None	Low (Local level)	Moderate (Provincial level)	High (National level)	Very High (National/ International level)

The scores assigned to the criteria in Table 25 were used to rate the overall EIS of each mapped unit according to Table 26, below, which was based on the criteria used by DWA for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane *et al*., 2008).

Table 28. 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.

A6 Wetland Present Ecological State – WET-Health Assessment

The qualitative/rapid wetland health assessment tool used was adapted from the Level 1 WET-Health tool (Macfarlane *et al*, 2009) 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 29). 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 29. 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
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 30, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table 30. 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.

It should be noted that the rapid assessment tool that relies on qualitative information and expert judgment. The methodology is still being tested and will be refined in the near future.

A7 Functional / Ecosystem Services Assessment – Level 2 WET-EcoServices Assessment

The effectiveness and importance of wetlands in providing ecosystem goods and services was rated using the level 1 (rapid) WET-Ecoservices (Kotze *et al.*, 2009) tool, a method suited for assessing the functioning of South African wetlands. Common wetland ecosystem goods and services that were evaluated using WET-Ecoservices are described in Table 31, below.

Table 31. 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.*

The level of predicted importance of ecosystem services provided by wetlands was rated according to the rating table found in Table 32, below. This was informed by wetland characteristics that affect the ability of wetlands to supply benefits and local and catchment context that affects the demand placed on wetlands to provide goods and services.

Table 32. Rating table used to rate level of ecosystem supply

Score Ranges	Rating	Importance or level of supply of ecosystem services
0 – 0.75	Low	The wetland is not considered to be important for providing this service/benefit.
0.76 – 1.5	Moderately-Low	The importance of the wetland in providing ecosystem goods and services is regarded as moderately low.
1.6 – 2.25	Moderate	The wetland is considered important for providing this particular ecosystem service to a moderate degree.
2.26 - 3	Moderate-High	The wetland is considered important for providing this particular ecosystem service to a high degree.
3.1 - 4	High	The wetland is considered very important for providing this particular ecosystem service to a high degree.

A8 Wetland Ecological Importance and Sensitivity (EIS)

The EIS of the delineated wetland areas was assessed using a rapid tool adapted from the DWAF EIS tool (DWAF, 1999) and an unpublished revision of the assessment tool developed by Rountree (*in prep*). The Wetland EIS tool includes an assessment of three components:

- Biodiversity support.
- Landscape scale importance.
- Sensitivity of the wetland to changes in floods, low flows and water quality.

The average score for these components was taken as the importance rating for the wetland which is rated using Table 33, below.

Table 33. Rating table used to rate EIS (adapted from DWAF, 1999)

EIS Score	EIS Rating	EIS Category Description	EIS Class
<3.5	Very High	Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	A
2.8 - 3.5	High	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	B
1.6 - 2.7	Moderate	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	C
0.6 - 1.5	Low	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not	D
0 - 0.5	Very Low		E

EIS Score	EIS Rating	EIS Category Description	EIS Class
		sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	

B9 Impact assessment

For the purposes of this assessment, the assessment of potential impacts was undertaken using an impact assessment method developed by Eco-Pulse (2015).

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.

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 impacts that can be valued like impacts to water resources, ecosystem services and biodiversity conservation can only be assessed in terms of significance. Put another way, the significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that ecosystem being assessed.

Therefore, the approach adopted is to identify and predict all potential primary and secondary/indirect impacts resulting from an activity from origin (e.g. catchment land hardening) to end point (e.g. loss of ecosystem services as a result of erosion) and assess the eventual or end point impact. For example, the development (hardening) of 1ha of land will result in an increase in surface runoff and a decrease in infiltration that will increase the volume and velocity of surface runoff and ultimately increase the floodpeaks within the watercourses into which the land drains. Increased floodpeaks will result in the erosion and sedimentation of the onsite and downstream watercourses and a degradation in ecosystem integrity/condition. Such degradation will lead to reduced levels of ecosystem services provided to the watercourse and a local reduction in ecosystem function that could ultimately contribute to the gradual deterioration in water resources and habitat representation/conservation targets.

In this regard, all potential impact resulting from the proposed activity were assessed in terms of impact on freshwater ecosystem services and freshwater habitat conservation/representation and assess the likelihood of these end point impacts being realised.

For this assessment, impact significance was calculated using the following formula:

Impact significance = (impact intensity + impact extent + impact duration) x impact likelihood

This formula is based on the basic risk formula: Risk = consequence x probability

The ratings and scores for each of the impact criteria are provided in Table 34. The general scoring and weighting system and some of the definitions have been taken from SE Solutions (2014).

Table 34. Impact assessment criteria descriptions and scoring system

Score	Rating	Description
Intensity (I) – defines the magnitude and importance of the impact		
16	High	Loss of human life.
		Deterioration in human health.
		High impacts to water resources: • Critical / severe local scale (or larger) ecosystem modification/degradation and/or collapse. • Critical / severe local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. Critical / severe ecosystem impact description: Impact affects the continued viability of the systems/components and the quality, use, integrity and functionality of the systems/components permanently ceases and are irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible, rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
		• Extinction of habitat type or serious impact to future viability of a critically endangered habitat type.
		• Extinction of species or serious impact to survival of critically endangered species.
8	Moderately-High	• Loss of livelihoods.
		• Individual economic loss.
		Moderately-high impacts to water resources: • Large local scale (or larger) ecosystem modification/degradation and/or collapse. • Large local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. Large ecosystem impact description: Impact affects the continued viability of the systems/components and the quality, use, integrity and functionality of the systems/components are severely impaired and may temporarily cease. High costs of rehabilitation and remediation, but possible.
		• Measurable reduction in extent of endangered and critically endangered habitat types.
		• Measurable reduction in endangered and critically endangered floral and faunal populations.
4	Moderate	Moderate impacts to water resources: • Moderate local scale (or larger) ecosystem modification/degradation and/or collapse. • Moderate local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. Moderate ecosystem impact description: Impact alters the quality, use and integrity of the systems/components but the systems/ components still continue to function but in a moderately modified way (integrity and functionality impaired but major key processes/drivers somewhat intact / maintained).
		• Measurable reduction in vulnerable habitat types.
		• Measurable reduction in non-threatened habitat types resulting in an up-listing to threatened status.
		• Measurable reduction in near-threatened and vulnerable floral and faunal populations.
		• Measurable reduction in non-threatened floral and faunal populations resulting in an up-listing to threatened status.
2	Moderately-Low	Moderately-low impacts to water resources:

Score	Rating	Description
		• Small but measurable local scale (or larger) ecosystem modification / degradation. • Small but measurable local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. <u>Small ecosystem impact description:</u> Impact alters the quality, use and integrity of the systems/components but the systems/ components still continue to function, although in a slightly modified way. Integrity, function and major key processes/drivers are slightly altered but are still intact / maintained.
		• Reduction in non-threatened endangered habitat types with no up-listing to threatened status.
		• Reduction in non-threatened floral and faunal populations with no up-listing to threatened status.
1	Low	Negative change to onsite characteristics but with no impact on: • Human life • Human health • Local water resources, local ecosystem services and/or key ecosystem controlling variables • Threatened habitat conservation/representation • Threatened species survival
Extent (E) – relates to the extent of the Impact Intensity		
5	Global	The scale/extent of the impact is global/worldwide.
4	National	The scale/extent of the impact is applicable to the Republic of South Africa
3	Regional	Impact footprint includes the greater surrounding area within which the site is located (e.g. between 20-200km radius of the site).
2	Local	Impact footprint extends beyond the cadastral boundary of the site to include the areas adjacent and immediately surrounding the site (e.g. between a 0-20km radius of the site).
1	Site	Impact footprint remain within the cadastral boundary of the site.
Duration (D) – relates to the duration of the Impact Intensity		
5	Permanent	The impact will continue indefinitely and is irreversible.
4	Long-term	The impact and its effects will continue for a period in excess of 30 years. However, the impact is reversible with relevant and applicable mitigation and management actions.
3	Medium-term	The impact and its effects will last for 10-30 years. The impact is reversible with relevant and applicable mitigation and management actions.
2	Medium-short	The impact and its effects will continue or last for the period of a relatively long construction period and/or a limited recovery time after this construction period, thereafter it will be entirely negated (3 – 10 years). The impact is fully reversible.
1	Short-term	The impact and its effects will only last for as long as the construction period and will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 3 years). The impact is fully reversible.
Likelihood (L) – relates to the likelihood of the Impact Intensity		
1	Definite	More than 75% chance of occurrence. The impact is known to occur regularly under similar conditions and settings.
0.75	Highly Probable	The impact has a 41-75% chance of occurring and thus is likely to occur. The impact is known to occur sporadically in similar conditions and settings.
0.5	Possible	The impact has a 10-40% chance of occurring. This impact may/could occur and is known to occur in low frequencies under the similar conditions and settings.
0.2	Unlikely	The possibility of the impact occurring is low with less than 10% chance of occurring. The impact has not been known to occur under similar conditions and settings.
0.1	Improbable	The possibility of the impact occurring is negligible and only under exceptional circumstances.
SIGNIFICANCE = (I+E+D)*L		
18 - 26	High	Totally unacceptable and fatally flawed. Impact should be avoided and limited opportunity for offset/compensatory mitigation.
13 – 17.9	Moderately-High	Generally unacceptable unless offset/compensated for by positive gains in other aspects of the environment that are of critically high importance i.e. national or international importance only. Strict conditions and high levels of compliance and enforcement are required. There should be a clear and substantiated need and desirability for the project to justify the risks.
8 – 12.9	Moderate	Impact has potential to be significant but is acceptable provided that there is strict conditions and high levels of compliance and enforcement. If there is reasonable doubt as to the successful implementation of the strict mitigation measures, the

Score	Rating	Description
		impact should be considered unacceptable. There should be a clear and substantiated need and desirability for the project to justify the risks.
5 – 7.9	Moderately-Low	Acceptable with moderately-low to moderate risks provided that specific/generic mitigation applied and routine inspections undertaken.
0 – 4.9	Low	Acceptable with low risks of environmental degradation. Basic duty of care must be ensured.