# FINAL REPORT -

# FRESHWATER HABITAT IMPACT ASSESSMENT:

## Doubling of the existing Gwaing River Bridge Crossing on the National Route N2 National Route, George, Eden District Municipality

**N002-070-2016 / J35495**

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# DECLARATION OF INDEPENDENCE

**Independent Specialist Consultant**

This is to certify that the following report has been prepared by Kerry Seppings Environmental Management Specialists (KSEMS Environmental Consulting) who:

- Act as independent specialist consultants, in this application, in the field of wetland and riparian ecology;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- Have, and will have, no vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014; and
- Will provide the competent authority with access to all the information at our disposal regarding the application, whether such information is favourable to the applicant or not.

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, 4th December 2014.
- In accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 - Environmental Impact Assessment 2014 Regulations and the National Environmental Management Act, 1998.
- Independently of influence or prejudice by any parties.

## AUTHORS

The KSEMS' team members involved in the compilation of this report and are in agreeance with the 'Declaration of Independence'.

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## INDEMNITY AND CONDITIONS RELATING TO THIS REPORT

The findings, results, observations, conclusions and recommendations given in this report are based on KSEMS Consulting's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and the abovementioned authors reserve the right to modify aspects of the report including the recommendations if and when new information may become available from on-going research or further work in this field, or pertaining to this investigation.

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Suggested report citation:

KSEMS Environmental Consulting, 2016. *Freshwater Aquatic Habitat Impact Assessment: Doubling of the existing Gwaing River Bridge Crossing on the National Route N2 National Route, George, Eden District Municipality*. June 2016.

# EXECUTIVE SUMMARY

Kerry Seppings Environmental Management Specialists (KSEMS Environmental Consulting) was appointed by GIBB Consulting to conduct a Freshwater Aquatic Habitat Impact Assessment for the proposed doubling of the N2 National Route Gwaing Bridge near George. The South African National Roads Agency Limited (SANRAL) proposes to realign a portion of section 7 of the National Road 2 (from km 16 to km 18.5 approximately), as well as refurbish the 191m long, 16m wide Gwaing River bridge, near George airport.

The following three possible alternatives have been conceptualised (all within the existing SANRAL road reserve):

- Preferred Alternative (34°00'31.32"S & 22°23'56.27"E) – Realign the existing N2 National Routeand construct a new 16m wide bridge upstream from the existing bridge location (15m offset from the existing structure);
    - Original design drawings dated in 1983 show that this road was designed to have two bridges, the existing bridge as well as this bridge located upstream.
- Alternative 2 (34°00'32.14"S & 22°23'56.59"E ) – Refurbish the existing bridge and columns to increase the width of the crossing over the N2 National Route National Route;
    - The existing columns are going to be assessed to determine if they will be able to accommodate this design.
- Alternative 3 (34° 0'32.71"S 22°23'56.13"E) – Realign the existing N2 National Route and build a new 16m wide bridge downstream from the existing bridge location (15m away from the existing structure).
    - This design will only be considered if the other alternatives are not feasible.

The freshwater habitats (wetland and/or riparian) within a 500 metre radius of the proposed scope of works were identified. The infield site assessment phase confirmed the location and extent of these systems, subsequent screening provided an indication of which of these systems may potentially be impacted upon by the proposed road and bridge upgrade (Table ES1).

***Table ES1: Water resources within a 500m radius of the proposed scope of work and their associated risk rating.***

| WATER RESOURCE (*CODE AS PER FIG 3*) | WATER RESOURCE TYPE – HGM UNIT | RISK RATING | NEED FOR FURTHER ASSESSMENT |
|---|---|---|---|
| Dam 4 | Artificial Depression | High | No |
| Dam 7 | Artificial Depression | Moderate - Low | No |
| Unchan 1 | Unchannelled Valley Bottom | High | **YES** |
| Unchan 3 | Unchannelled Valley Bottom | High | **YES** |
| Unchan 5 | Unchannelled Valley Bottom | Moderate - Low | No |
| Rip 1 | C Channel Riparian | High | **YES** |
| All other Dams | Artificial Depression | Very Low | No |
| Riparian (Desktop) and all other riparian systems | A- and B-Channel Systems | Very Low | No |
| Wetlands (Desktop) | Wetland systems | Very Low | No |

The assessed systems were delineated and classification confirmed. Due to the impact that the scope of works may potentially going to have on water resources, there is a need for these systems to be assessed utilising an appropriate assessment tool.

### *Present Ecological State (PES)*

The PES of the various systems were assessed (Table ES2). The systems ranged from largely modified to critically modified, where significant changes in ecosystem processes and loss of natural habitat and biota and has occurred. Water quality was also tested and as a whole, water quality at the time of the sampling can be considered to be **poor** for the system.

***Table ES2: Summarised Present Ecological State (PES) Scores for the riparian and wetland systems assessed***

| SYSTEM | PES (OVERALL) |
|---|---|
| *Wetland* | |
| **Unchan 1** | **F** |
| **Unchan 3** | **D** |
| *Riparian* | |
| **Rip 1** | **E** |

### *Wetland Functional Importance (Goods and Services)*

Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The poor present ecological state of the systems is indicative of the transformation that has occurred within the catchment and the system. This transformation has a detrimental impact on the goods and services provided for by the systems (Figures ES1 & ES2).

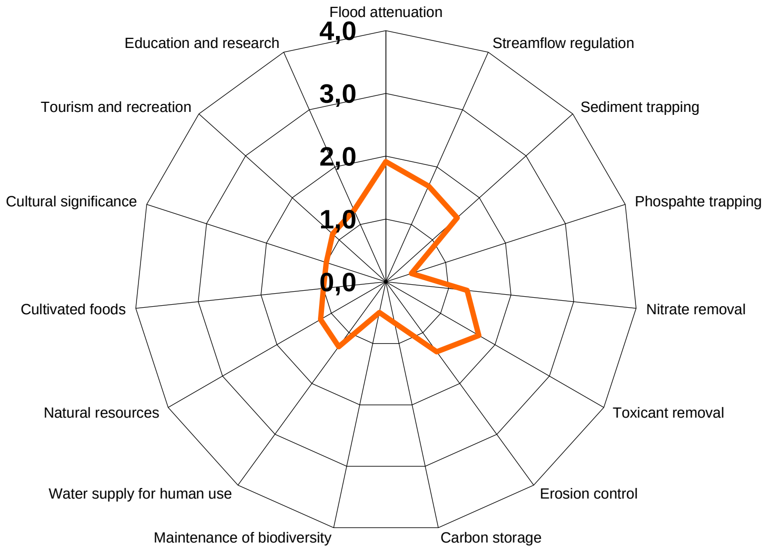


***Figure ES1: Wet-Ecoservices of the wetland systems impacted in Unchan 1.***

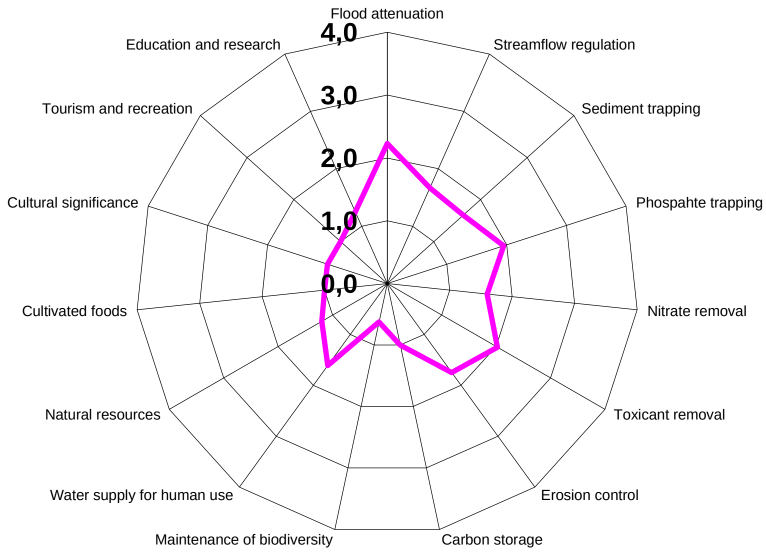


***Figure ES2: Wet-Ecoservices of the wetland systems impacted in Unchan 3.***

### *Ecological Importance and Sensitivity (EIS)*

In general the all freshwater resources have a moderate EIS scores (Table ES3). All systems assessed have low direct benefits to society. The highest scores obtained were for ecological importance due to the regional setting being in a CBA and ESA.

***Table ES3: The Ecological Importance and Sensitivity of the Assessed Systems***

| HGM Unit | ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORIES | |
|---|---|---|
| | *Overall Importance* | |
| | SCORE (0-4) | RATING |
| | ***Riparian*** | |
| **Rip 1** | 1.75 | Moderate |
| | ***Wetlands*** | |
| **UNCHAN 1** | 2.33 | Moderate |
| **UNCHAN 3** | 2.33 | Moderate |

### *Management Objectives*

The respective general management objectives for both the riparian and wetland systems that were assessed should be to ***maintain*** the current status quo of these freshwater ecosystems without any further loss of integrity (PES) or functioning (EIS).

The types of impacts on freshwater habitats can be categorised into three (3) broad categories, namely direct, indirect and cumulative impacts. Direct impacts are associated with disturbances occurring within the system such as canalisation, infilling, removal of vegetation, infrastructure development. Indirect impacts include disturbances outside the system, such as increased surface water and sediment, loss of recharge area, changes in local drainage patterns. Cumulative impacts include disturbances resulting from combined direct and/or indirect impacts to the system over time. These cumulative impacts take into account existing anthropogenic impacts and combined impact of these existing impacts and potential impacts associated with the proposed upgrades.

The proposed scope of work must take into account the risk to the surrounding environment and must be planned, designed and implemented in a sustainable manner ensuring further disturbance is avoided or, where they cannot be altogether avoided, appropriate mitigative measures be applied in the form of reactive practical actions that minimises or reduces in situ impacts.

The major impacts associated with the proposed alternatives on the above-mentioned riparian and wetland systems were determined. The three alternatives were each assessed separately in terms of the significance of their impacts. The Preferred Alternative and Alternative 2 had very similar impacts as, although the Preferred Alternative will have a bigger footprint, the worst case scenario of each alternative scores similarly and therefore either of these options are feasible, provided the relevant mitigation measures are adhered to and implemented accordingly. The poor condition and low levels of ecosystem services these freshwater resources provide, plays a factor in the significance of these impacts. The Alternative 3 had the highest level of impacts. The construction of the Alternative 3 system will likely result in the destruction of the largest amount of wetland habitat. In addition to which, several dams within this critically modified wetland will likely be destroyed. These dams act as buffers for the effluent runoff from the nearby dairy farms and if not reconstructed, alternative treatment of the effluent runoff from these farms will need to be sourced to prevent this effluent from polluting systems downstream. Should all mitigative measures ad rehabilitation procedures be properly implemented, then all impacts reduce in significance during all proposed phases of this project for every alternative and become **minimal and limited in extent**.

There is the need for a Water Use License according to Section 21 of the National Water Act No. 36 of 1998. No protected/threatened species of fauna were observed, however there was a *Sideroxylon inerme*, and *Aloe pluridens* individuals present within the possible construction footprint and these will require permits to transplant. It is however possible that there are more protected plant species present in the terrestrial habitat that will require permits and therefore a vegetation specialist study is also recommended.

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# 1 INTRODUCTION

## 1.1 Locality

The South African National Roads Agency Limited SOC Limited (henceforth referred to as SANRAL) propose to upgrade the Gwaing Bridge and the associated N2 National Route Section 7 (km 16 to km 18.5) located near the George Airport within the George Local and Eden District Municipalities. Kerry Seppings Environmental Management Specialists (KSEMS Environmental Consulting) was appointed by GIBB Consulting to conduct a Freshwater Aquatic Habitat Impact Assessment for the proposed construction activities.


***Figure 1: Location of the proposed Gwaing Bridge and N2 National Route Route upgrade in relation to the George Airport***

The upgrade is proposed to consist of:

- The design and construction of a new bridge structure (16m in width), either upstream or downstream (±15m either side) from the existing bridge location or the widening of the existing bridge structure at the current location;
- The realignment of at least one of the N2 National Route Carriageways to tie into the proposed new bridge structure;
- The completion of geotechnical drilling during the design phase and potential piling into the Gwaing watercourse; and
- Widening of the existing road cuts to accommodate for the realignment.

The following three possible alternatives have been conceptualised (all within the existing SANRAL road reserve) (Table 1):

- Preferred Alternative – Realign the existing N2 National Routeand construct a new 16m wide bridge upstream from the existing bridge location (15m offset from the existing structure);
    - Original design drawings dated in 1983 show that this road was designed to have two bridges, the existing bridge as well as this bridge located upstream.
- Alternative 2 – Refurbish the existing bridge and columns to increase the width of the crossing over the N2 National Route National Route;
    - The existing columns are going to be assessed to determine if they will be able to accommodate this design.
- Alternative 3 – Realign the existing N2 National Route and build a new 16m wide bridge downstream from the existing bridge location (15m away from the existing structure).
    - This design will only be considered if the other alternatives are not feasible.

***Table 1: Geographic co-ordinates showing the location of the site alternatives***

| SITE | COORDINATES | |
|---|---|---|
| Preferred Alternative | 34° 0'31.32"S | 22°23'56.27"E |
| Alternative 2 | 34° 0'32.14"S | 22°23'56.59"E |
| Alternative 3 | 34° 0'32.71"S | 22°23'56.13"E |

*(a) The existing bridge has no shoulder and has resulted in accidents*

*(b) The preferred alternative is to build a new bridge upstream of the existing bridge*

*(c) Alternative 2 involves increasing the size of the existing bridge, if the columns are sufficient*

*(d) Alternative 3 involves placing another bridge downstream.*

***Figure 2: Photographs of the site and various alternatives for the bridge.***

## 1.2 Scope of Work

The Scope of Work in accordance with the specific Terms of Reference supplied by KSEMS, required a two-phased approach as described below:

### *1.2.1 Phase 1: Initial Risk/Screening Assessment*

- Desktop delineation and illustration of **all** watercourses within a 500 metre radius of the site utilising available site-specific data such as aerial photography, contour data and municipal water resource data;
- The risk/screening assessment of these identified watercourses to determine which will measurably be impacted upon by the proposed development. This is based on professional opinion which may be scientifically substantiated.

### *1.2.2 Phase 2: Freshwater Habitat Impact Assessment*

- Infield delineation and illustration of all watercourses (freshwater habitats) in relation to the site, identified within Phase One of the Assessment in accordance with the methods contained in the manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005);
- Classification of delineated freshwater habitats in accordance with the, '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*., 2013)
- Identification of site-specific biophysical characteristics, e.g. hydrology, vegetation composition, geomorphological features, soils;
- Determination of the freshwater habitats which will measurably be impacted upon by the proposed development. The determination will be based on the Phase 1 assessment and the infield assessment of the freshwater habitats in relation to the sites;
- Present Ecological State (PES) and present Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats, utilising:
    - Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
    - DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- Water quality sampling and analysis (by independent laboratory) to provide a 'snap-shot' indication of the habitat water quality condition and insight into the possible surrounding land use pressures acting upon the system.
- Identification, prediction and description of the potential impacts of the development on the delineated riparian or wetland areas and the significance of these impacts (qualitative assessment).
- Mitigative measures for the abovementioned identified impacts
- Rehabilitation guidelines for disturbed areas associated with the development.
- Monitoring Protocol

# 2 METHODOLOGY

The methods utilised within this assessment follow the phased approach as indicated in the scope of works above:

- a desktop assessment;
- infield verification and refinement of the location and extent of water resources;
- determination of which water resources may be impacted upon by the proposed development within the 500 metre investigation buffer;
- mitigative measures and monitoring protocols are recommended based on site and project-specific information determined during the desktop and infield assessments.

## 2.1 Data Utilised

Data from various sources was required to accurately assess the proposed project site and surrounding areas (Table 2). This data was utilised along with data gathered during the site investigation.

***Table 2: Utilised data and associated source and relevance to the proposed development***

| DATA | SOURCE | APPLICATION TO PROJECT |
|---|---|---|
| Google Earth Pro™ Imagery | Google Earth Pro™ | Up-to-date satellite imagery of the proposed development site, area (size) determination, desktop watershed determination, desktop identification of catchment and HGM impacts |
| Contours (elevation) - 5m intervals | Surveyor General | Desktop identification and mapping of potential freshwater habitats utilising contour data. |
| DWS Eco-regions (GIS data) | DWS (2005) | Local eco-region classification associated with the proposed sites. |
| Geology | ENPAT and Council for Geoscience South Africa | Determine the soil type and geology of the study site |
| Critical Biodiversity Areas of the Western Cape (GIS Coverage) | Pence, Genevieve Q.K. 2014. | Determine where the Critical Biodiversity Areas relative to the study site. |
| Vegetation of the Western Cape (GIS Coverage) | Pence, Genevieve Q.K. 2014. | Determine the vegetation type and status relative to the study site. |
| NFEPA river and wetland inventories (GIS Coverage) | CSIR (2011) | Identify potential onsite and local rivers and wetlands which need to be investigated and conserved if present. |
| NEFPA river, wetland and estuarine FEPAs (GIS Coverage) | CSIR (2011) | Shows national aquatic ecosystem conservation priorities |

## 2.2 Assessment Methodologies/Tools

The specific methodologies/tools utilised for the assessment of the water resources impacted upon by the project were determined utilising the desktop and infield assessments and professional opinion (Table 3).

***Table 3: Methodologies/tools utilised for the assessment of water resources impacted upon by the proposed development***

| METHOD/TOOL* | SOURCE | REFERENCE | APPENDIX (ANNEXURE) |
|---|---|---|---|
| Delineation of wetland and/or Riparian areas | *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas.* | (DWAF 2005) | 16.1 |
| Classification of wetlands and/ or other aquatic ecosystems | *National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa & WET-Ecoservices* | (Ollis *et al.*, 2013), Kotze *et al.*, 2009) | 16.2 |
| Present Ecological State (PES) Assessment (Wetland) | *WET-Health Assessment* | (McFarlane *et al.* 2009) | 16.3 |
| Functional Importance Assessment (Wetland) | *WET-Ecoservices Assessment* | (Kotze *et al.*, 2009) | 16.4 |
| Ecological Importance & Sensitivity (EIS) Assessment (wetland) | *DWAF Wetland EIS Tool* | (Duthie 1999) | 16.5 |
| Present Ecological State (PES) Assessment (River) | *Rapid IHI (Index of Habitat Integrity) tool developed Kleynhans (1996), Modified by DWAF* | (Ecoquat) | 16.6 |
| Ecological Importance & Sensitivity (EIS) Assessment (River) | *DWAF EIS tool developed by Kleynhans (1999)* | (Kleynhans, 1999) | 16.7 |

# 3 ASSUMPTIONS AND LIMITATIONS

The following assumptions and qualifications are relevant to this freshwater habitat assessment:

- The location of the site was provided by the client. Accurate geo-referenced shapefiles were not provided or used, possibly because the project is at the initial scoping phase.
    - The construction footprint was delineated based on the description received from the client. It is assumed that near each end of the construction footprint there will be little to no change in the deviation from the existing road footprint, however this will gradually increases in size towards the bridge. This report should be revised when relative drawings become available to determine if any additional systems would be assessed.
- Freshwater habitats vary both temporally and spatially. Once-off assessments such as this may potentially miss certain ecological information, thus limiting accuracy, detail and confidence.
- Wetland and/or riparian boundaries are essentially based on GPS coordinate waypoints taken onsite of soil sampling points and of important morphological features. The variations experienced in GPS precision will ultimately affect the accuracy of the GPS waypoints and consequently will affect the accuracy of the recorded water resource boundaries. All sampling waypoints were recorded using a Garmin Oregon 600 GPS and captured, analysed and geo-processed utilising a Geographical Information Systems (GIS).
- Only the wetland/riparian boundaries within a specific focal area in relation to the proposed construction were accurately delineated, since this is the area most likely to be impacted upon by the project. The remaining water resources (HGM units) were delineated at a desktop level and broadly verified in the field to obtain an extent of the wetland/riparian areas, and to facilitate an understanding of the dynamics of the system.

- No formal vegetation plot surveys were conducted and therefore all information pertaining to vegetation is based on observation and relates to the dominant and/or indicator wetland/riparian species located within the water resources. Sampling by its definition, is indicative that not all aspects of ecosystems can be assessed and identified.

# 4 SITE AND STUDY AREA CHARACTERISTICS

Analysis of the site and area characteristics of where any development is proposed, assists wetland specialists in characterising the sensitivity of any wetland systems, and understanding how wetlands have formed within the region. The summarised biophysical characteristics are indicated below (Table 4).

***Table 4: A Summary of the biophysical characteristics of the study area***

| Biophysical categories | Site characteristics | Source |
|---|---|---|
| Elevation | 135 m.a.s.l | Google Earth |
| Mean annual precipitation (MAP) | 787.2 mm | Schultz, 1998 |
| Mean annual potential evaporation (MAPE) | 1203.6 mm | Schultz, 1998 |
| Rainfall seasonality | Late - summer | DWAF, 2007 |
| Quaternary catchment | K30B | Schultz, 1998 |
| Water Management Area (WMA) | 16 - Gouritz | DWAF, 2007 |
| DWA Ecoregion | Southern Coastal Belt | Kleynhans *et al.* 2005 |
| FEPA Sites | No | Nel *et al.* (2011) |
| Geology | Mainly gneissic granite and granodiorite, Kaaimans Group, and quartzitic sandstone of the Table Mountain Group, Cape Supergroup. | Surveyor General |
| Western Cape Vegetation type | Cape Lowland Alluvial Vegetation (CR) and Garden Route Granite Fynbos (EN) | Pence, Genevieve Q.K. 2014 |
| Western Cape CBA | Environmentally Sensitive Area (ESA) Critical Biodiversity Area (CBA) | Pence, Genevieve Q.K. 2014 |

## 4.1 Local/Regional Setting

The 500m study area of the road section to be upgraded is located within the DWS Quaternary Catchment K30B and falls within the Gouritz Water Management Area. The region falls within the DWS Southern Coastal Belt Ecoregion (Kleynhans *et al.* 2005). There are no Freshwater Ecosystem Priority Area's (FEPA) within the study area although the study did delineate known wetlands and watercourses within the study area. The study area has been heavily transformed and disturbed by agricultural activities and alien vegetation with only small patches indigenous vegetation remaining.

## 4.2 Vegetation and Conservation Plans

Mucina and Rutherford (2006) delineated vegetation units throughout Southern Africa. Since then vegetation map has been updated and refined in 2012. The purpose of this exercise was to map the extent of various vegetation at a finer scale to be able to accurately assess the historical extent of vegetation within South Africa. The outcomes of this exercise allowed Mucina and Rutherford (2006) to revised conservation targets for various vegetation units.

The 500m radius study area is located within the Cape Lowland Alluvial Vegetation and Garden Route Granite Fynbos vegetation units which is under immense pressure from agricultural development within its extent. According to Mucina and Rutherford (2012), these vegetation types are listed as *Critically Endangered* and *Endangered* accordingly.

According to Pence and Genevieve (2014), the study area is located within a CBA and ESA regions. The CBA region has a management objective of being maintained in as much a natural state as possible degraded areas being rehabilitated to a natural or near natural condition and no further degradation of these regions should be permitted. The ESA regions are often used as buffers for the CBA region and all ecological processes should be maintained.

### 4.3 Geology

The geology of the 500m study site consists of soils that prismacutanic and/or pedocutanic diagnostic horizons dominant and the B horizons are mainly not red. In terms of the geology according to ENPAT, of the region it is mainly gneissic granite and granodiorite, as well as phyllite, schist, grit, hornfels and quartzite of the Kaaimans Group, and quartzitic sandstone of the Table Mountain Group, Cape Supergroup.

## 5 RESULTS AND FINDINGS

Following desktop, field and laboratory analysis of the freshwater habitats, relevant to the proposed works, the subsequent results were obtained.

### 5.1 Initial Risk/Screening Assessment (Phase 1)

The freshwater habitats (wetland and/or riparian) within a 500 metre radius of the site were identified and mapped on a desktop level utilising available data, the Geographic Information System, QGIS 2.14 and Google™ Earth Pro (Figure 3). The infield site assessment phase confirmed the location and extent of these systems, subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project. Factors considered for determining if a system was at risk, included if a system’s flow (surface or groundwater), water quality, biota or habitat would be negatively altered by the project. Additional factors which influenced how a system will be impacted include the type of system, position of the system in relation to the activity and position the system in the landscape.

All the systems identified within the abovementioned 500m study area were identified on a desktop level, investigated infield, screened and rated in accordance to their risk on being impact upon (Table 5).

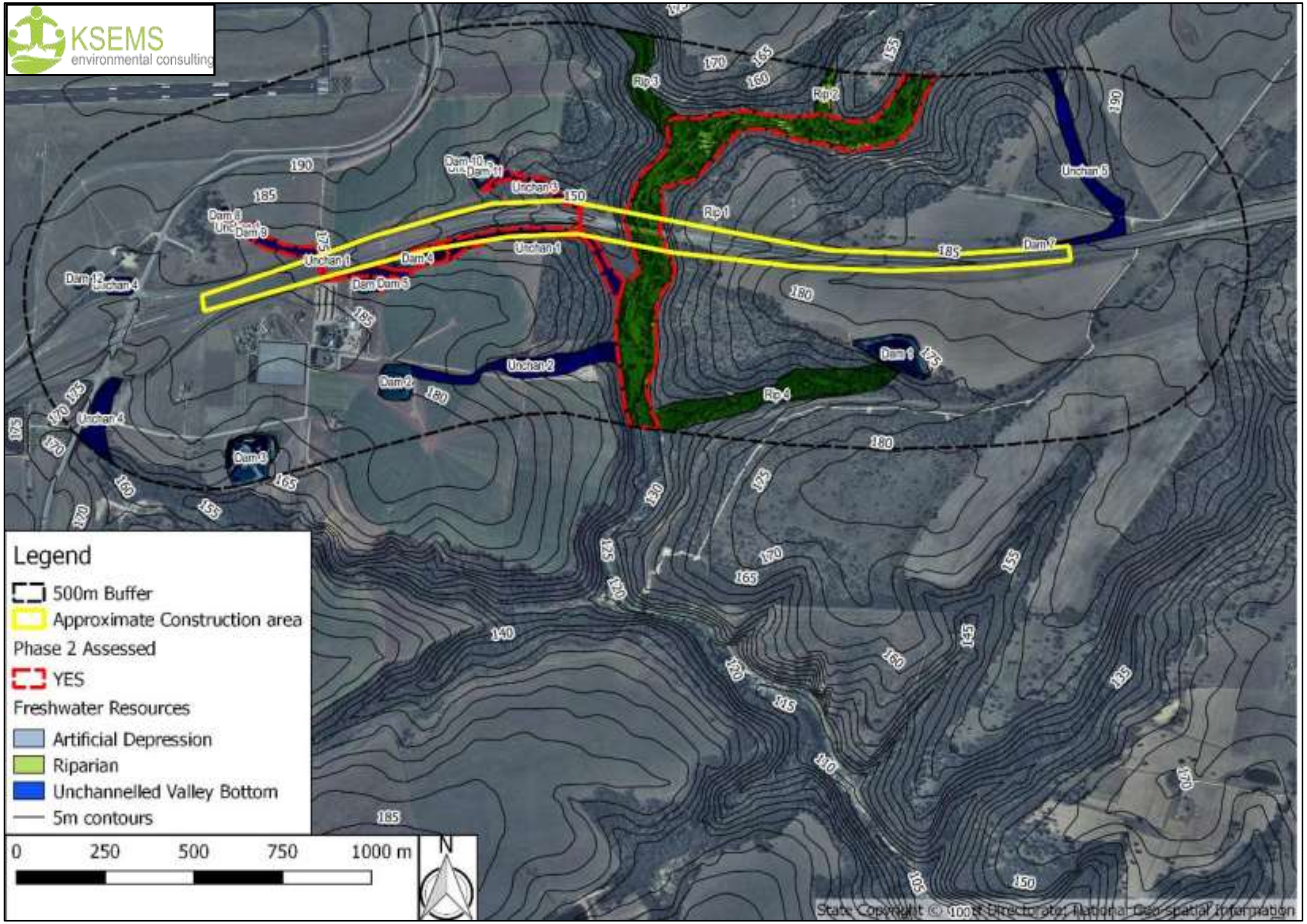


Figure 3: The site in relation to water resources identified within the 500m study area.

*Table 5: Water resources within a 500m radius of the site and their associated risk rating*

| WATER RESOURCE (CODE AS PER FIGS 3) | WATER RESOURCE TYPE – HGM UNIT | CHARACTERISTIC POTENTIALLY IMPACTED (YES/NO =Y/N) | | | | RISK RATING | NEED FOR FURTHER ASSESSMENT | JUSTIFICATION [(IMPACTS ON FLOW (SURFACE AND GROUND WATER), WATER QUALITY, BIOTA AND/OR HABITAT)] |
|---|---|---|---|---|---|---|---|---|
| | | Habitat | Biota | Water Quality | Flow Regime | | | |
| Dam 1 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 2 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 3 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 4 | Artificial Depression | Y | Y | Y | Y | High | No | This dam is located within the Unchan 1 system and will likely be destroyed if Alternative 3 is selected. However as this is an artificial system it is not possible to determine the reference state for the system and therefore it was not assessed further. |
| Dam 5 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 6 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 7 | Artificial Depression | N | N | Y | Y | Moderate - Low | No | This dam is located at the top of the Unchan 5 system is located adjacent to the N2 National Route near the start of where construction is likely to begin. Without more information regarding the construction footprint and road designs it is difficult to determine if this system will be impacted by the proposed construction activities. With the current information supplied it was determined that this system will not be significantly impacted by the proposed scope of works. It is however likely that there could be minor changes in water quality and flow regime. |
| Dam 8 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 9 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 10 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Dam 12 | Artificial Depression | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Unchan 1 | Unchannelled Valley Bottom | Y | Y | Y | Y | High | **YES** | This unit was dissected when the N2 National Route was built and has been heavily impacted by the construction of 5 separate dams located on this relatively small system. There system is also under heavy agricultural pressure due to the location of a dairy farm and pastures located on the system. Given the proposed scope of works any construction activities related to the construction of any of the alternatives will directly impact this system. The largest impact on this system will be as a result of the construction of Alternative 3, which will likely result in the largest volume of infilling directly into this system. |

| WATER RESOURCE (CODE AS PER FIGS 3) | WATER RESOURCE TYPE – HGM UNIT | CHARACTERISTIC POTENTIALLY IMPACTED (YES/NO = Y/N) | | | | RISK RATING | NEED FOR FURTHER ASSESSMENT | JUSTIFICATION [(IMPACTS ON FLOW (SURFACE AND GROUND WATER), WATER QUALITY, BIOTA AND/OR HABITAT)] |
|---|---|---|---|---|---|---|---|---|
| | | Habitat | Biota | Water Quality | Flow Regime | | | |
| Unchan 2 | Unchannelled Valley Bottom | N | N | N | N | Very - Low | No | This wetland complex is located within a separate micro catchment from the proposed scope of work and it is unlikely this system could be impacted by the proposed scope of works. |
| Unchan 3 | Unchannelled Valley Bottom | Y | Y | Y | Y | High | YES | Similar to the Unchan 1 system this unit was also dissected when the N2 National Route was built. It has also had its flow captured within a stormwater pipeline and diverted under the N2 National Route into the Unchan 1 system. Besides the N2 National Route this unit has been impacted by the construction of 2 separate dams located on this relatively small system. There system is also under heavy agricultural pressure due to the location of a pastures on the system. Given the proposed scope of works any construction activities related to the construction of any of the alternatives will directly impact this system. The largest impact on this system will be as a result of the construction of the Preferred Alternative, which will likely result in the largest volume of infilling. |
| Unchan 4 | Unchannelled Valley Bottom | N | N | N | N | Very - Low | No | This wetland is located within a separate micro catchment from the proposed scope of work and it is unlikely this system could be impacted by the proposed scope of works. |
| Unchan 5 | Unchannelled Valley Bottom | N | N | Y | Y | Moderate - Low | No | This system is located adjacent to the N2 National Route near the start of where construction is likely to begin. Without more information regarding the construction footprint and road designs it is difficult to determine if this system will be impacted by the proposed construction activities. With the current information supplied it was determined that this system will not be significantly impacted by the proposed scope of works. It is however likely that there could be minor changes in water quality and flow regime. |
| Rip 1 | C Channel Riparian | Y | Y | Y | Y | High | YES | This is the riparian system associated with the Gwainq River. This is the largest system in the study area and will be impacted by all three alternatives proposed. It was therefore determined that this system needed to assessed further. |
| Rip 2 | C-Channel Riparian | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Rip 3 | B-Channel Riparian | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |
| Rip 4 | B-Channel Riparian | N | N | N | N | Very - Low | No | Remote and separate catchment to any project activities. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | High Risk | | Moderate | | Low | | Very Low |

### 5.2 Freshwater Habitat Assessment (Phase 2)

The water resources (HGM units) that may potentially be impacted upon by the proposed scope of works were verified through infield soil samples and documentation of vegetation communities and species and key features within the landscape. The boundaries of the assessed water resources were identified and delineated as they were within the 500m buffer of the proposed scope of work (Table 6; Figures 4 - 6). Majority of the delineation of the other systems were completed on desktop level after the field surveys for the systems that were deemed not be impacted upon by the proposed scope of works. It was determined that the other systems have a very low or low risk of being impacted upon and therefore no further assessment was deemed necessary.

***Table 6: Assessed Water Resources associated with the proposed scope of works***

| ALTERNATIVE THAT IMPACTS WETLAND | HGM UNIT CODE | FIGURES |
|---|---|---|
| Alternative 3 | Unchan 1 | 4 |
| Preferred Alternative | Unchan 3 | 5 |
| All alternatives | Rip 1 | 6 |

The assessed systems (Table 6) were delineated and classification confirmed. Due to the impact that the scope of works may potentially going to have on water resources, there is a need for these systems to be assessed utilising an appropriate assessment tools.


***Figure 4: The Unchan 1 system, illustrating the extent of the gully through the system (a and b), as well as the Dam 4 (c) and the remaining indigenous vegetation (d).***


***Figure 5: The Unchan 3 system illustrating the extensive vegetation dominance and gully present (a,c), the system being concentrated through the stormwater pipe (b); and d) the system in relation to the National Route N2 National Route proposed to be upgraded.***

***Figure 6: The Rip 1 system showing upstream (a), downstream (b), river bed and bank morphology (c and d), existing column (e), Prionium serraturm individuals (f) and lastly an existing abstraction point (g).***

### 5.3 Water Quality

Water samples were taken on the 20th May 2016 were directly from the Gwaing River upstream of the existing bridge. The water quality was analysed by an independent laboratory for selected physico-chemical and biological parameters and a summary of the results are shown in Table 7 below. The results of the analysis indicate elevated nitrate, chloride and ammonia (highlighted below) levels pointing towards increased nutrient inputs possibly from the input of animal/ human wastes, detergents and soaps from the waste water treatment works located upstream. The presence of agricultural activities within the catchment as well as the high faecal indicator bacteria *Escherichia coli (E. coli)* (highlighted below) indicating that there is a high input of human and/or animal waste into the system. As a whole, water quality at the time of the sampling can be considered to be **poor** for the system.

*Table 7: A table showing water quality from samples taken from the Gwaing River Rip 1 system*

| DETERMINAND | UNITS | TWQR (AQUATIC ECOSYSTEMS) | CHRONIC EFFECT VALUE (CEV) | ACUTE EFFECT VALUE (AEV) | DOMESTIC TWQR | RESULTS |
|---|---|---|---|---|---|---|
| | | | | | | RIP 1 |
| Ammonia | mg N/ℓ | > 0.007 | 0.015 | 0.1 | 0 - 1 | **3.99** |
| Chemical oxygen demand (total) | mg $O_2$/ℓ | Not available | Not available | Not available | Not Available | 36 |
| Chloride | mg Cl/ℓ | Not available | Not Available | Not Available | 0-100 | 180 |
| *E. coli* | colonies per 100mℓ | 130 (full contact) | Not Available | Not Available | 0 | **7300** |
| Conductivity at 25°C | mS/m | Not available | Not Available | Not Available | 0-70 | 85 |
| Nitrate/Nitrite | mg N/ℓ | Not vary 15% of background unimpacted conditions, <0.5 will limit eutrophication | 2.5-10 (Eutrophic) | >0.10 (Hypertrophic) | 0 - 6 | **2.65** |
| Orthophosphate | mg P/ℓ | Not vary 15% of background unimpacted conditions, <0.005 will limit eutrophication | 0.025 - 0.25 (Eutrophic) | >0.25 (Hypertrophic) | Not Available | 0.090 |
| pH at 25°C | pH units | Not vary >0.5 or 5% of background | Not Available | Not Available | 6.0-9.0 | 7.4 |
| Suspended solids at 105°C | mg/ℓ | Not increase <15% of background and <100mg/l for all aquatic ecosystems | Not Available | Not Available | Not Available | <10 |

| | | |
|---|---|---|
| Within DWAF TWQR (aquatic ecosystems) | Exceeds DWAF TWQR (aquatic ecosystems) | No standards or TWQR available |

### 5.4 Catchment and Site-specific Impacts

The entire region is characterised by the closed steep valleys and plateaus with the town of George dominating the upper catchment of the Gwaing system. The study area is characterised by commercial agricultural activities which consist of pastures and dairy farming. The formal agricultural activities have also resulted in the construction of various stock dams and settling ponds within the study area. The majority of the freshwater resources have been impacted by these practises, showing varying degrees of erosion.

The hydrological regime of the region is fairly uniform with farming impacts and infrastructure development having resulted in modified surface runoff regimes as there is a reduction in surface roughness modified soil permeability. Alien invasive plant species are also present within these catchments in disturbed areas in the form of *Acacia mearnsii, Acacia cyclops, Eucalyptus camaldeunsis, Pinus pinaster and Pennisetum caldestum* dominating large portions of the study area. The presence of a dairy farming activities as well as a sewage treatment works located upstream has resulted in additional water inputs into the Gwaing River. Erosion of the wetlands and watercourse is evident as a result of the change in land use. The land use change impacts include transformation/loss of vegetation cover, hardening of surfaces and erosion through the presence of: infrastructure ranging from blacktop roads to informal gravel roads; building infrastructure, pastures, structures; livestock/human tracks; excessive livestock grazing and; infilling due to the creation of platforms.

Besides hydrological aspects wetlands are also highly reliant on geomorphological health. Sediment inputs into a wetland are very important to ensure the wetlands continued survival. The presence of dams upstream of wetlands plays a major factor in determining the geomorphological health of the wetland. Macfarlane *et al.* (2008) explained how dams located upstream or within wetlands are highly damaging to the systems. Dams reduce water velocity which causes sediment to drop out of the water column and settle in the dam itself. The water that is released from a dam is then starved of sediment which deprives the wetland of its natural sediment load and leads to degradation. This is evident from the gullies that have formed within both the Unchan 1 and Unchan 2 systems and the significant level of erosion taking place within the Gwaing River (Rip 1).

The vegetation of all the catchments is mostly converted to pasture with clumps indigenous fynbos remaining and drainage lines dominated by alien tree species. Pasture creation results in the complete destruction of vegetation and the remaining portions of fynbos have been extensively grazed. Pastures decrease the water quality by means of increasing sediment, pesticide, herbicide as well as phosphate, nitrate and ammonia levels entering freshwater systems. The increase in grazing pressure on existing vegetative cover and the steep slopes of the region place erosion pressure on the freshwater systems. This level of disturbance has resulted in species such as *Acacia mearnsii, Acacia cyclops, Eucalyptus camaldeunsis, Pinus pinaster* and *Pennisetum clandestinum* dominating large portions of the study area

# 6 PRESENT ECOLOGICAL STATE (PES)

The PES of the system that required additional assessment were assessed. The PES assessment only applies to the portions of the water resource units delineated in the vicinity of the proposed scope of works and not the entire HGM unit or complex. Thus, the PES of the HGM unit proper may be substantially different from that assessed.

The assessment of the condition or PES (Present Ecological State) of the HGM's is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of wetland vegetation. WET-Health (Macfarlane *et al.*, 2007) works by comparing a wetland in its current state with baseline/reference conditions for the site.

## 6.1 Riparian Present Ecological State (PES)

A general description of the riparian system's habitat and catchment characteristics are presented in Table 8 below and in Section 5.4 above. This description formed the basis for the calculation of the PES for both of these systems under assessment the results of which represented in Table 8.

***Table 8: Description of the Riparian Habitat impacted upon by the project***

<table>
<tr><th rowspan="2">CHARACTERISTIC</th><th colspan="2">Riparian Water Resource</th></tr>
<tr><th colspan="2">Rip 1</th></tr>
<tr><td>Watercourse Name</td><td colspan="2">Gwaing River</td></tr>
<tr><td>Longitudinal gradient</td><td colspan="2">0.9%</td></tr>
<tr><td>Sinuosity</td><td colspan="2">Medium</td></tr>
<tr><td>Flow type</td><td colspan="2">Perennial</td></tr>
<tr><td>Length of system</td><td colspan="2">535m</td></tr>
<tr><td>Reach of system assessed</td><td colspan="2">Approximately 50m</td></tr>
<tr><td>Channel Dimensions</td><td colspan="2">Width: +- 20m, Depth: 5m-30m</td></tr>
<tr><td>Instream Habitat</td><td>Morphology:<br>The system has eroded down to bedrock and is stable. The system does however meander within the extent of its macro-channel as is evident by the 5m high river channel walls which are unstable and continually being reshaped according to stream channel flow and flooding events. The system has a series of pools with varying sized, sand, pebbles and rocks dispersed along the bedrock.</td><td>Vegetation: There is instream vegetation, which consists of indigenous species such as Cyanodon dactylon, Juncus dregeanus, Juncus lomatophyllum, Isolepis prolifera, Lemma spp. and Pycreus mundtii present. Alien plants do however dominate the system in the form of Acacia mearnsii, Arundo donax, Datura ferox, Eucalyptus camaldeunsis, Nasturtium officinale, Solanum mauritianum, Pennisetum caldestum and Ricinus communis.</td></tr>
<tr><td>Riparian Habitat</td><td>Morphology: The banks are sandy and being eroded by the shifting active channel.</td><td>Vegetation: The dominance of alien plants increases within the riparian habitat with species such as Acacia mearnsii, Arundo donax, Eucalyptus camaldeunsis, Nasturtium officinale, and Solanum mauritianum increasing in density. Indigenous species noted within the extent of the riparian extent include Prionium serratum and Pteridium aquilinum.</td></tr>
<tr><td>Vegetation Unit</td><td colspan="2">Cap Lowlands Alluvial Wetlands Critically Endangered (Mucina & Rutherford 2006)</td></tr>
<tr><td>Western Cape Biodiversity Framework</td><td colspan="2">ESA and CBA</td></tr>
</table>

The riparian system was categorised as Largely Moderately ('D' category systems), indicating that there has been a loss and change in the hydrological, geomorphological and biological processes and characteristics, however the basic ecosystem functions are still occurring, either in a largely modified way (Table 9).

***Table 9: The summarised PES scores for the riparian system assessed***

| Resource | IHI Score (Average % Intact) | Class | Rationale |
|---|---|---|---|
| **Rip 1** | 55.8 | **E** (Seriously Modified) | The system is located in a large catchment, within which the presence of various infrastructure as well as agricultural activities had a profound effect on this watercourse. Roads present within the system change the flow regime and increase the amount of hardened surfaces within the active river channel. The active and macro channels are vegetated, yet are dominated by alien vegetation and have fundamentally low species richness. There is modified land cover in the catchment, which has increased the volume and concentration of run-off and flow regimes. The water quality of the system is in a poor condition, which could be attributed to the sewage treatment works located upstream as well as the presence of agricultural activity dominating the catchment. |

*Please note that IHI assessment (Ecoquat) Excel spreadsheets can be made available by upon request.*

## 6.2 Wetland Present Ecological State (PES)

A level 1 WET-Health assessment was conducted to determine the Present Ecological State of all wetlands to be assessed. The summarised PES scores are shown in the table below (Table 10).

***Table 10: Summarised WET-Health Scores for the wetlands assessed***

| **Wet-Health Scores** | | | | |
|---|---|---|---|---|
| **Wetland** | Hydrology | Geomorphology | Vegetation | Overall Score |
| Unchan 1 | F | E | F | **F** |
| Unchan 3 | E | C | E | **D** |

### *6.2.1 Unchan 1*

This wetland is located adjacent to the N2 National Route on the southern side. Should the Alternative 3 be constructed it will likely result in direct infilling into this wetland. It is likely that this wetland did however historically have a different flow path and that the construction of the N2 National Route historically infilled much of the system as it is now located at the bottom of the embankment adjacent to the N2 National Route. Besides the N2 National Route the landuse of the region consists of dairy farmers, with effluent from these farmers being channelled into this system. The agricultural setting has impacted the hydrological health of the system through pasture planting and the abstraction of water for farming activities. The system is heavily dammed with 7 dams located within or directly adjacent to the HGM unit. Given the extent of these modifications within the catchment and wetland itself, the hydrology health of the wetland has been critically modified with an impact rating of 10.0 (F) (Table 11). As has been aforementioned dams starve the water column of sediment and directly impact the wetlands geomorphological health. The system also has a deep gully located within its extent changing distribution patterns of water and sediment within system. The location of the N2 National Route, also resulted in the shortening of the system in terms of its sinuosity. All these factors have had a damaging effect on the geomorphological health of the system which has been seriously modified with a score of 6.2 (Table 11). As can be expected these severe disturbances have also had a negative impact on the vegetation health score of the system. Besides the perennial sections of this system are in sections lower down the system void of vegetation besides the odd *Isolepis prolifera*, while the seasonal and temporary portions of the wetland are dominated by *Acacia mearnsii*, which has shaded out the majority of indigenous species. There are remnants of indigenous vegetation remaining in the central portions of the wetland with some *Phragmites australis* individuals present, as well as some fynbos species such as the shrubs *Cliffortia strobilifera, Conyza scabrida, Helichrysum helianthemifolium* and *Laurembergia repens*. Further upstream however alien *Pennisetum clandestinum* dominates pastures. It is anticipated that all of the assessed PES scores will continue to deteriorate over for the next 5 years.

***Table 11: Detailed WET-Health Scores for the Unchan 1 wetland assessed***

| WET-HEALTH LEVEL 1 ASSESSMENT | | |
|---|---|---|
| SCORE/10 | CLASS | HYDROLOGY |
| 10.0 | F | The hydrological score for this wetland has primarily being influenced by the changes to the water distribution and retention patters within the wetland and catchment. The presence of dairy farming infrastructure and pastures as well as numerous dams adjacent and within the HGM unit have critically changed the volume and numerous homesteads have also changed the distribution patters of the system. These aforementioned factors contributed to the critically modified hydrological health score. |
| GEOMORPHOLOGY | | |
| 6.2 | E | The presence of a large gully within the system, numerous dams, dairy farming activities and the N2 National Route, as well as the poor hydrological health score has significantly impacted the geomorphological health of this system. The N2 National Route appeared to have also shortened and modified the systems sinuosity and all of these factors combined have seriously modified the systems geomorphological integrity. |
| VEGETATION | | |
| 8.8 | F | There are large levels of disturbance associated with the construction of the N2 National Route and land use activities within and adjacent to this wetland system. Lower portions of the wetland are dominated by the alien *Acacia mearnsii*, with only a few *Isolepis prolifera* surviving. There are remnants of indigenous vegetation remaining in the central portions of the wetland with some *Phragmites australis* individuals present, as well as some fynbos species such as the shrubs *Cliffortia strobilifera, Conyza scabrida, Helichrysum helianthemifolium* and *Laurembergia repens*. The upper portions of the system are almost exclusively dominated by pastures of *Pennisetum clandestinum*. The presence of infrastructure, infilling, erosion and the alien plant species in portions of the wetland decreased the score of this system and without intervention it is likely this score will continue to decrease over the next 5 years. |
| OVERALL PES | | |

| | | |
|---|---|---|
| **8.57** | **F** | **Critically Modified.** The systems has had various aspects of its health severely damage, by landuse activities, various dams as well as the presence of the N2 National Route having infilled large portions of this system. It is likely that all aspects of this wetland will continue to decline over the next 5 years. |

### *6.2.2 Unchan 3*

The Present Ecological State (PES) of the wetland is defined as largely modified represented by an overall 'D' category for the WET-Health assessment (Table 12). The wetland itself have not undergone extensive changes, the hydrology score for the wetland has an impact rating of 6.5 (E) indicating that the hydrological processes have been extensively modified. This hydrological score was primarily influenced by the presence of two dams located within the extent of the HGM unit, while pastures dominated the extent of the catchment. The presence of dams also influenced the geomorphological scores. The geomorphological processes are in a moderately modified state and therefore have "C" Category impact score. Besides dams starving the system of sediment, this geomorphological score can primarily be attributed to the presence of infrastructure (in the form of the N2 National Route), within the system and the evidence of erosion occurring. The vegetation element has been the most heavily impacted by several alien species, however there are portions of the system which are still in a fair condition. Several alien plant species including *Eucalyptus camaldeunsis* trees encroaching and the vegetation has undergone significant modification resulting in an impact score of 7.3 (Category "D"). It is anticipated that should the Preferred Alternative or Alternative 2 be developed there will be additional infilling occurring within this system and therefore all aspects are likely to continue decrease in terms of the Wet-Health scores.

***Table 12: Detailed WET-Health Scores for the Unchan 3 wetland assessed***

| WET-HEALTH LEVEL 1 ASSESSMENT | | |
|---|---|---|
| **SCORE/10** | **CLASS** | **HYDROLOGY** |
| 6.5 | E | The hydrological score for this wetland has primarily being influenced by the presence of dams within the system as well as pastures within the extent of the catchment. Due to the N2 National Route road passing through the system this has resulted in the formation of a gully and changed the distribution patterns of water through the HGM unit. |
| **GEOMORPHOLOGY** | | |
| 2.3 | C | The presence dams within the extent of the HGM unit starved the water column of sediment and the infilling of portions of the wetland for the N2 National Route road also concentrated the flow of water into a stormwater pipe and likely resulted in the headcut gully above the road forming directly negatively influenced the geomorphological score of this system. The agricultural setting has also changed the sediment regime of the system. |
| **VEGETATION** | | |
| 7.3 | E | There are large levels of disturbance associated with the construction of the N2 National Route road and the agricultural practices within the wetland system and its catchment. The wetland is predominantly dominated by the reed, *Typha capensis*, and the sedges *Isolepis prolifera* and |

| | | |
|---|---|---|
| | | the herb *Watsonia galpinii*. Shrubs *Cliffortia strobilifera, Conyza scabrida, Helichrysum helianthemifolium, Laurembergia repens* and *Passerina rigida* are present where fynbos indigenous vegetation is present. Further upstream however alien *Pennisetum caldestum* dominates pastures, with *Acacia mearnsii* and *Eucalyptus camaldeunsis* encroaching the indigenous vegetation. The primary reason however that the vegetation score is low is as a result of the extensive alien plant infestation encroaching into the wetland and within the pastures. The presence of infrastructure, infilling, erosion and the alien plant species in portions of the wetland decreased the score of this system and without intervention it is likely this score will continue to decrease over the next 5 years. |
| **OVERALL PES** | | |
| **5.52** | **D** | ***Largely modified.*** *The system is has undergone significant changes and is still provides a moderate level of ecosystem processes.* |

# 7 WETLAND FUNCTIONAL IMPORTANCE

Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The WET-Ecoservices tool is utilised to assess the goods and services that the individual wetlands under assessment provide, thereby aiding informed planning and decision-making. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).

At a desktop level the functionality of channelled valley-bottom wetlands as a whole tend to contribute less towards flood attenuation and sediment trapping than typical floodplain wetland types, but would supply these benefits to a certain extent. The potential for removal of nutrients and toxicants would generally be expected to some degree, particularly from diffuse water inputs from adjacent hillslopes (Kotze *et al.*, 2009).

## 7.1 Unchan 1

There were little to no significant levels of overall goods and services generated by the Unchan 1 wetland (Figure 7). The Unchan 1 system is approximately 4.4ha size and has a moderate gradient of 3.9%. Unchan 1 provided little to no ecosystem services primarily as a result of the system's size, its poor wetland health and location near the N2 National Route.

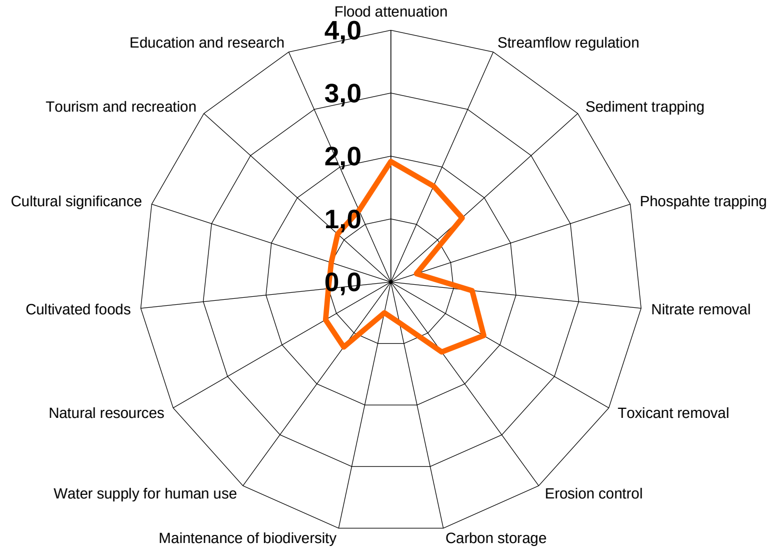


***Figure 7: Visual representation of the Wet-Ecoservices assessment of the Unchan 1 wetland assessed.***

### 7.2 Unchan 3 Wetland

The Unchan 3 system is a relatively small system being only 1.44ha in size and having a moderate slope of 7.27%. Similar to the Unchan 1 system the Unchan 3 wetland is situated in a region with extensive agricultural and infrastructural development, and this extensive development has decimated the level of ecosystem services this wetland provides (Figure 8). The poor wet health score for this system essentially compromised the level of ecosystem services that the Unchan 3 wetland provides.

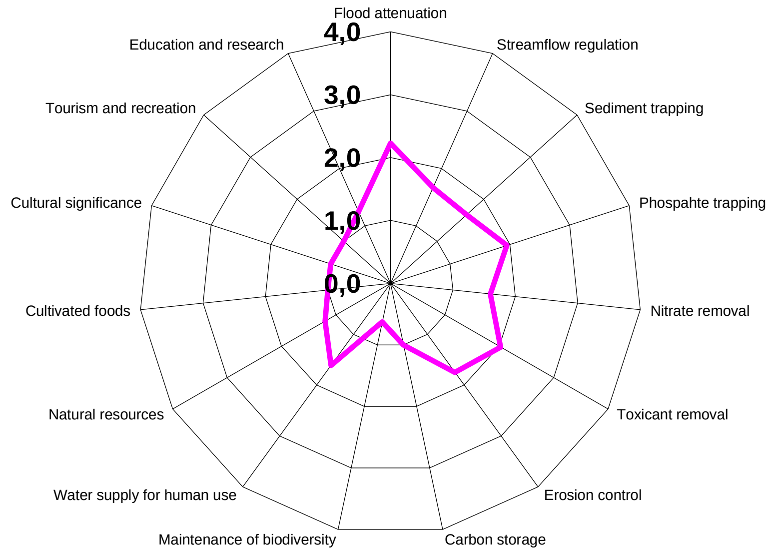


***Figure 8: Visual representation of the Wet-Ecoservices assessment of the Unchan 3 wetland assessed.***

### 7.3 Riparian Systems

The WET-EcoServices assessment tool is not applicable to riparian habitats, however the typical role of riparian habitats is provided below.

The riparian zone has specific important biotic and abiotic characteristics which are important for the continued functioning of the riparian system and ensuring the provision of goods and services. According to Rogers (1995) the riparian zone must be considered and managed not in isolation but with full awareness of its roles and functions in the landscape as a whole. There are numerous functions associated with riparian zones include (but not limited to):

- The binding action of riparian plant roots on the soil would reduce erosion of the stream bed and banks during flooding and elevated flows;
- Similarly, the changes in flow characteristics caused by the vegetation results in increased deposition of both organic and inorganic suspended materials within the macro-channel which in turn results in a decrease in flood energy;
- Certain fauna may utilise the riparian zone during parts of their life cycles and others may be confined solely to the system;
- Despite the presence of some alien invasive species occurring in the riparian zone, it nevertheless forms a centre of species biodiversity within the surrounding landscape;
- More generally, the riparian zone provides an aesthetic quality to the overall landscape of the area; and
- The riparian zone is commonly considered a corridor for the movement of animals and it is also important for the dispersal of plants (Naiman and Decamps, 1997).

# 8 ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS)

The Ecological Importance and Sensitivity (EIS) of freshwater habitats is an expression of the importance of the water 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).

## 8.1 Riparian EIS:

The Rip 1 system scored **Moderate (C Class)** in terms of its EIS (Table 16). The Rip 1 system scored moderate to poor primarily as were no rare/endangered species/biota identified onsite, with species richness being regarded as poor, with the potential of a few species being intolerant to change in flow regime. The system is also located in a rural setting with alternative freshwater resources in the region that providing good alternative habitat for species.

*Table 13: The Ecological Importance and Sensitivity of the Rip 1*

| RIPARIAN SYSTEM | ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS) | RATIONALE |
|---|---|---|
| **Rip 1** | **MODERATE, EC=C (1.75)** | *This system scored moderately in terms of EIS scores due to the level of alien plant infestation, low species richness and poor water quality. The biodiversity of this system is ubiquitous and the system not sensitive to flow and habitat modifications. There is alternative habitat of a higher quality in the immediate catchment.* |

### 8.2 Wetland EIS:

In general the wetlands in the various clusters had a moderate EIS scores (Table 14). All systems assessed have low direct benefits to society. The only scores of significant for both these systems were related to the sensitivity of these wetlands I terms to their wetland types and water quality changes. Other scores that registered in this tool were that both wetlands at a regional level were occurring in Endangered vegetation types within an ESA and CBA. However in general the poor wet health status of these systems directly impacted the EIS scores of these systems. The poor ecosystem services scores also negatively influenced the hydrological and functional importance scores of these systems, resulting in these low scores.

*Table 14: The Ecological Importance and Sensitivity of the Assessed Wetland Systems*

| HGM Unit | ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Ecological Importance* | | *Functional/Hydrological Importance* | | *Direct Benefits to Society* | | ***Overall Importance*** | |
| | SCORE (0-4) | RATING | SCORE (0-4) | RATING | SCORE (0-4) | RATING | **SCORE (0-4)** | **RATING** |
| **UNCHAN 1** | 2.33 | Moderate | 1.25 | Moderate | 0 | Very Low | **2.33** | **Moderate** |
| **UNCHAN 3** | 2.33 | Moderate | 1.5 | Moderate | 0 | Very Low | **2.33** | **Moderate** |

## 9 MANAGEMENT OF THE FRESHWATER SYSTEMS

The DWAF (2007) recommended management objectives for water resources is generally based on Present Ecological State (PES) and the Ecological Importance and Sensitivity (EIS) when there is a lack of classification of a water resource and should form an integral part of the future management of freshwater ecosystems. Utilising these PES and EIS scores, the management objectives can be determined (Table 15). The general management objective for the majority of the systems assessed should be to **maintain** the current status quo of the freshwater ecosystem without any further loss of integrity (PES) or functioning (EIS).

***Table 15: Management objectives for the assessed water resources based on PES & EIS scores (DWAF 2007).***

| | | | Ecological Importance and Sensitivity (EIS) | | | |
|---|---|---|---|---|---|---|
| | | | Very High | High | Moderate | Low |
| PES | A | Pristine | A Maintain | A Maintain | A Maintain | A Maintain |
| PES | B | Natural | A Improve | A/B Improve | B Maintain | B Maintain |
| PES | C | Good | B Improve | B/C Improve | C Maintain | C Maintain |
| PES | D | Fair | C Improve | C/D Improve | **D Maintain 1, 3** | D Maintain |
| PES | E/F | Poor | D Improve | E/F Improve | **E/F Maintain2** | E/F Maintain |

***Rip 1 = 1, Unchan 1 = 2 and Unchan 3 = 3***

# 10 DISTURBANCE/IMPACT ASSESSMENT AND ASSOCIATED MITIGATIVE MEASURES

## 10.1 Disturbance/Impact Assessment

An understanding of the relationship between the landscape and the dynamic characteristics of freshwater habitats is vital for the accurate assessment of the freshwater functions and values. Freshwater habitats are adjusting to disturbance occurring within them and within the greater landscape, on a continuous basis. The recognition to what extent these various disturbances have on freshwater systems and their associated Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) is vital when assessing disturbance and impact and when considering mitigative measures.

The types of impacts on freshwater habitats can be categorised into three (3) broad categories, namely direct, indirect and cumulative impacts. Direct impacts are associated with disturbances occurring within the system such as canalisation, infilling, removal of vegetation, infrastructure development. Indirect impacts include disturbances outside the system, such as increased surface water and sediment, loss of recharge area, changes in local drainage patterns. Cumulative impacts include disturbances resulting from combined direct and/or indirect impacts to the system over time.

The direct and indirect impacts associated with the scope of work are grouped into three (3) encapsulating impact categories where associated or interlinked impacts are grouped. Impacts have been separated into construction and operational phases of the scope of work within these categories (Tables 16 and 17).

***Table 16: Impact categories and associated impacts (without mitigation) relating to the proposed scope of work***

| BROAD IMPACT CATEGORY | | | PROJECT-SPECIFIC IMPACTS | |
|---|---|---|---|---|
| | | | CONSTRUCTION PHASE | OPERATIONAL PHASE |
| 1 | Direct habitat destruction/ modification | **Potential cause of impact**<br>- *Vegetation removal*<br>- *Direct infilling and/or excavation*<br>- *Establishment of alien invasive plant species*<br>- *Modification of profile (e.g. beds and banks)*<br>- *Alteration in habitat types*<br>**Potential Consequence**<br>- *Partial or total loss of freshwater systems and/or habitat*<br>- *Partial or total loss of currently conserved freshwater systems and/or habitat*<br>- *Partial or total loss of ecosystem goods and services*<br>- *Partial or total loss of rare/unique/endangered species*<br>- *Introduction or increased infestation of alien invasive plant species* | - Access to the sites will be along the existing roads and footpaths (where terrain is inaccessible). However, there will be vegetation destroyed as vehicles, equipment and personal need to access the new road located within and adjacent to wetlands.<br>- Loss of habitat and impact on hydrological functioning of the systems due to infilling for the road.<br>- Alien invasive species have established throughout the site and, the construction activities may result in the continued invasion of these invasive species.<br>- There will be modification of the river banks and bed due to construction activities.<br>- Harvesting of indigenous vegetation by construction personnel.<br>- Alteration of hydrological regime due to dam destruction for Alternative 3 construction. | - Possibility of continued introduction of alien invasive species, weeds and pioneer plants due to ineffective rehabilitation and maintenance.<br>- Potential continued temporary destruction of vegetation due to maintenance activities. |
| 2 | Catchment modifications (land cover and surface runoff) | **Potential cause of impact**<br>- *Vegetation removal*<br>- *Erosion*<br>- *Sedimentation*<br>- *Increased surface runoff volume and velocity*<br>- *Reduced infiltration*<br>- *Alteration in habitat types*<br>**Potential Consequence**<br>- *Partial or total loss of freshwater systems and/or habitat* | - Reduction in bank stability, exposed bank erosion.<br>- Vegetation removal may potentially result in an increase in exposed surfaces and subsequent potential for decreased soil particle cohesion and soil binding capacity, increasing the potential for erosion and sedimentation. Formation of rills and gullies from increased concentrated runoff. This increase in volume and velocity of runoff increases the particle carrying capacity of the water flowing over the surface and into the | - Any maintenance activities may result in increased possibilities of erosion and sedimentation of freshwater resources. |

| | | | | |
|---|---|---|---|---|
| | | - *Incision and sedimentation of freshwater habitats*<br>- *Decrease in present state of systems*<br>- *Introduction or increased infestation of alien invasive plant species*<br>- *Partial or total loss of ecosystem goods and services* | riparian unit resulting in increased rates of erosion and sedimentation within the riparian and in-stream habitat.<br>- Soil compaction resulting in reduced infiltration and increased surface runoff together with the artificial creation of preferential flow paths due to construction activities, will result in increased quantities of flow entering the system.<br>- Should Alternative 3 be built there could be a decrease in water quality due to dam destruction resulting in pollutants that have settled in the dam being released down the watercourse, resulting in catchment level impacts. | |
| 3 | Water Quality (Pollution) | **Potential cause of impact**<br>- *Changes in physical, chemical and biological characteristics of water*<br>- *Hydrocarbon input from vehicles utilising the existing road.*<br>- *General waste being deposited into the system by the general public.*<br>- *Increased nutrients (faecal matter from infant diapers deposited within the channel).*<br>**Potential Consequence**<br>- *Decrease in present state of systems*<br>- *Partial or total loss of rare/unique/endangered species*<br>- *Introduction or increased infestation of alien invasive plant species* | - During construction there are a number of potential pollution inputs into the system. These pollutants alter the water quality parameters such as turbidity (increased suspended solids), nutrient levels, chemical oxygen demand and pH. These alternations impact the species composition of the system, especially species sensitive to minor changes in these parameters.<br>- Instream and riparian habitat sedimentation downslope and downstream.<br>- Burying of aquatic habitat.<br>- Potential aquatic fauna fatalities.<br>- Should Alternative 3 be built there could be a decrease in water quality due to dam destruction resulting in pollutants that have settled in the dam being released down the watercourse.<br>- The potential direct and indirect impacts on the riparian habitat will result in deterioration in local freshwater ecosystem ecological condition and a reduction in the availability of intact | - Any additional change in the state of the wetland/riparian habitat is likely to be due to maintenance activities during operation.<br>- Decrease in water quality should dams not be rebuilt and effluent continue to enter the Unchan 3 system |

| | | | | |
|---|---|---|---|---|
| | | - *Partial or total loss of ecosystem goods and services* | natural habitat, especially if mitigation measures are not implemented effectively.<br>- Hydrocarbons including petrol/diesel and oils/grease/lubricants associated with construction activities (machinery, maintenance, storage, handling) may potentially enter the system by means of surface runoff or through dumping by construction workers.<br>- Raw cement entering the system through incorrect batching procedure and/or direct disposal.<br>- The incorrect positioning and maintenance of the portable chemical toilets and use of the surround environment as ablution facilities may result in sewage and chemicals entering the system.<br>- The abovementioned contaminants may enter the channel during construction activities and have the capacity to negatively affect the in-stream aquatic habitat within the construction footprint and downstream, particularly aquatic flora and fauna sensitive to changes in turbidity levels, nutrient levels, chemical oxygen demand and toxicants. | |

The major impacts associated of the proposed scope of work activities will directly impact freshwater resources. Therefore, the impacts and mitigative measures will be focused on these systems and associated catchments.

A methodology for assigning scores to the respective impacts is described in Annexure 15, with the assessment for each impact below per alternative illustrated in (Tables 17 - 19). The strength of this approach is that the critical components of each impact, namely duration, extent, magnitude, probability and significance, are carefully considered, allowing a balanced perspective of each impact to be gained. It should be noted that the impacts for the Preferred Alternative and Alternative 2 are envisaged to be very similar. This is primarily due to the fact that similar amounts of wetland habitat and vegetation will likely be destroyed. Alternative 3 will result in the likely infilling and destruction of greater amounts of the Unchan 1 system as well as the destruction of several dams. Therefore this alternative had the highest impacts.

***Table 17: Evaluation of potential impacts of the prroposed scope of works on the surrounding freshwater habitats for the Preferred Alternative.***

| | | Impact | Mitigation Level | Extent | Duration | Magnitude | Probability | Significance | Reversibility | Irreplaceable Resource Loss | Mitigative Potential |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Construction Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Regional (3) | Long-term (4) | High (8) | Probable (3) | **Medium (45)** | Medium | Yes | High |
| | | | **Good (best-case scenario)** | Site only (1) | Long-term (4) | Small (2) | Improbable (2) | **Low (14)** | High | No | High |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Regional (3) | Long-term (4) | Moderate (6) | Highly Likely (4) | **Medium (51)** | Medium - Low | No | High |
| | | | **Good** | Local (2) | Very short (1) | Low (4) | Probable (3) | **Low (21)** | Low | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Very short (1) | Moderate (6) | Highly Likely (4) | **Medium (40)** | Medium | No | High |
| | | | **Good** | Local (2) | Very short (1) | Small (2) | Improbable (2) | **Low (10)** | Medium | No | High |
| ***Operational Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Local (2) | Long-term (4) | Low (4) | Highly Likely (4) | **Medium (40)** | High | No | High |
| | | | **Good (best-case scenario)** | Site only (1) | Short (2) | Minor (2) | Improbable (2) | **Low (10)** | High | No | High |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Local (2) | Permanent (5) | Moderate (6) | Highly Likely (4) | **Medium (52)** | Medium – Low | No | High |
| | | | **Good** | Local (2) | Short (2) | Low (4) | Improbable (2) | **Low (16)** | Medium | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Permanent (5) | Moderate (6) | Probable (3) | **Medium (42)** | Medium – Low | No | Low |
| | | | **Good** | Local (2) | Permanent (5) | Low (4) | Probable (3) | **Medium (33)** | Low | No | Low |

***Table 18: Evaluation of potential impacts of the prroposed scope of works on the surrounding freshwater habitats Alternative 2.***

| | | Impact | Mitigation Level | Extent | Duration | Magnitude | Probability | Significance | Reversibility | Irreplaceable Resource Loss | Mitigative Potential |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Construction Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Regional (3) | Long-term (4) | Medium (6) | Probable (3) | **Medium (39)** | Medium | No | High |
| | | | **Good (best-case scenario)** | Site only (1) | Long-term (4) | Small (2) | Improbable (2) | **Low (14)** | High | No | High |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Regional (3) | Long-term (4) | Moderate (6) | Highly Likely (4) | **Medium (51)** | Medium - Low | No | High |
| | | | **Good** | Local (2) | Very short (1) | Low (4) | Probable (3) | **Low (21)** | Low | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Very short (1) | Moderate (6) | Highly Likely (4) | **Medium (40)** | Medium | No | High |
| | | | **Good** | Local (2) | Very short (1) | Small (2) | Improbable (2) | **Low (10)** | Medium | No | High |
| ***Operational Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Local (2) | Long-term (4) | Low (4) | Highly Likely (4) | **Medium (40)** | High | No | High |
| | | | **Good (best-case scenario)** | Site only (1) | Short (2) | Minor (2) | Improbable (2) | **Low (10)** | High | No | High |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Local (2) | Permanent (5) | Moderate (6) | Highly Likely (4) | **Medium (52)** | Medium – Low | No | High |
| | | | **Good** | Local (2) | Short (2) | Low (4) | Improbable (2) | **Low (16)** | Medium | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Permanent (5) | Moderate (6) | Probable (3) | **Medium (42)** | Medium – Low | No | Low |
| | | | **Good** | Local (2) | Permanent (5) | Low (4) | Probable (3) | **Medium (33)** | Low | No | Low |

***Table 19: Evaluation of potential impacts of the prroposed scope of works on the surrounding freshwater habitats for the Alternative 3.***

| | | Impact | Mitigation Level | Extent | Duration | Magnitude | Probability | Significance | Reversibility | Irreplaceable Resource Loss | Mitigative Potential |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Construction Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Regional (3) | Long-term (4) | High (8) | Probable (3) | **Medium (45)** | Medium | Yes | Low |
| | | | **Good (best-case scenario)** | Regional (3) | Long-term (4) | Moderate (6) | Probable (3) | **Medium (39)** | Medium | Yes | Low |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Regional (3) | Long-term (4) | Moderate (6) | Highly Likely (4) | **Medium (51)** | Medium - Low | No | High |
| | | | **Good** | Local (2) | Very short (1) | Low (4) | Probable (3) | **Low (21)** | Low | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Very short (1) | High (8) | Highly Likely (4) | **Medium (48)** | Medium | No | High |
| | | | **Good** | Local (2) | Very short (1) | Small (2) | Improbable (2) | **Low (10)** | Medium | No | High |
| ***Operational Phase*** | 1 | Direct habitat destruction/ modification | **Poor (worst-case scenario)** | Local (2) | Long-term (4) | Low (4) | Highly Likely (4) | **Medium (40)** | High | No | High |
| | | | **Good (best-case scenario)** | Site only (1) | Short (2) | Minor (2) | Improbable (2) | **Low (10)** | High | No | High |
| | 2 | Catchment modifications (land cover & surface runoff) | **Poor** | Local (2) | Permanent (5) | Moderate (6) | Highly Likely (4) | **Medium (52)** | Medium – Low | No | High |
| | | | **Good** | Local (2) | Short (2) | Low (4) | Improbable (2) | **Low (16)** | Medium | No | Medium |
| | 3 | Water Quality (Pollution) | **Poor** | Regional (3) | Permanent (5) | High (8) | Probable (3) | **High (64)** | Medium | No | High |
| | | | **Good** | Local (2) | Permanent (5) | Low (4) | Probable (3) | **Medium (33)** | Low | No | Low |

# 11 MITIGATIVE MANAGEMENT MEASURES

The scope of work must take into account the risk to the surrounding environment and must be planned, designed and implemented in a sustainable manner ensuring further disturbance is avoided or, where they cannot be altogether avoided, appropriate mitigative measures be applied in the form of reactive practical actions that minimises or reduces in situ impacts. This is to ensure no unsustainable degradation of sensitive, vulnerable, highly dynamic or stressed ecosystems occurs due to the proposed scope of works.

According to Chapter 1 Principle 2. (4) of the National Environmental Management Act (Act No. 107, 1998) regarding sustainable development and management of sensitive ecosystems:

- (**a**), "*Sustainable development requires the consideration of all relevant factors including the following:*
  - *(i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;*
  - *(ii) that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;*
  - *(vi) that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;*
  - *(vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and*
  - *(viii) That negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied."*
- (**r**) *Sensitive*, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, **wetlands, and similar systems** require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

The mitigation of negative impacts on biodiversity and ecosystem goods and services is a legal requirement for authorisation purposes and must take on different forms depending on the significance of the impact and the specific area being affected. Mitigation requires proactive planning that is enabled through a mitigation hierarchy (Figure 9). Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining significant residual negative impacts on biodiversity (DEA 2013).

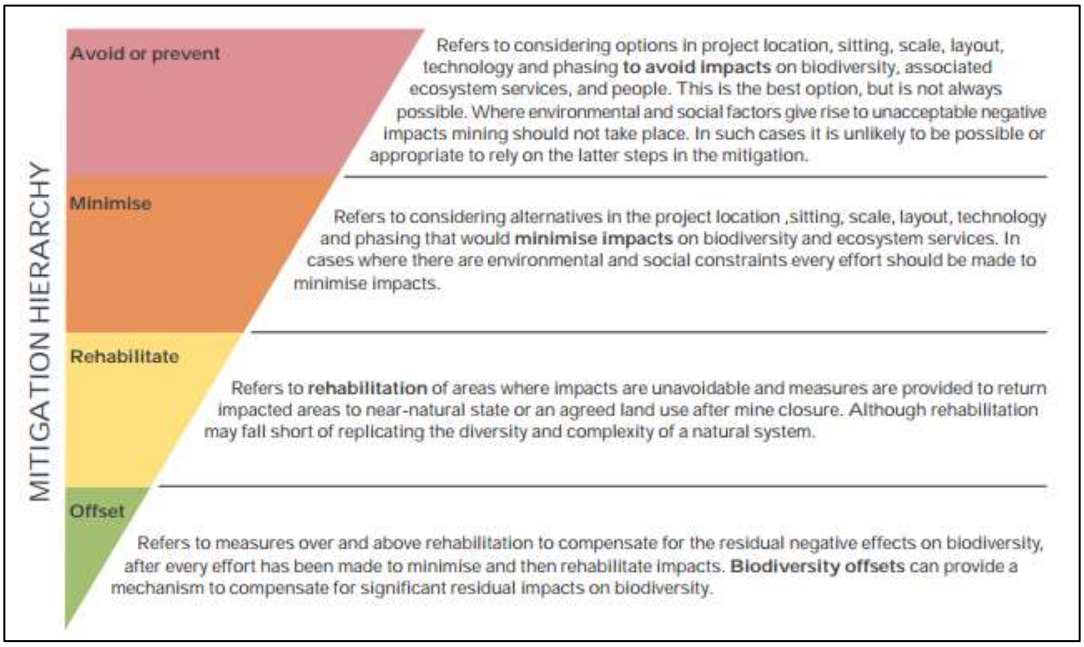


***Figure 9: The mitigation hierarchy for dealing with negative impacts on biodiversity. Its application is intended to require companies to first strive to avoid disturbance of ecosystems and loss of biodiversity, and where they cannot be avoided altogether, to minimise, rehabilitate or offset any residual negative impacts on biodiversity (DEA 2013).***

The mitigative measures detailed within this report must be taken into consideration during financial planning of the construction phase of the development. This to ensure that sufficient funds are available to implement all the measures required to maintain/improve the current PES score of the water resources impacted upon. The proof of this financial capacity must be made available if requested.

Mitigation measures, presented below, generic and specific to the impacts associated with the construction activities are intended to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMPr). The EMPr must be amended to ensure the generic/broad and site/project-specific mitigative measures are included.

### 11.1 Construction Mitigative Measures

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | CONSTRUCTION |
| Generic (Broad) | - A construction method statement is required to be compiled by the applicant/contractor for all activities associated with the development. This method statement must include the phases of the project, activities associated with the development and all mitigation measures stipulated within this report and the site-specific Environmental Management Programme (EMPr). The applicant, engineer, contractor and ECO must agree and approve the statement as this will become binding document which must be implemented onsite. The independent ECO must ensure this document is continuously implemented onsite to ensure no unnecessary disturbance.<br>- A serial plan of construction must be developed:<br>• Construction must be immediately followed by rehabilitation;<br>• Excavation of any soils in the riparian area must be done to allow the storage of soil in sequence<br>• Soil replacement must be conducted in same sequence as excavated;<br>• Soil surfaces must not be left open for lengthy periods to prevent erosion.<br>• Affected surface vegetation must be removed, appropriately stored then reinstated, immediately post-construction, as close to their original position as possible, to reduce the possibility of longer-term change to the vegetation community. The vegetation must be removed keeping the root systems intact as far as possible.<br>• If required vegetation plugs can be sort from areas adjacent to the construction site, under the supervision of the Environmental Control Officer.<br>- Environmental inductions and training must include the contents of the above method statement.<br>- Cut and fill must be avoided where possible during the set-up of the construction camp. The utilisation of the already heavily disturbed areas should be encouraged.<br>- The relocation of services, i.e. water, stormwater and especially sewerage infrastructure, must not result in the contamination of the surrounding environment.<br>- Removal of vegetation must only be when essential for the continuation of the road and bridge construction. Do not allow any disturbance to the adjoining natural vegetation cover or soils. All disturbed areas must be prepared and then re-vegetated to the satisfaction of the ECO as per the relevant Rehabilitation Plan.<br>- Where feasible, construction activities should be conducted during the drier months of the year (April – August) to minimise the possibility of erosion, sedimentation and transport of suspended solids associated with disturbed areas and rainfall events.<br>- All potential stormwater contaminants must be bunded in the site camp to prevent run-off into the surrounding environment. A drainage system must be established for the construction camp. The drainage system must be regularly checked to ensure an unobstructed water flow. Establish cut off drains and berms to reduce stormwater flow through the construction site. The contractor must prepare a Stormwater Control Plan (which may form part of the construction method statement) to ensure that all construction activities do not cause, or precipitate, soil erosion sediment which may result in sediment input into the surrounding environment. The designated responsible person on site, as indicated in the stormwater control plan (usually |

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT<br>CONSTRUCTION |
|---|---|
| | the contractor/ECO) must ensure that no construction work takes place before the stormwater control measures are in place and must include post-construction/operational phase stormwater requirements.<br>- The drainage plan must ensure no downstream erosion occurs through increased stormwater inputs and that the stormwater system has sufficient capacity for water inputs and drainage. The use of soft engineering (grassed swales) instead of hardening gutters should be used where possible.<br>- No contaminated runoff or grey water is allowed to be discharged from the construction camp.<br>- Designated areas for stockpiling of raw materials must be identified before material is brought onto site. No stockpiling is to occur on or near slopes or water resources. All stockpiling areas must be approved by the ECO before stockpiling occurs.<br>- No-go areas must be determined and demarcated and agreed upon by contractors, engineers and ECO before any construction activities occur onsite. Special attention must be given to the identified water resources in the vicinity of the development activities and these are illustrated in Figure 10. Unnecessary intrusion into these systems is prohibited. These areas must be clearly demarcated onsite and indicated to all construction workers onsite before any construction activities (including site establishment) takes place. Where intrusion is required, the working corridor must be kept to a minimum and identified and demarcated clearly before any construction commences to minimise the impact. |

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | CONSTRUCTION |

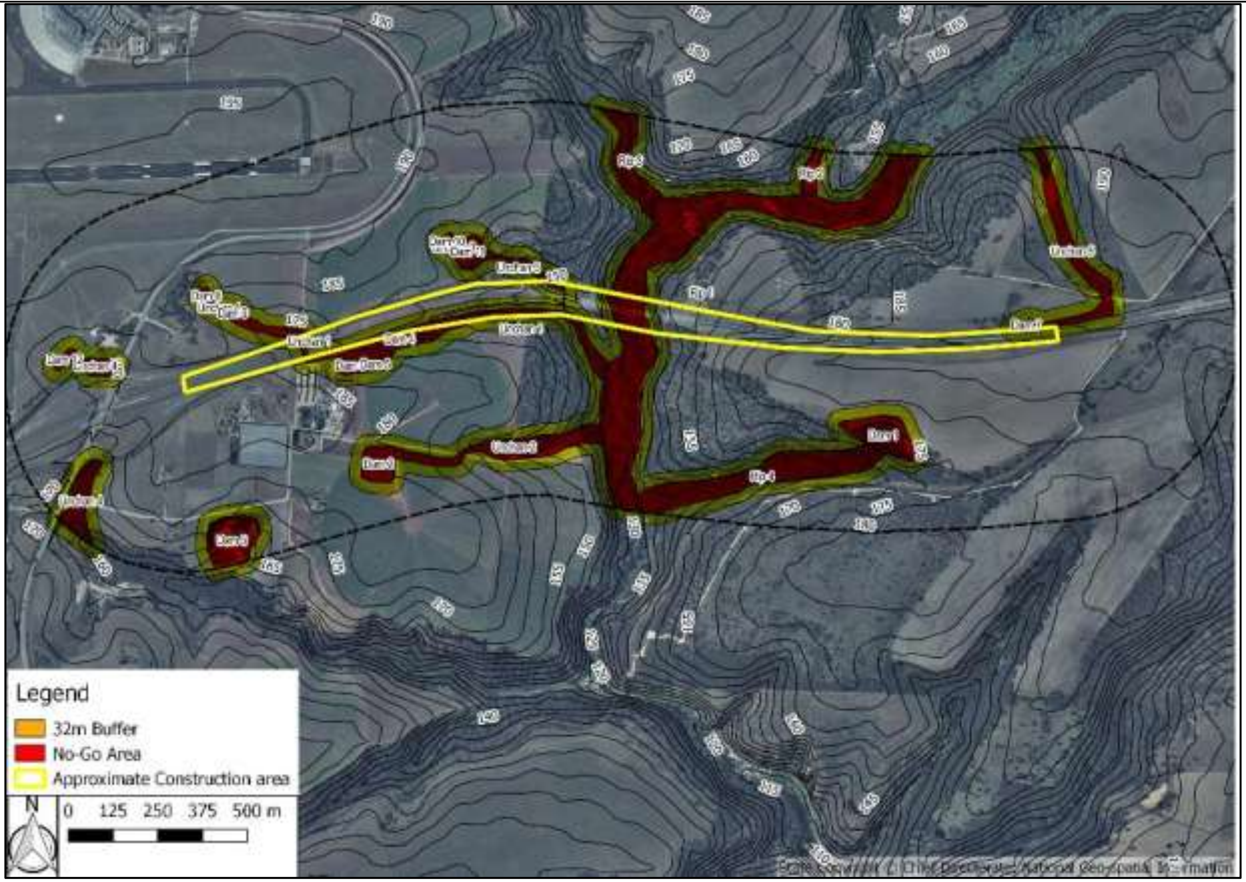


***Figure 10: A map illustrating the Senstive No-Go area and suitable buffers in terms of freshwater resources delineated within the study area***

- The upgrade of the stormwater infrastructure must be sufficiently incorporated into the design to prevent the concentration of surface runoff resulting in erosion.
- All staff are to be trained on their environmental responsibilities before commencing work. All new staff are to be trained before they start work on site. This should be adequately covered within the site-specific EMPr and should not require input from a freshwater habitat specialist (above what is detailed within this report).

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | CONSTRUCTION |
| | - The demarcated wetlands and riparian systems must be protected from erosion and direct or indirect spills of pollutants, e.g. sediment, refuse, sewage, cement, oils, fuels, chemicals, wastewater etc.<br>- Stockpiles must not be located within 50 metres of any rivers, wetlands and/or riparian channels or within the 1:100 year flood lines. The furthest threshold must be adhered to. They should not be placed in vegetated areas that will not be cleared. Erosion control measures including silt fences, low soil berms and/or shutter boards must be put in place around the stockpiles to limit sediment runoff from stockpiles.<br>- Care must be taken to avoid the introduction of alien plant species to the site. Alien vegetation re-growth must be controlled throughout the entire site during the construction and rehabilitation periods.<br>- All exposed surfaces within the construction site must be checked for alien invasive plant species on a monthly basis and any identified alien species must be removed by hand pulling/uprooting and appropriately disposed of. Herbicides should **only** be utilised where manually removing is not possible. Herbicides utilised are restricted to products which have been certified safe for use in wetland and riparian areas by an independent testing authority. The ECO must be consulted before the purchase of any herbicide.<br>- Water used on site must be from an approved source. Should the water be extracted from a natural source, a water use licence must be acquired from DWS before abstraction. Water use on the site must be recorded and monitored.<br>- The digging of pit latrines is not allowed under any circumstances.<br>- None of the open areas or the surrounding environment may be used as ablution facilities.<br>- No contaminated runoff or grey water may be discharged from the site camp or site into the surrounding environment. Portable toilets must be situated outside of the 1:100 year floodline of all rivers, tributaries and wetlands. A maintenance plan for the servicing of these toilets must be drawn up and strictly adhered to, to prevent malfunctioning and neglect resulting in environmental contamination.<br>- Should any spills of hazardous materials occur on the site or in the storage area, the relevant clean-up specialists must be contacted immediately. Materials that absorb fuel & oil, such as Drizit or earth should be placed over the spill. This contaminated material must be uplifted, placed within impermeable container and disposed of at a recognized disposal site.<br>- In the event of a spillage that cannot be contained and which poses a serious threat to the local environment, the following Departments must be informed of the incident in accordance with Section 30 of the National Environmental Management Act, Act 107 of 1998, within forty-eight (48) hours:<br>• The Local Authority;<br>• Department of Water and Sanitation;<br>• The Department of Environmental Affairs and Development Planning |

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | CONSTRUCTION |
| | • The Local Fire Department when relevant; and<br>• Any other affected departments.<br>- An incident record must be completed for all spills that do occur onsite. Minor incidents will include small spills of less than 5 litres that do not enter a watercourse, stormwater drains, housekeeping issues and general small non compliances with the requirements of this report, method statements, EA and/or EMPr. The record of incidents is to be included in the reporting to the authorities. Major incidents must be reported to the authorities, which include spills larger than 5L and all incidents involving contamination of water resources, stormwater or other reportable incidents. **Minor incidents**: small spills less than 5l that do not enter stormwater, minor non-compliance with EMPr that does not cause major environmental impact i.e. Housekeeping issues etc. **Action**: Supervisor and staff on site to record and address and notify ECO. ECO to advise on remediation measures and to follow up on actions taken to address incident. **Records**: On site incident register. **Major incidents**: Large spills or any spills that enter watercourses, stormwater, contamination of soil, fires, explosions. **Action**: Report immediately to ECO, action to be taken to prevent further damage and incident to be reported to authorities. ECO to advise on remediation measures and to follow up on actions taken to address incident. **Records**: On site incident register and report to authorities as listed above.<br>- Topsoil must be stored on a level area at least 50 m away from any river, tributary and/or wetland, and outside the 1:100 year flood line. The furthest threshold must be adhered to.<br>- The harvesting of firewood, medicinal plants, tree bark, flowers or other natural materials is forbidden on the site and surrounding environment.<br>- The Contractor must, as an initial and on-going exercise, implement erosion and sedimentation control measures to the satisfaction of the ECO. Stabilisation of cleared areas to prevent and control erosion and/or sedimentation must be actively managed.<br>- A designated waste area must be utilised at all times. Bins must be provided and emptied at no less than monthly intervals.<br>- All solid waste generated during the construction process (including packets, plastic, rubble, cut plant material, waste metals etc.) must be placed in the waste collection area in the construction camp and must not be allowed to blow around the site, be accessible by animals, or be placed in piles adjacent the skips / bins.<br>- Burying of waste, rubble on site, or dumping in drainage lines/rivers is prohibited.<br>- Material Safety Data Sheets (MSDSs) must be readily available on site for all chemicals and hazardous substances to be used on site. Where possible and available, MSDSs should additionally include information on ecological impacts and measures to minimize negative environmental impacts during accidental releases or escapes.<br>- Hazardous material storage areas must not be within 50 m of any watercourse or within the 1:100 year flood line. The furthest threshold must be adhered to. Hazardous storage areas to be hard surfaced and bunded with an impermeable liner to protect groundwater quality and undercover. The bunded a catch pit must have at least 110% the storage capacity of the total stored quantity. |

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | CONSTRUCTION |
| Site/Project Specific | - The footprint of the upgrade of the roads must be kept to a minimum, to ensure there is no unnecessary intrusion into any water resource. It is noted that intrusion is required for the realignment and bridge building activities.<br>- Existing access routes must be utilised during construction. No additional access roads are required and therefore no further disturbance is necessary. All access points, roads and turning areas must be agreed by the engineer and ECO prior to commencement of construction. No ad hoc haulage roads or turning areas may be created.<br>- Stormwater infrastructure must not be positioned where concentrated flows will enter these systems with efficient energy dissipaters.<br>- The use of temporary detour lanes must make use of existing road networks where possible. In areas where the road traverses the wetland systems and leading up to these areas, no temporary lanes are permitted. The use of construction half widths must be utilised as an alternative to prevent an unnecessary increase in road footprint into the wetland systems.<br>- The mitigation of impacts should focus on managing the runoff generated by the newly aligned road, and introducing it responsibly into the receiving environment. Therefore, the stormwater infrastructure must not be positioned where concentrated flows will enter these systems without efficient energy dissipaters. Additionally, on the steeper sections of the road, and on slopes where stormwater will drain into a water resource, it is recommended that the frequency of stormwater outlets is increased to prevent erosion at discharge points.<br>- The road upgrade must promote an unhindered longitudinal flow through the riparian system, to prevent preferential surface flow and confinement. Additionally, the impoundment of water upslope of the crossing must be avoided.<br>- It is therefore recommended that the crossing structure utilised be wide enough to unhindered through-flow of the riparian system and avoid impoundment upslope. This may be achieved through the correct bridge design at the crossing. |

### 11.2 Post-Construction Mitigative Measures/ Rehabilitation Guidelines

<table>
<tr><th rowspan="2">MITIGATIVE MEASURES</th><th>PHASE OF PROPOSED DEVELOPMENT/PROJECT</th></tr>
<tr><th>POST-CONSTRUCTION/REHABILITATION</th></tr>
<tr><td>Generic (Broad)</td><td>- Rehabilitation is not the static endpoint of a recipe-like process (Kusler and Kentula, 1990). Rather, it is a process in its own right, whereby the wetland system is given an opportunity for a new beginning (Grenfell et al., 2007).<br>- Rehabilitation requires that there is an attempt to imitate natural processes and reinstate natural ecological driving forces in such a way that it aids the recovery (or maintenance) of dynamic systems so that, although they are unlikely to be identical to their natural counterparts, they will be comparable in critical ways so as to function similarly (Jordan et al., 1987).<br>- It must be recognised that rehabilitation interventions may have different ecological starting points (ranging from totally degraded to slightly degraded) and different goal endpoints (ranging from a state that is close to the pristine to one which is still far from pristine, but nonetheless an improvement on the state of the system without any rehabilitation intervention). The chosen goal endpoint depends on what is achievable, given the site conditions, and those ecosystem attributes and services that are considered most important. Any rehabilitation project should therefore be based on an understanding of both the ecological starting point and on a defined goal endpoint, and should accept that it is not possible to predict exactly how the wetland is likely to respond to the rehabilitation interventions.<br>- The most typical rehabilitation interventions designed to assist in the recovery of degraded wetland ecosystems are ‘plugs’ constructed within artificial drainage channels. The ‘plugs’ are placed with the intention of reinstating a more natural hydrology. Typical interventions for maintaining the health wetland ecosystems that are in the process of degrading are the placement of erosion control structures which assist in halting the advance through a wetland of an erosion headcut. However, rehabilitation is not confined to physical structures, and rehabilitation may include interventions such as reducing livestock grazing-pressure or reducing the frequency of burning. Please see the generic wetland rehabilitation methods in Annexure 15.9.<br>- It is the responsibility of the contractor to appoint a suitably experienced rehabilitation specialist to implement an approved Wetland Rehabilitation Plan. The specialist shall have a sound knowledge of the vegetation types and communities of the site and his/her appointment must be approved by the Environmental Control Officer (ECO). The plan shall include (but not limited to):<br>• Detailed rehabilitation methodology;<br>• Details for potential structures proposed within existing systems to assist with the prevention of further erosion and improve flooding of wetland systems;<br>• Methods for the removal and control of alien invasive plant species within the wetland and riparian areas;<br>• Assessment of current vegetation species within the study site;<br>• Proposed plant species to be replanted in the wetland and/or riparian areas; and<br>• Monitoring requirements to assess how successful the rehabilitation techniques are within the systems.</td></tr>
</table>

## 11.3 Operational Phase

| MITIGATIVE MEASURES | PHASE OF PROPOSED DEVELOPMENT/PROJECT |
|---|---|
| | OPERATIONAL |
| Generic (Broad) | - The establishment and infestation of alien invasive plant species must be prevented, managed and eradicated in the areas impacted upon by the road and bridge upgrade. The type of species and location of that species will determine the type of methodology required for its management and eradication. This methodology should target all lifecycle phases and propagules of the specific species, e.g. seedlings/saplings, seeds, roots, etc.<br>- Indigenous vegetation within the site must not be removed or damaged, where possible, during the alien plant control, increasing the probability of indigenous species propagating and preventing the reestablishment of alien species.<br>- As stated above, any use of herbicides in removing alien plant species is required to be investigated by the ECO before use, for the necessity, type proposed to be used, effectiveness and impacts of the product on aquatic biota. |
| Site/Project Specific | - The stormwater management infrastructure must be designed to ensure the run-off from the newly roads is not highly concentrated before entering the surrounding environment. The volume and velocity of water must be reduced through discharging the surface flow at regular intervals along the length road into the surrounding environment, preventing erosion. Any evidence of erosion from this stormwater system must be rehabilitated and the volume/velocity of the water reduced through further structures such as gabions, renomattresses and/or energy dissipaters at the exit of the stormwater culverts.<br>- Monitoring is required as per the monitoring requirements (section 12) below. |

# 12 MONITORING REQUIREMENTS

The recommendations for this project are intended to reinforce the envisaged very low/ low risk of disturbance associated with the construction of the road and bridge. They are proposed to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMPr) and compliance with the recommendations must be audited by a suitability qualified independent Environmental Control Officer. In the case where there is extensive damage to any freshwater system and rehabilitation is required, a suitably qualified aquatic specialist must audit the site. Monitoring for non-compliance must be done on a daily basis by the contractors under the guidance of the Project Manager / Environmental Officer / Engineer. An appropriately timed audit report should be compiled by the independent ECO. Paramount to the reporting of non-conformance and incidents is that appropriate corrective and preventative action plans are developed and adhered to. Photographic records of all incidents and non-conformances must be retained. This is to ensure that the no impacts on the freshwater habitat occur.

- A monitoring programme shall be in place not only to ensure compliance with the EMPr throughout the construction phase, but also to monitor any post-construction environmental issues and impacts during the vegetation establishment phase. Compliance against the EMPr and rehabilitation plan must be monitored during the construction phase on a monthly basis by an independent ECO. The period and frequency of monitoring required post-construction must be determined by the horticulturist and/or the ECO and approved by the ECO. Once the initial transplants / plugs are planted, the landscaper must conduct weekly site visits to 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. >80% indigenous cover). An accepted monitoring period of re-vegetated areas after this initial period is monitoring every 3 months for the first 12 months and every 6 months thereafter until the vegetation has successfully been established. If the re-vegetated areas have inadequate surface coverage (less than 30% within 9 months after re-vegetation) the area should be prepared and re-vegetated again.
- The cost-effective qualitative monitoring of the rehabilitation area may be time based through the use of periodic photographs taken from permanent photo points. These points are required to be established during site inception. The timeline created between the pre- and post-rehabilitation photos will provide an invaluable visual representation of the progress that is conveyed in a straightforward manner. The photographer should be an environmental scientist therefore allowing an expert assessment of the site adding to the qualitative information gathered from the photographs.
- The below mentioned criteria must be adhered to, ensuring the quality of the information collected:
    - Establishment of the photo points must be completed during site inception/establishment. This will allow for pre-rehabilitation imagery spanning more than a once off photograph.
    - These points should be permanently marked and assigned a unique identify number to ensure continual relocation and accuracy of the photographs. GPS co-ordinates should be recorded of each site. This is to ensure if any markers are removed or vandalised then they can be replaced.

- Photo point locations should be easily relocated and accessible and must not be obscured by future vegetation growth.
- The level of detail captured must be appropriate to the area that has undergone rehabilitation.
- Photo record forms must be development and utilised for every photo taken. The information required will be project name, location, unique identity number, directional point (e.g. North, South), date, time, photographers name and additional comments.
- Qualitative ecological information that must be visually interpreted and recorded at the same time as taking the photograph include:
    - Evidence of any channelling.
    - Extent of the site vegetation ground cover.
    - General level of plant growth, substrate levels, and water levels.
    - General observations of water quality such as clarity and presence of litter.
    - Evidence of anthropogenic presence and bird species.
    - Vegetation condition, extent of alien invasive plants and;
    - Evidence of erosion.

# 13 CONCLUSION

The South African National Road Agency SOC Limited is proposing doubling the capacity of the Gwaing River bridge, located on the N2 National Route near the George Airport. Three alternatives were proposed, the preferred being to build a new bridge upstream of the existing bridge. Alternative 2 is to double the size of the existing bridge and Alternative 3 is to build a new bridge downstream of the existing bridge. The construction of these new bridges will also result in the realignment of the existing N2 National Route to align with the relevant selected alternative. The aim of this project was to assess how the construction of the road and bridge will impact freshwater resources within the 500m study area.

Within the study there has been extensive agricultural development, in the form of pastures and infrastructure in the form of Dams (12 in total). In full 3 separate freshwater resources were assessed a being at a high enough risk rating to be considered for Phase 2 assessments. These resources included one riparian and two wetland systems.

The PES and EIS scores for each of these systems were calculated, in addition to which, the Ecosystem services supplied by the wetlands was also determined. The PES of each system was assessed, with the only riparian system assessed was classified as **seriously modified (Class E).** The two wetland systems were also seriously damaged with the Unchan 3 system being **largely modified (Class D)** and the Unchan 1 system classified as has been **Critically Modified (Class F)**. This was typical of the extensive agricultural land use of the region which has negatively impacted the heath of these numerous systems.

All systems scored **moderate** in terms of their EIS, this can mainly be attributed to the Ecological importance of the region which increased the EIS scores accordingly. No significant wetland ecosystem services were noted.

The major impacts associated with the proposed alternatives on the above-mentioned riparian and wetland systems were determined. The three alternatives were each assessed separately in terms of the significance of their impacts. The Preferred Alternative and Alternative 2 had very similar impacts and the worst case scenario of each alternative scores similarly and therefore either of these options are be feasible, provided the relevant mitigation measures are adhered to and implemented accordingly. Despite this the Alternative 3 had the highest levels of impacts. The construction of Alternative 3 will likely result in the destruction of the largest amount of wetland habitat. In addition to which, several dams within this critically modified wetland will likely be destroyed. These dams act as buffers for the effluent runoff from the nearby dairy farms and if not reconstructed, alternative treatment of the effluent runoff from these farms will need to be sourced to prevent this effluent from polluting systems downstream. Should all mitigative measures ad rehabilitation procedures be properly implemented, then all impacts reduce in significance during all proposed phases of this project for every alternative and become **minimal and limited in extent**.

The management objectives of these freshwater ecosystems during and post-construction must centre on **maintaining the current status quo** of the freshwater ecosystem without any further loss of integrity (PES) or functioning (EIS). This may be achieved through implementing the recommendations/ mitigative measures regarding the design of the project as well as the provision of practical mitigation measures and impact management consideration to deal with anticipated construction phase and operational impacts and risks. The proposed scope of works, if completed in accordance with this document and the site-specific EMPr, should not have heavy impacts on the freshwater habitats.

There is the need for a Water Use License according to Section 21 of the National Water Act No. 36 of 1998. No protected/threatened species of fauna were observed, however there was a *Sideroxylon inerme*, and *Aloe pluridens* individuals present within the possible constructon footprint and these will require permits to transplant. It is however possible that there are more protected plant species present in the terrestrial habitat that will require permits and therefore a vegetation specialist study is also recommended.

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# 15 ANNEXURE (METHODOLOGIES):

## 15.1 Wetland delineation and HGM type identification

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. 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). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

Four specific wetland indicators were used in the detailed field delineation of wetlands, which include:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

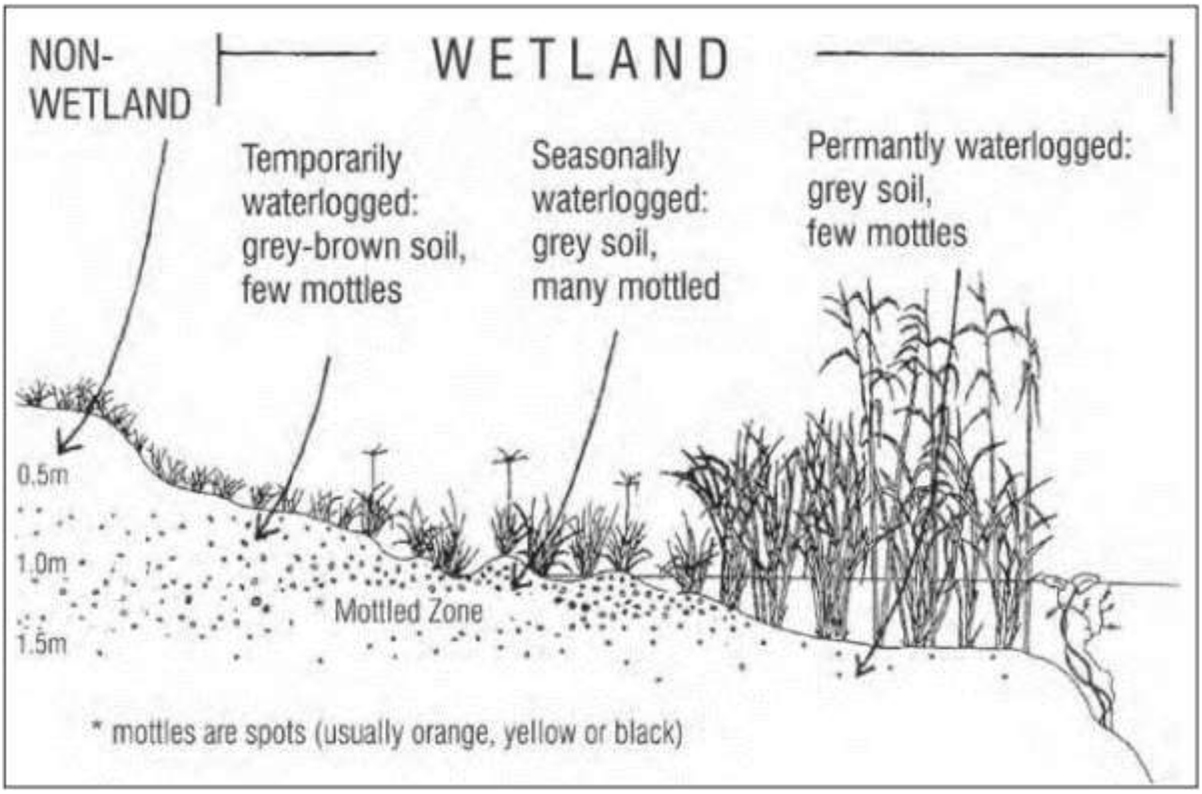


***Figure A15.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.***

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table A15.1a)

***A15.1a: Soil Wetness Indicators in the various wetland zones***

| TEMPORARY ZONE | SEASONAL ZONE | PERMANENT ZONE |
|---|---|---|
| Minimal grey matrix (<10%) | Grey matrix (<10%) | Prominent grey matrix |
| Few high chroma mottles | Many low chroma mottles present | Few to no high chroma mottles |
| Short periods of saturation (less than three months per annum) | Significant periods of wetness (at least three months per annum) | Wetness all year round (possible sulphuric odour) |

***Table A15.1b: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands***

| VEGETATION | TEMPORARY WETNESS ZONE | SEASONAL WETNESS ZONE | PERMANENT WETNESS ZONE |
|---|---|---|---|
| Herbaceous | Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas | Hydrophilic sedges and grasses restricted to wetland areas | Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants. |
| Woody | Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas. | Hydrophilic woody species restricted to wetland areas | Hydrophilic woody species, which are restricted to wetland areas. 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/F+ | 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/F- | Facultative dryland species | Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence) | |
| D | Dryland species | Almost always grow in drylands | |

In order to identify the wetland types, using Kotze *et al.* (2009) and Ollie *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. These have been defined based on the geomorphic setting of the wetland in the landscape (e.g. hillslope or valley bottom, whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Figure A15.1b).

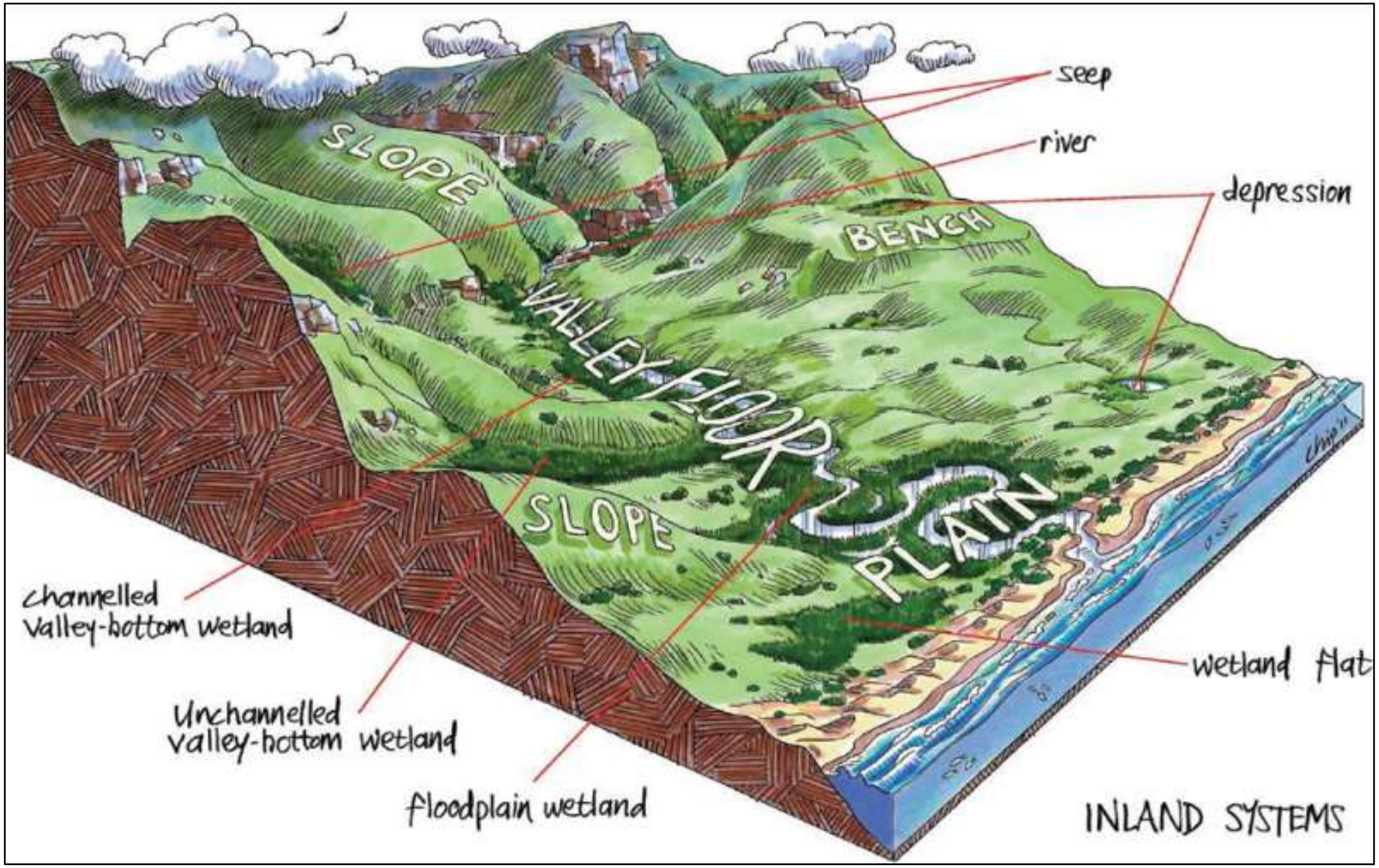


***Figure A15.1b: Illustration of wetland types and their typical landscape setting (From Ollie et al. 2013)***

## 15.2 Delineation of Riparian Areas

Riparian zones are described as “the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas” i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (Figure 8). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units (Figure 2), namely the: - Crest (hilltop); - Scarp (cliff); - Midslope (often a convex slope); - Footslope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or stream channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

Topography and recently deposited material associated with riparian areas The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised “macro-channels” which are typical of many of southern Africa’s eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

As with the delineation approach for wetlands, the field delineation method for riparian areas focuses on two main indicators of riparian zones: - **Vegetation Indicators**, and - **Topography** of the banks of the river or stream.

Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or stream channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of "restrictive floodplain" within which one or more active channels flow. Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

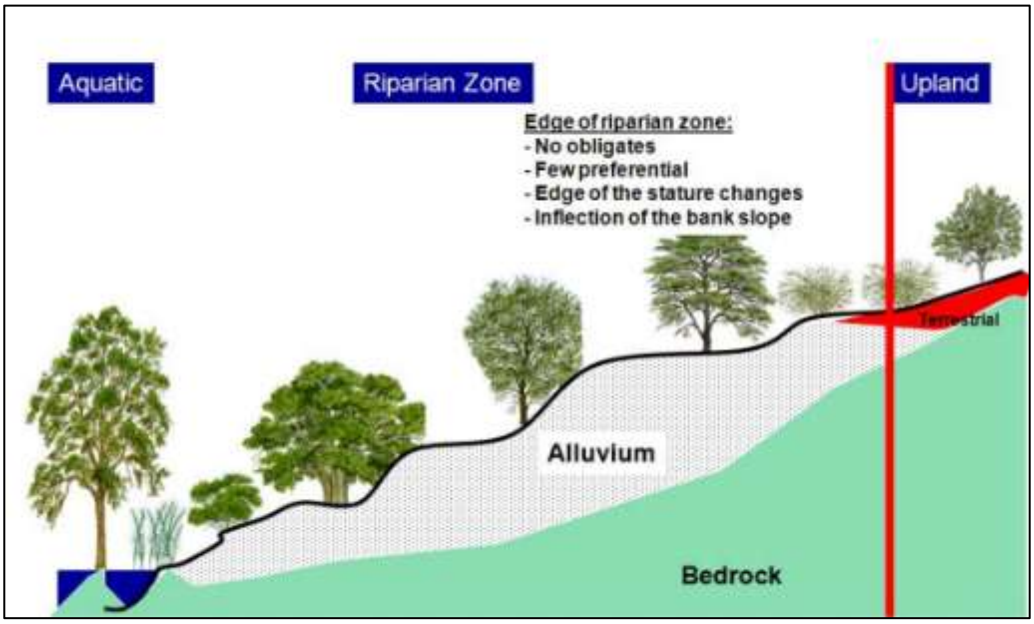


***Figure A15.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).***

### 15.3 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively. Level 1 was utilised for the assessment of the wetlands impacted by this project.

WET-Health is a tool designed to assess the health or integrity of a wetland. Wetland health is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health in three separate modules.

**Hydrology** is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland.

**Geomorphology** is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

**Vegetation** is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (Table A15.2a).

***Table A15.2a: Guideline for interpreting the magnitude of impacts on wetland integrity (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 A15.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

***Table A15.2b. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).***

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

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.

## 15.4 Wetland Functional Importance (Goods and Services)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table A15.4a) - that is, the benefits provided to people by the ecosystem.

***Table A15.4a: Ecosystem services assessed by WET-Ecoservices***

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

The steps involved in applying WET-EcoServices can be summarised as follows.

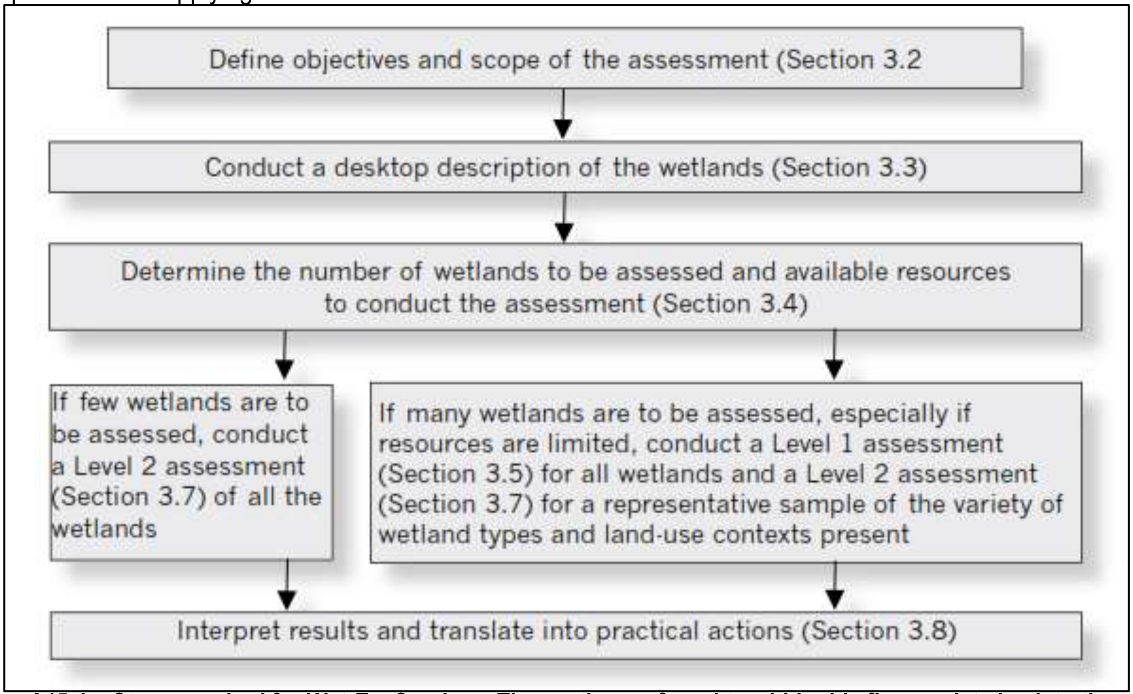


***Figure A15.4a: Steps required for Wet-EcoServices. The sections referred to within this figure relate back to the Wetland Management Series: Wet-Ecoservices. WRC Report TT 339/08***

### 15.5 Ecological Importance & Sensitivity (EIS) - Wetlands

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table A15.5a. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 14.5b.

*Table A15.5a: Example of scoring sheet for Ecological Importance and sensitivity*

| ECOLOGICAL IMPORTANCE AND SENSITIVITY: | | | |
|---|---|---|---|
| **Ecological Importance** | Score (0-4) | *Confidence (1-5)* | **Motivation for site** |
| **Biodiversity support** | | | |
| Presence of Red Data species | | | |
| Populations of unique species | | | |
| Migration/breeding/feeding sites | | | |
| **Landscape scale** | | | |
| Protection status of the wetland | | | |
| Protection status of the vegetation type | | | |
| Regional context of the ecological integrity | | | |
| Size and rarity of the wetland type/s present | | | |
| Diversity of habitat types | | | |
| **Sensitivity of the wetland** | | | |
| Sensitivity to changes in floods | | | |
| Sensitivity to changes in low flows/dry season | | | |
| Sensitivity to changes in water quality | | | |
| ECOLOGICAL IMPORTANCE & SENSITIVITY | | | |
| HYDROLOGICAL/FUNCTIONAL IMPORTANCE | | | |
| IMPORTANCE OF DIRECT HUMAN BENEFITS | | | |
| **OVERALL IMPORTANCE** | | | |

*Table A15.5b: Category of score for the Ecological Importance and Sensitivity*

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

## 15.6 Present Ecological State (PES) – Riparian

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

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table A15.6a) according to the following metrics:

- Bed modification
- Flow modification
- Inundation
- Bank condition
- Riparian zone condition
- Water quality modification

This assessment was informed by (i) a site visit where potential impacts to each metric were assessed and evaluated and (ii) an understanding of the catchment feeding the river and landuses / activities that could have a detrimental impact on river ecosystems.

***Table A15.6a: The rating scale for each of the various metrics in the assessment***

| RATING SCORE | IMPACT CLASS | DESCRIPTION |
|---|---|---|
| 0 | **None** | *No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.* |
| 0.5 - 1.0 | **Low** | *The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.* |
| 1.5 - 2.0 | **Moderate** | *The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.* |
| 2.5 - 3.0 | **Large** | *The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.* |
| 3.5 - 4.0 | **Serious** | *The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.* |
| 4.5 - 5.0 | **Critical** | *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.* |

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table A15.6b).

***Table A15.6b: The habitat integrity PES categories***

| HABITAT INTEGRITY PES CATEGORY | DESCRIPTION |
|---|---|
| A: Natural | Unmodified, natural. |
| B: Good | Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. |
| C: Fair | Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. |
| D: Poor | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. |
| E: Seriously modified | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |
| F: Critically modified | Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible. |

## 15.7 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh et al., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table A15.7a).

***Table A15.7a: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided.***

| Ecological Importance and Sensitivity assessment (Rivers) | | |
|---|---|---|
| | **Determinants** | **Score (0-4)** |
| BIOTA (RIPARIAN & INSTREAM) | Rare & endangered (range: 4=very high - 0 = none) | 0.5 |
| | Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none) | 1.5 |
| | Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none) | 2.0 |
| | Species/taxon richness (range: 4=very high - 1=low/marginal) | 0.5 |
| RIPARIAN & INSTREAM HABITATS | Diversity of types (4=Very high - 1=marginal/low) | 2.0 |
| | Refugia (4=Very high - 1=marginal/low) | 0.5 |
| | Sensitivity to flow changes (4=Very high - 1=marginal/low) | 2.0 |
| | Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low) | 1.0 |
| | Migration route/corridor (instream & riparian, range: 4=very high - 0 = none) | 2.0 |
| | Importance of conservation & natural areas (range, 4=very high - 0=very low) | 3 |
| | MEDIAN OF DETERMINANTS | 1,75 |
| | **ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)** | **MODERATE, EC=C** |

The scores assigned to the criteria in Table A15.7a were used to rate the overall EIS of each mapped unit according to Table A15.7b, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane et al., 2008).

***Table A15.7b: The ratings associated with the assessment of the EIA for riparian areas***

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

## 15.8 Direct, Indirect and Cumulative Impacts Methodology

Direct, indirect and cumulative impacts should be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration**, wherein it will be indicated whether:
    - The lifetime of the impact will be of a very short duration (0-1 years) – assigned a score of 1.
    - The lifetime of the impact will be of short duration (2-5 years) – assigned a score of 2;
    - Medium term (5-15 years) – assigned a score of 3;

- Long-term (> 15 years) – assigned a score of 4; or
- Permanent – assigned a score of 5.

- The **magnitude**, quantified on a scale of 0-10, where:
  - 0 is small and will have no effect on the environment,
  - 2 is minor and will not result in an impact on processes,
  - 4 is low and will cause a slight impact on processes,
  - 6 is moderate and will result in processes continuing but in a modified way,
  - 8 is high (processes are altered to the extent that they temporarily cease), and
  - 10 is very high and results in complete destruction of patterns and permanent cessation of processes.

- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5, where:
  - 1 is very improbable (probably will not happen),
  - 2 is improbable (some possibility, but low likelihood),
  - 3 is probable (distinct possibility),
  - 4 is highly likely (most likely) and;
  - 5 is definite (impact will occur regardless of any prevention measures).

- The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high;
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources; and
- The degree to which the impact can be mitigated.
- The significance is calculated by combining the criteria in the following formula, **S = (E+D+M) P**, where:
  - S = significance weighting
  - E = extent
  - D = duration
  - M = magnitude
  - P = probability

- The significance weightings for each potential impact are as follows:
  - <30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop the area),

- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- >60 points: High (i.e. where the impact must have an influence on the decision process to develop the area).

### 15.9 Generic Wetland Rehabilitation Methods *(Water Wise & Rand Water: Wetland Rehabilitation)*

- Blocking drainage channels that drain water from or divert polluted water to the wetland, with gabions or earthen plugs; Placing plugs in gullies, to help with bank and soil stabilisation;
- Fencing off sensitive areas to keep grazers out and fence off areas that have been disturbed and need time for vegetation to re-establish;
- Planting of vegetation to stabilise the soil;
- Filling in and compacting gullies with soil from other areas;
- Plug channels to restore or create wetlands. These can also be used to stabilise and raise the channel floors, thereby reducing velocity;
- Cement structures such as a cement head cut repair. This assists in reducing water velocity and helps reduce erosion and contain the headcut. Another option is a cement head-cut repair this creates a type of settling pond which reduces the speed at which the water flows through the wetland. It also creates an area where settlement can occur.
- Gabion structures which assist in bank and soil stabilisation, reducing erosion and decreasing the speed of water flow. They also provide an area for vegetation to establish.
- Insertion of grass bales, these help bind soil and slow the rate at which water travels. The slower the water flow, the lower the erosive power of water. Binding and stabilising soil prevents the soil from being washed downstream. The insertion of grass bales creates a backflow of water back into the wetland, pushing the water outwards to create a marshy area. Protect them from veld fires. They will degrade over time.
- These methods will help wetland plants re-establish themselves. Wetland and riverbank plants are vital for preventing erosion; they play a crucial role in the purification of water, reduce the severity of floods and regulate water especially during droughts.

The following are a set of general rehabilitation ideas that can be used in stabilising the soil and restoring the water flow of the wetland.

- *Reclaim the drains:* Drains and gullies lower the water table and dry out the wetland. They produce excess sediment that affects the wetland below. It is important to stabilise gully sides and also to stop the vertical erosion in the gully. This prevents the further lowering of the water table. Materials that can be used are herbaceous or woody plants, hay bales, clay plugs, gabions filled with rock, a geo-textile lining`, soil, or even just packing loose rock against head-cut faces.

- *Stabilise the banks of rivers:* Plants are the best and cheapest solution to solving riverbank erosion. For shallow slopes a large variety of herbaceous plants with a dense surface root mat and ground cover are effective for stabilising the soil that can erode rapidly. Examples include papyrus, bulrushes, reeds, sedges and couch grass. Herbaceous plants protect against scouring of riverbeds and wetlands increasing soil stabilisation. Herbaceous plants absorb the energy of fast flowing water rather than reflecting it, slowing it down so it does not cause erosion. Other erosion control measures include mesh mats made of either coir or sisal. These mats help stabilise banks and help vegetation to establish. In approved areas Vetiver grass can also be used. Plants or grass used to stabilise banks must be planted in rows along the contour lines in order for them to be effective in reducing soil erosion. Herbaceous cover plants are ideal for shallow banks and gentle slopes but for steeper slopes indigenous trees (suitable for riparian zones) are a better option as their roots reach deep down and stabilise the soil. For rehabilitation it is important to select and correctly place plants with vigorous rooting growth characteristics that will accelerate natural plant succession and deal directly with the problem on site. Look around and see what indigenous species are growing in the area you are about to rehabilitate; it is always best to use local plant species.