# AQUATIC AND WETLAND ECOLOGICAL ASSESSMENT AS PART OF THE ENVIRONMENTAL AUTHORISATION AND WATER USE AUTHORISATION PROCESS FOR THE PROPOSED PONGOLA (MBOZA) RIVER BRIDGE, KWAZULU-NATAL

## Prepared for

## Royal Haskoning DHV (Pty) Ltd

## November 2015


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# EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a floral, faunal, wetland and aquatic assessment as part of the Environmental assessment and authorisation process for the proposed Mboza Bridge Project; hereafter referred to as the “proposed bridge and road crossing”. A summer (October 2015) assessment was performed. The study area is located in the Lowveld Ecoregion and Usutu to Mhlatuze Water Management Area, KwaZulu-Natal Province. The study area assessment site (Mboza 1 at the proposed crossing point) is located within the W45A quaternary catchment.

The purpose of this report is to define aspects and areas of increased aquatic Ecological Importance and Sensitivity (EIS) and to define the Present Ecological State (PES) of the aquatic resources in the vicinity of the proposed crossing point. Furthermore, detailed information is to be provided to guide the activities associated with the proposed river crossing, should it proceed, in the vicinity of wetland and riverine areas, to ensure that the ongoing functioning of the wetlands and rivers are facilitated. The study also aims to identify and quantify any impacts on the aquatic resources in the area and to develop a list of mitigatory measures, which could be employed to minimise impacts on the receiving aquatic environment.

The sections below summarise the key findings of the baseline study

A summary of the PES/EIS data, as obtained from the databases consulted, is tabulated below.

| Quaternary catchment (Kleynhans 1999) | | | | |
|---|---|---|---|---|
| Catchment | EIS[1] | PES[2] | | DEMC[3] |
| W45A | Very high | Class B: Largely natural | | Class A: Highly sensitive |
| Sub-quaternary catchment reach (Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database; accessed 21 August 2015) | | | | |
| SQRs | PES[7] | Mean EI[8] | Mean ES[9] | Default EC[10] |
| W45A-02246 (Pongola River)[5] | D | Moderate | Very high | A |
| Refer to main document for footnotes. | | | | |

The Kleynhans (1999) indicate more natural conditions for the PES for the catchment as a whole, when compared to that obtained from the DWS RQIS database for the specific SQRs in question. With reference to the latter, it is clear that the system is already facing moderate to large impacts with the PES being far removed from the desired/default ecological state, especially in the SQR within which the proposed bridge construction will take place. Both fish and invertebrate fauna are of high importance, with specific reference to *Chiloglanis swierstrai* (Lowveld suckermouth) and *Redogobius dewaali* (checked goby) on a catchment-wide scale by Kleynhans (1999). Using the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, et. al. 2013), the entire system was classified as a floodplain wetland. The wetland is registered as a RAMSAR wetland.

## Wetland assessment

- The floodplain wetland has a moderately high importance in terms of function and service provision. Although transformation of the wetland vegetation has occurred, the wetland is considered to be of high importance from a socio- cultural service provision perspective;
- The floodplain wetland has an EIS falling within Category C (moderate sensitivity);
- The Present Ecological State (PES) of the wetland features was determined using the Integrated Habitat Integrity (IHI) methodology. The overall PES score calculated for the floodplain wetland fall within Category C/D (moderately to largely modified);
- Taking into consideration the PES and EIS values obtained for the wetland feature, the appropriate REC of the floodplain wetland should be a Class C.

## Physico-Chemical Water Quality

- General water quality can be considered largely natural, with the exception of the slightly elevated EC value from what is expected under completely natural conditions. Some variation from the expected natural condition is deemed likely due to return flows and run-offs from agricultural activities;
- The pH is slightly acidic but can be regarded as largely natural (within the 6 to 8 pH value range) and suitable for supporting a diverse and sensitive aquatic community (DWS formerly DWAF, 1996);
- No significant impact on pH is deemed likely at the current time and not impact is deemed likely to be expressed on the aquatic ecology of the system;
- The DO percentage of saturation was not within the desired 80% to 120% range for aquatic ecosystems (DWS formerly DWAF, 1996). However, the percentage saturation exceeded 75% and was still considered largely capable of supporting a relatively diverse and sensitive aquatic community at the time of assessment;
- Temperature can be regarded as normal for the time of year and time of day when assessment took place.

### Vegetation Response Assessment Index (VEGRAI)

The results of this assessment indicate that the Pongola River falls within Ecostatus Category D, indicating that the vegetation within the system is largely modified. Large changes to the riparian vegetation (mainly the non-marginal zone) of the river due to alien floral invasion and cultivated fields were observed. No deviations as a result of impacted water quality were observed.

## Intermediate Habitat Integrity Assessment (IHIA)

The site achieved a 78% score for instream zone integrity and 71% score for riparian zone integrity. Overall the site obtained an IHIA rating of 74%, which is indicative of moderately modified (Class C) conditions. This classification is in agreement with the PES classification for the larger catchment (Kleynhans 1999), but improved from the Class D classification allocated to the relevant SQR (DWS RQIS PES/EIS database).

## Invertebrate Habitat Assessment System (IHAS)

From the results of the application of the IHAS index it is evident that the Pongola River in the study area (site Mboza 1 at the crossing point) provided inadequate habitat conditions for sustaining a diverse macro-invertebrate community at the time of assessment. This was largely due to a lack of rocky substrate in the system and the dominance of laminar flow over sandy substrate with limited niche habitat for aquatic biota. In addition the sandy substrate is unstable and does not provide cover for all but the most highly adapted aquatic macro-invertebrate taxa. The lack of leafy marginal vegetation and the absence of aquatic macrophytes also limit the availability of suitable cover for aquatic macro-invertebrates.

## Aquatic Macro-invertebrates:

- SASS scores indicated Class D (largely impaired) conditions at the crossing point according to the Dickens and Graham (2001) classification system;
- According to the Dallas (2007) classification system, a Class C (moderately impaired) Category was obtained for the crossing point ;
- The apparent discrepancy in results obtained for the crossing point is due to the Dallas (2007) classification system being more sensitive to changes in ASPT compared to the Dickens and Graham (2001) classification system. For the purpose of this assessment both classification systems are deemed relevant although it must be noted that no Data is available for the Lowveld Lower Aquatic ecoregion and the Lebombo Uplands (Lower) dataset was used as a surrogate for the Dallas (2007) classification.
- Results employing the Dickens and Graham (2001) classification system are in agreement with the PES for the SQR in which the proposed river crossing is planned (DWS RQIS PES/EIS database, PES classified as Class D). As a result this classification system is deemed most applicable and representative of conditions at the time of assessment. Furthermore the Dallas (2007) indicate limited data from which to make inferences, confirming that the Dickens and Graham (2001) classification system may be better suited to meet the assessment objectives;
- The SASS data indicates that the aquatic macro-invertebrate community of this system, prior to the proposed river crossing development taking place, supports an aquatic community of

limited abundance and diversity when compared to the reference score for a Lebombo Uplands Lower aquatic ecoregion stream;

- As observed in the IHAS index, this limited community diversity can partially ascribed to natural limitations posed in the system by the lack of suitable habitat and cover for aquatic macro-invertebrates;
- However, other factors such impacts from agricultural return flows as well as the potential for other unidentified point and diffuse sources of pollution in the larger catchment resulting from other anthropogenic activities (for example informal rural settlements with associated water quality impacts), may also contribute to the observed trend (impaired macro-invertebrate community);
- Future SASS5 and ASPT results should be monitored and any alterations in the scores should be identified, with particular reference to potential seasonal/annual variations in SASS score which seem relatively stable in the data collected to date;
- Considering the proposed bridge crossing construction activities, three potential impacts that may affect the aquatic community have been identified. These are impacts on instream flow and hydrological function, changes to instream habitat and impacts on instream biota;
- Such impacts can have a negative effect on both macro-invertebrate diversity and sensitivity which, based on the PES EIS database, is known to be sensitive to changes in flow. Such potential impacts should be mitigated and close monitoring of trends must take place.

## Macro-Invertebrate Response Assessment Index (MIRAI)

In terms of ecological category classification, the MIRAI Ecostatus tool revealed an ecostatus category classification Class D for the crossing point. As discussed previously the reasons for this appears to be a combination of current anthropogenic impacts, most notably return flow and run-off from agricultural activities, combined with inadequate habitat conditions (lack of rocky habitat, limited vegetation habitats and lack of depth and flow diversity) unable to support a diverse macro-invertebrate community.

## Fish Community Integrity

The **HCR (Habitat Cover Rating)** results indicate that, under low flows resulting in shallow conditions, a combination of slow and fast flows dominate the system.

To apply the **FRAI (Fish Response Assessment Index)** sampling for fish was conducted within the Pongola River at the proposed crossing point over a 30 minute period using electronarcosis methods as well as cast netting and using a hand held sweep net. No fish species were observed or captured during the assessments:

- The most likely reasons for the absence of fish in the system is
  - limited habitat and cover;
  - limited flow and depth diversity;
  - anthropogenic activity around the assessment site as the river at the proposed crossing point is often used by the local community for recreational activities such as swimming (personal observation at time of assessment).
- Fish migration, with specific reference to eel species, is likely to occur within a free flowing river system such as the Pongola River and some seasonal variation in fish community assemblage is deemed likely. In addition such migratory patterns are likely to be affected by impoundments upstream of the assessment site, most notably the Pongolapoort Dam;
- The results of the survey thus did not support the findings of survey data in the DWS RQIS PER/EIS database, where a large variety of expected fish species were listed;
- Due to the high integrity, diversity and sensitivity of the fish community based on the desktop assessment, it is deemed possible that site specific limitations and impacts on the fish community of the aquatic resources in the area due to the proposed road crossing operation may occur.

Because no fish were collected during the assessments, the FRAI score was defined as Class F when compared to the expected fish assemblage. This is not considered a representative sample of the Pongola River due to the reasons discussed above. However, the sampling effort does indicate that the proposed crossing point is not sensitive from a fish conservation point of view and can be considered a good point for crossing from that perspective.

### Aquatic Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity Assessment analysis of the Pongola River provided a score of 2.3 which is regarded as highly important and sensitive. The increased importance and sensitivity of the stream is mainly as a result of high diversity and sensitivity of aquatic biota. The system also has some importance with regards to use as a migration corridor with specific reference to eels and the provision of refugia for species relying on the system. The system has poor diversity of habitat features, but is considered moderately sensitive to alterations in flow and flow-related water quality changes with year round water required in the system. The EIS classification corresponds with that provided in the databases provided (Kleynhans 1999 as well as DWS RQIS PES/EIS database).

| Variable | | Site |
|---|---|---|
| | | Mboza 1 |
| VEGRAI | | D |
| IHIA | | C |
| IHAS | | Inadequate |
| SASS5 score | Dickens and Graham (2001) | D |
| | Dallas (2007) | C |
| MIRAI | | D |
| FRAI | | F |
| * Dallas (2007) classification more sensitive to ASPT score. Dickens and Graham (2001) classification considered to be more representative of conditions at the time of assessment. | | |

Based on the findings of this study it is evident that the conditions at the time of assessment were in agreement with the desktop assessment results. Prior to any impact from the proposed river crossing construction, the system is already significantly impacted upon. Impacts include agricultural run-off and return water flow with associated water quality impact, flow related impacts from the upstream impoundment (Pongolapoort Dam), vegetation removal and use of the riverine resource by the local population.

Based on the impact assessment it is evident that there are three major impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed bridge crossing. The table below summarise the findings indicating the significance of the impacts before mitigation takes place as well as the significance of the impacts if appropriate management and mitigation takes place.

| Pre-Construction phase | | |
|---|---|---|
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative low | Negative low |
| 2: Changes to instream habitat | Negative high | Negative low |
| 3: Impacts on instream biota | Negative moderate | Negative low |
| **Construction phase** | | |
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative moderate | Negative low |
| 2: Changes to instream habitat | Negative high | Negative low |
| 3: Impacts on instream biota | Negative high | Negative low |
| **Operational phase** | | |
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative very high | Negative moderate |
| 2: Changes to instream habitat | Negative high | Negative moderate |
| 3: Impacts on instream biota | Negative high | Negative moderate |

Should the project proceed it may potentially have an ecological impact of high significance both within and potentially beyond the boundaries of the project if mitigation is not applied. With mitigation the impact can be limited to a low to moderate level significance of low severity with limited spatial impact. However, due to the duration of the activity, the impact is expected to remain at moderate levels during the operational phase, whilst it can be reduced to low levels during the planning and construction phases.

The table below serves to summarise the significance of perceived impacts on the wetland biodiversity associated with the proposed bridge infrastructure.

| Impact | Phase | Unmanaged | Managed |
|---|---|---|---|
| Loss of wetland habitat and ecological structure | Pre-construction | Negative Moderate | Negative Low |
| | Construction | Negative Moderate | Negative Low |
| | Operation | Negative Low | Negative Low |
| Changes to wetland ecological and socio-cultural service provision | Pre-construction | Negative Moderate | Negative Low |
| | Construction | Negative Moderate | Negative Low |
| | Operation | Negative Moderate | Negative Low |
| Impacts on wetland hydrological function and sediment balance | Pre-construction | Negative Moderate | Neutral |
| | Construction | Negative Moderate | Neutral |
| | Operation | Negative Low | Negative Low |

It is the opinion of the wetland ecologists that the proposed development activities will have a Negative moderate to Negative low impact on the wetland resources, specifically with regards to impacts on hydrology and sedimentation of the Pongola River if mitigation measures are not adhered to. Provided that the management and maintenance recommendations as provided in the impact assessment of this report are strictly adhered to, impacts on the wetland features are likely to Negative low to Neutral impacts.

After conclusion of the freshwater assessment, it is the opinion of the ecologists that the proposed development activities be considered favourably, provided that the management and monitoring recommendations as provided in the impact assessment of this report are strictly adhered to.

The objective of this study was to provide sufficient information on the ecology of the area, together with other studies on the physical and socio-cultural environment, in order for the Environmental Assessment Practitioner (EAP) and the relevant authorities to apply the principles of Integrated Environmental Management (IEM) and the concept of sustainable development. The needs for conservation as well as the risks to other spheres of the physical and socio-cultural environment need to be compared and considered, along with the need to ensure economic development of the country.

It is the opinion of the ecologists that this study provides the relevant information required in order to implement IEM and to ensure that the best long term use of the resources on the subject property will be made in support of the principle of sustainable development.

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# 1. INTRODUCTION

## 1.1 Background Information

Scientific Aquatic Services (SAS) was appointed to conduct a wetland and aquatic assessment as part of the Environmental assessment and authorisation process for the proposed Mboza Bridge Project; hereafter referred to as the “proposed bridge and road crossing” (Figures 1 and 2) A summer (October 2015) assessment was performed.

The proposed bridge (two pier design) and road crossing is located in the Lowveld Uplands Ecoregion and Usutu to Mhlatuze Water Management Area, KwaZulu-Natal Province. The study area assessment site (Mboza 1, proposed crossing point) is located on the Pongola River within the W45A quaternary catchment.

The purpose of this report is to define areas of increased aquatic Ecological Importance and Sensitivity (EIS) and to define the Present Ecological State (PES) of the aquatic resources in the vicinity of the proposed bridge construction. Furthermore, detailed information is to be provided to guide the activities associated with the proposed bridge construction development, should it proceed, in the vicinity of wetland and riverine areas, to ensure that the ongoing functioning of the wetlands and rivers are facilitated, with specific mention of the following:

- Maintain the Present Ecological State (PES) of the system in support of the Ecological Important and Sensitivity (EIS) of the various aquatic ecosystems;
- Ensure that connectivity of the wetland and river areas are maintained between the areas upstream and downstream of the proposed bridge construction operation areas;
- Ensure that no incision and canalisation of the wetland and river systems takes place as a result of the proposed bridge construction operation activities;
- Ensure that no significant persistent impact on water quality will take place; and
- Minimise impacts on the aquatic ecology of the resources within and adjacent to the proposed bridge construction operations.

The study also aims to identify and quantify any impacts on the aquatic resources in the area and to develop a list of mitigatory measures which could be employed to minimise impacts on the receiving aquatic environment.


**Figure 1: Digital satellite image depicting the location of the proposed bridge and road construction area to the surrounding areas.**

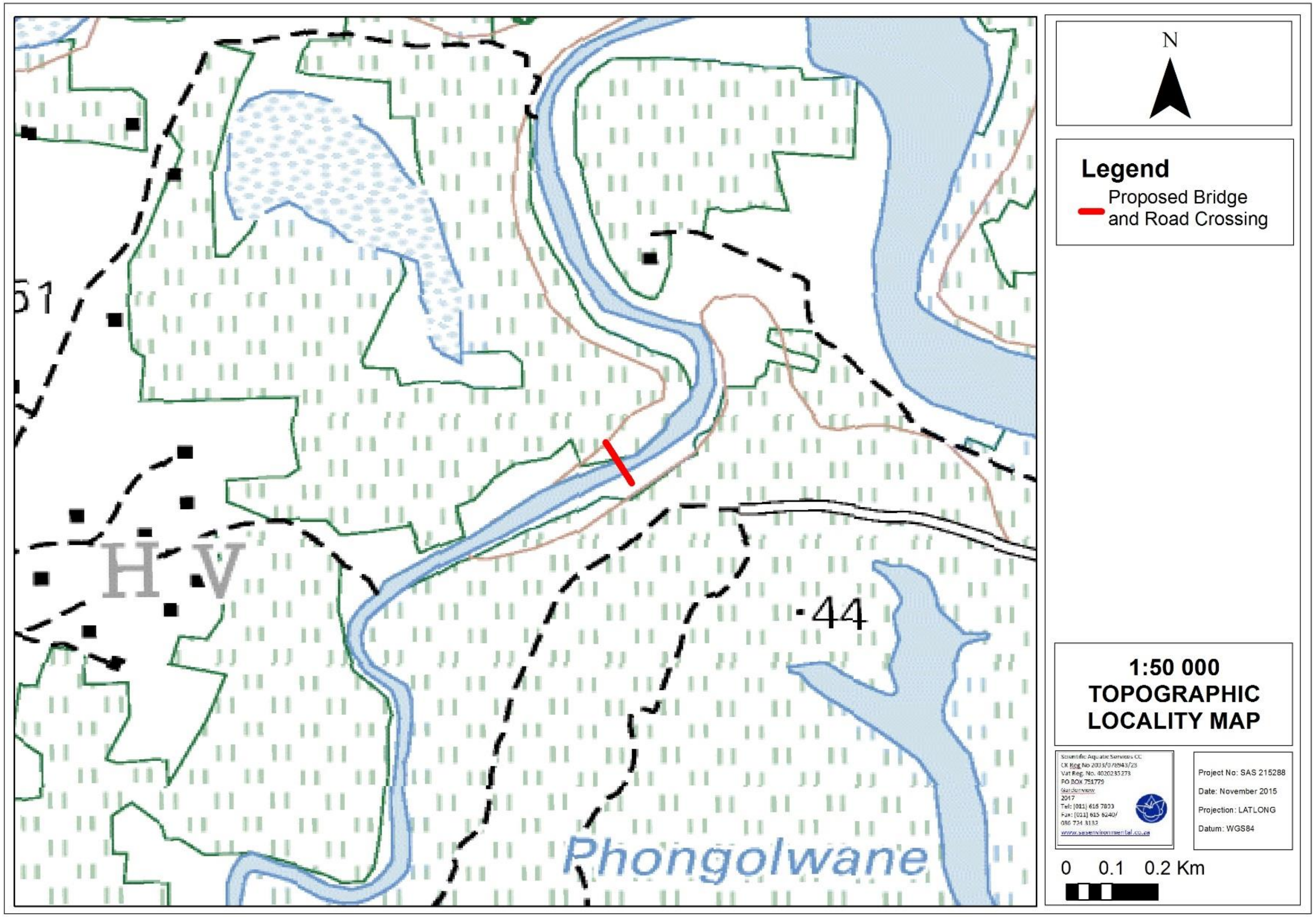


**Figure 2: The proposed bridge and road construction area depicted on a 1:50 000 topographical map in relation to the surrounding area**

The following aspects were considered in the selection of a suitable site for assessing the level of aquatic ecological integrity in the area of the proposed river crossing.

- Site location and the location of proposed infrastructure and proposed bridge construction activities;
- Consideration was given to the area and position for the assessment point on the Pongola River to indicate the aquatic ecological reference conditions, in order to assist in defining the PES of the systems and any impacts in this area.
- A single site was selected to best represent conditions at the point of the proposed bridge construction. The site was selected based on what was deemed the most representative habitat conditions, with the best level of diversity in relation to the condition of the system assessed. In other words, the assessment site was considered suitable for supporting the best representation of the aquatic community likely to be present in the system in relation to the proposed bridge construction development.
- Accessibility with a vehicle in order to allow for the transport of equipment.

## *1.2 Project execution and scope*

The aquatic assessment included a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates as well as fish and aquatic macro-invertebrate community integrity. The protocols of applying the indices were strictly adhered to and all work was performed by a South African River Health Program (SA RHP) accredited assessor or under supervision of such an assessor. A single aquatic ecological assessment point was identified which was used to define the Present Ecological State of the riverine features in the vicinity of the study area. The aquatic assessment section of this report serves to document the condition at the time of sampling to indicate the state of the riverine ecological integrity during the summer season (October 2015). The assessment was thus performed at a time when predominantly low to moderately high flow was being experienced, prior to the proposed bridge construction being commissioned. The position of the reference site is presented in the table below and displayed in Figure 3.

**Table 1: Co-ordinates of biomonitoring reference site**

| Site | Description | GPS co-ordinates | |
|---|---|---|---|
| | | South | East |
| Mboza 1 | Site on the Pongola River at the proposed river crossing (bridge construction site). | 27°11'16.67"S | 32°14'21.52"E |


**Figure 3: Aquatic ecological assessment point presented on a digital satellite image**

## 1.3 Assumptions and Limitations

The following points serve to indicate the assumptions and limitations with regard to the aquatic assessment:

- ***Reference conditions are unknown:*** The composition of aquatic biota in aquatic resources associated with the study area, prior to major disturbance, is limited and based only on a single assessment performed in October 2015. For this reason, reference conditions are largely hypothetical, as based on professional judgement and/or inferred from limited data available. Based on the reference data available and based on the observations on site, the information available is, however, deemed adequate to provide the required level of understanding of the system for purposes of this study;
- ***Temporal variability:*** The data presented in this report are based on a single assessment (summer) performed in October 2015. Temporal comparison is thus limited and largely precludes identification of seasonal trends. The effects of natural seasonal and long term variation in the ecological conditions and aquatic biota found in the streams are, therefore, largely unknown. Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the purposes of this study;
- ***Ecological assessment timing:*** Aquatic and terrestrial ecosystems are dynamic and complex. It is likely that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require routine seasonal sampling, with sampling being undertaken on a quarterly basis to cover seasonal variability Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the purposes of this study;
- ***Accessibility:*** The area is dominated by private agricultural land within the study area and as such access to sampling sites was hampered to some degree. In addition the Pongola River is dominated by deep pools which reduced the areas suitable for sampling even further. Furthermore infestation of the riparian zone of the system by alien invasive species and in particular *Lantana camara* reduced the availability of suitable sampling points even further. In addition the presence of crocodiles also limited safe access to the river and sampling areas. Due to the limitations some aspects of the aquatic ecology of the area, some which may be important, may have been overlooked.

Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study.

## *1.4 Legislative requirements*

**National Water Act (NWA; Act 36 of 1998)**

- The NWA; Act 36 of 1998 recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse and no storage or abstraction of water may take place unless it is authorised by the Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF).

**National Environmental Management Act, 1998**

- The Environmental Impact Assessment (EIA) Regulations (2014) promulgated in terms of NEMA identifies a suite of activities, which "*could have a substantial detrimental effect on the environment*". The listed activities identified require an Environmental Authorisation (EA) from the environmental authority, the Department of Environmental Affairs (DEA), prior to commencement of the activity.

**Table 2: Legal Requirements for All Specialist Studies Conducted.**

| Legal Requirement | | | Relevant Section in Specialist study |
|---|---|---|---|
| (1) | A specialist report prepared in terms of these Regulations must contain- | | |
| (a) | details of- | | |
| | (i) | the specialist who prepared the report; and | Annexure A |
| | (ii) | the expertise of that specialist to compile a specialist report including a curriculum vitae | Annexure A |
| (b) | a declaration that the specialist is independent in a form as may be specified by the competent authority; | | Annexure B |
| (c) | an indication of the scope of, and the purpose for which, the report was prepared; | | Section 1.2 |
| (d) | the date and season of the site investigation and the relevance of the season to the outcome of the assessment; | | Section 1.2 |
| (e) | a description of the methodology adopted in preparing the report or carrying out the specialised process | | Section 4 |
| (f) | the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure; | | Section 5.12 |
| (g) | an identification of any areas to be avoided, including buffers; | | Section 5.11 |
| (h) | a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | | Section 5.11 and 5.12 |

| Legal Requirement | | | Relevant Section in Specialist study |
|---|---|---|---|
| (i) | a description of any assumptions made and any uncertainties or gaps in knowledge; | | Section A: 1.3 |
| (j) | a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment; | | Section 6 |
| (k) | any mitigation measures for inclusion in the EMPr; | | Section 6 |
| (l) | any conditions/aspects for inclusion in the environmental authorisation; | | Executive Summary section |
| (m) | any monitoring requirements for inclusion in the EMPr or environmental authorisation; | | Section 6 |
| (n) | a reasoned opinion | | |
| | (iii) | as to whether the proposed activity or portions thereof should be authorised; and | Executive Summary section |
| | (iv) | if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan; | Section 6 |
| (o) | a description of any consultation process that was undertaken during the course of preparing the specialist report; | | N/A |
| (p) | a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | | N/A |
| (q) | any other information requested by the competent authority. | | N/A |

**National Environmental Management: Biodiversity Act (NEMBA) (Act No. 10 of 2004)**

The objectives of this Act are (within the framework of NEMA) to provide for:

- the management and conservation of biological diversity within the Republic of South Africa and of the components of such diversity;
- the use of indigenous biological resources in a sustainable manner;
- the fair and equitable sharing among stakeholders of benefits arising from bio-prospecting involving indigenous biological resources;
- to give effect to ratified international agreements relating to biodiversity which are binding to the Republic;
- to provide for co-operative governance in biodiversity management and conservation; and

This act alludes to the fact that management of biodiversity must take place to ensure that the biodiversity of surrounding areas are not negatively impacted upon, by any activity being undertaken, in order to ensure the fair and equitable sharing among stakeholders of benefits arising from indigenous biological resources.

**The Protected Areas Act (Act No. 57 of 2003)**

To provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; and for matters in connection therewith.

This Act as alludes to the fact that the conservation status of all river types needs to be considered when any development is taking place to ensure that the adequate conservation of all vegetation types is ensured.

# 2. AQUATIC ECOLOGICAL DESCRIPTION

## *2.1 Ecoregions*

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the mining rights area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The proposed bridge construction project area falls within the Lowveld aquatic ecoregion and the Mfolozi/ Pongola catchment (quaternary catchment W45A).

**Table 3: Key Attributes of the Lowveld Ecoregion**
**(Source: A level 1 river ecoregional classification system for South Africa, Lesotho and Swaziland, DWAF 2005)**

| MAIN ATTRIBUTES | LOWVELD |
|---|---|
| Terrain Morphology: Broad division<br>(dominant types in bold) (Primary) | Plains; Low Relief;<br>**Plains; Moderate Relief;**<br>Lowlands, Hills and Mountains; Moderate and High Relief (limited)<br>Open Hills, Lowlands; Mountains; Moderate to High Relief; (limited)<br>Closed Hills; Mountains; Moderate and High Relief (Limited) |
| Vegetation types (dominant types in bold)<br>(Primary) | **Mopane Bushveld**; Mopane Shrubveld; **Mixed Lowveld Bushveld;** Sour Lowveld Bushveld; Sweet Lowveld Bushveld; Natal Lowveld Bushveld; Lebombo Arid Mountain Bushveld; Mixed Bushveld<br>North Eastern Mountain Grassland; |
| Altitude (m a.m.s.l) (modifying) | 0-700; 700-1300 limited |
| MAP (mm) (modifying) | 200 to 1000 |
| Coefficient of Variation (% of annual precipitation) | <20 to 35 |
| Rainfall concentration index | 30 to > 65 |
| Rainfall seasonality | Early to late summer |
| Mean annual Temp. (°C) | 16 to> 22 |
| Mean daily max. Temp. (°C): February | 24 to 32 |
| Mean daily max. Temp. (°C): July | 18 to >24 |
| Mean daily min. Temp. (°C): February | 14 to >20 |
| Mean daily min Temp. (°C): July | 4 to >10 |
| Median annual simulated runoff (mm) for quaternary catchment | 10 to >250 |

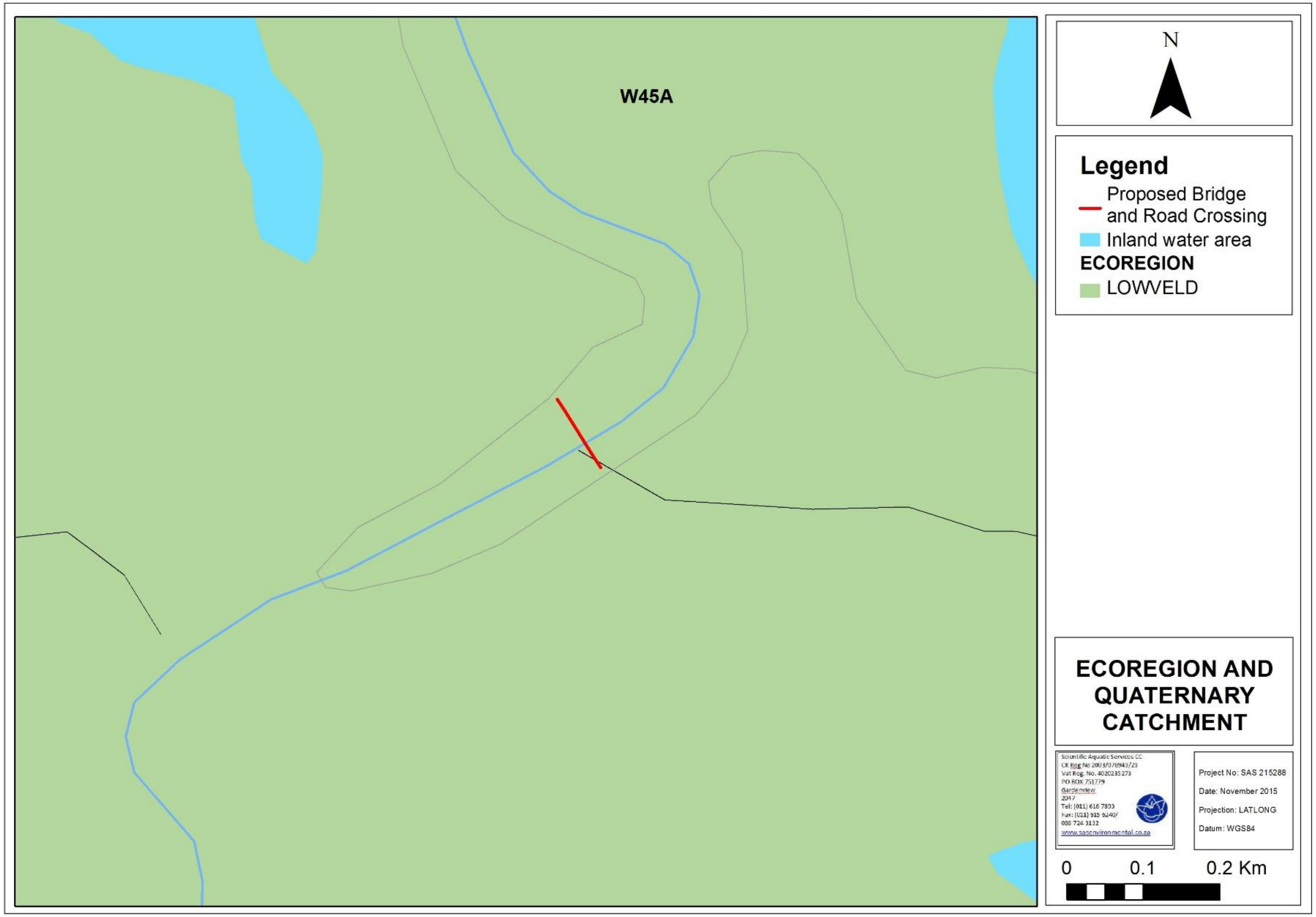


**Figure 4: Aquatic ecoregion and quaternary catchment associated with the proposed bridge infrastructure**

## *2.2 Ecostatus*

### 2.2.1 Water Management Area

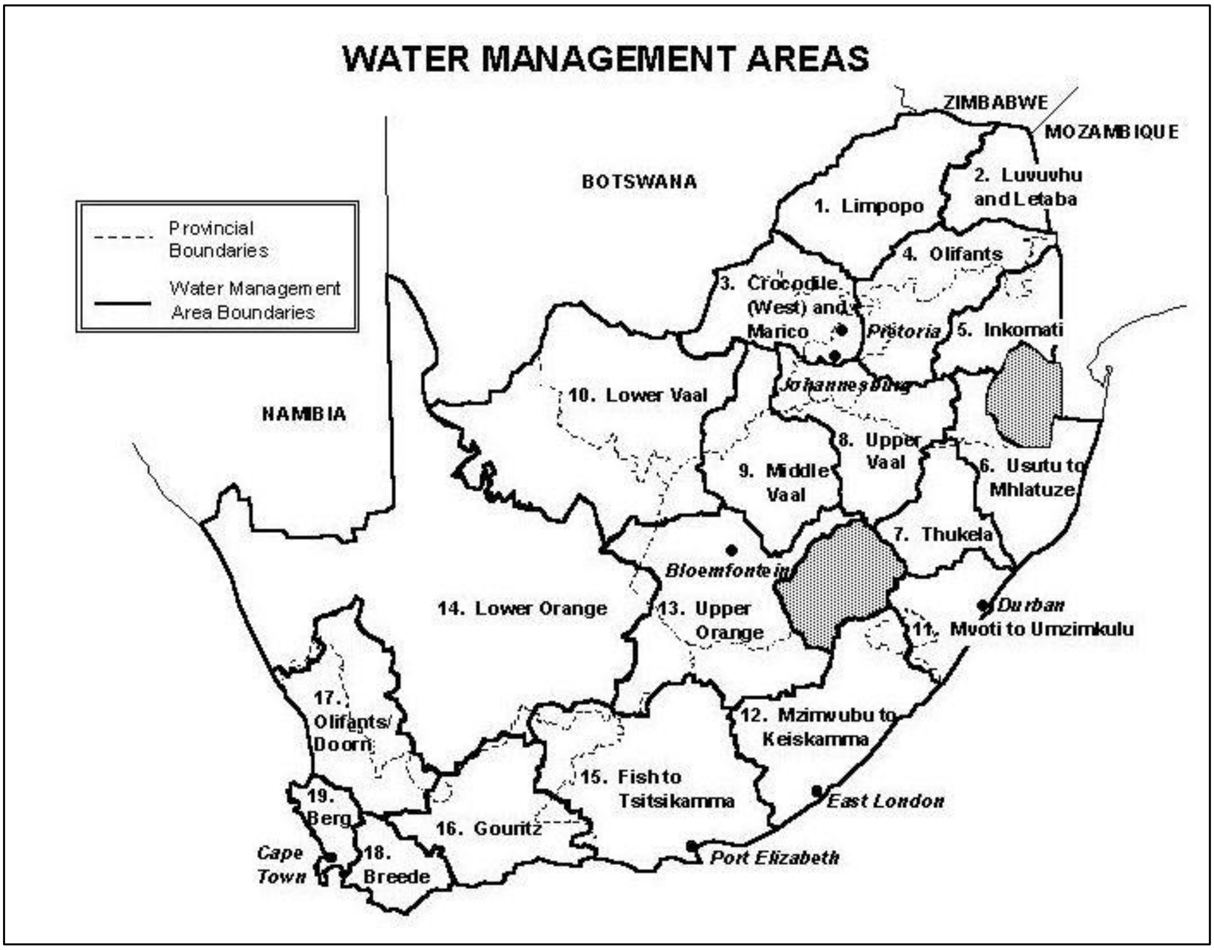


**Figure 5: Map showing the position of the Water Management Areas (WMAs). In South Africa Source: http://www.africanwater.org/SAPolicyEnv_and_water.htm**

The following information on these WMAs has been gleaned from Appendix D of the National water resource strategy compiled by the Department of Water and Sanitation (DWS), formerly the Department of Water affairs and Forestry (DWAF) (DWS formerly DWAF, 2004). (https://www.dwaf.gov.za/Documents/Policies/NWRS/Sep2004/pdf/AppendixD.pdf )

The study area falls within water management area number 6, namely the Usutu to Mhlatuze Water Management Area (WMA)

**Usutu to Mhlatuze Water Management Area**

The Usutu to Mhlatuze WMA falls predominantly within northern KwaZulu-Natal. However, a part of it extends into Mpumalanga and borders on Swaziland and Mozambique. Two rivers are shared with these countries, in that the Usutu River has its headwaters in South Africa but flows into Swaziland, whilst part of the Pongola River catchment also lies in the latter country. The two rivers flow together in South Africa to form the Maputo River just prior to entering Mozambique.

Climate in the region varies considerably, with sub-humid to humid conditions and mean annual rainfall ranging between 600 mm and 1500 mm. Economic activity is diverse and includes rain fed and subsistence farming, irrigation, afforestation, ecotourism and heavy industries in the Richards Bay/Empangeni area.

Water resources have been well developed in the Upper Usutu, Mkuze and Mhlatuze catchments. However, undeveloped potential exists in the Pongola and Mfolozi catchments. Ground water utilisation in most parts of the water management area is relatively limited and can be developed further. Strong interdependencies between surface and groundwater occur in many areas, with groundwater levels, together with surface flows, being particularly important to water balances in the ecologically sensitive coastal lakes and wetlands, some of which are internationally recognised conservation areas.


**Figure 6: Base map of the Usutu to Mhlatuze Water Management Area (WMA). Source: Department of Water and Sanitation, previously Department of Water Affairs and Forestry (2004) National water resource strategy, Appendix D.**

### 2.2.2 SANBI Wetland Inventory and NFEPA databases

The SANBI Wetland Inventory (2006) and National Freshwater Ecosystem Priority Areas (NFEPA) (2011), databases was consulted to define the aquatic ecology of the wetland or river systems close to or within the development area and the study area that may be of ecological importance. Aspects applicable to the study area and surroundings are discussed in the wetlands desktop assessment results section (Section 3).

### 2.2.3 Historical Quaternary catchment information from 1999

Water resources are generally classified according to the degree of modification or level of impairment.

The classes used by the South African River Health Program (RHP) are presented in the table below and will be used as the basis of classification of the systems in this field and desktop study as well as future field studies.

**Table 4: Classification of river health assessment classes in line with the RHP**

| Class | Description |
|---|---|
| A | Unmodified, natural. |
| B | Largely natural, with few modifications. |
| C | Moderately modified. |
| D | Largely modified. |
| E | Extensively modified. |
| F | Critically modified. |

In addition, the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans et al, 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 7.

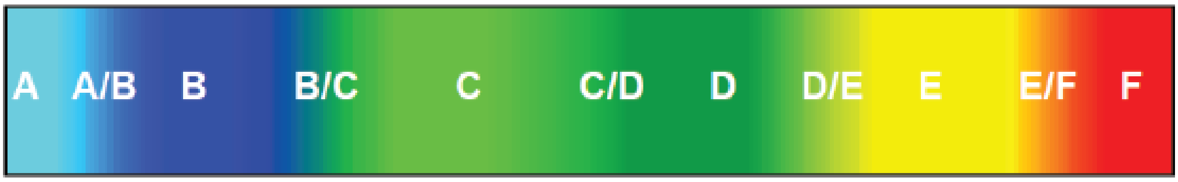


**Figure 7: Ecological categories (EC) eco-status A to F continuum approach employed**

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC)/ Recommended Ecological Category (REC) were defined and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems prior to assessment or as part of a desktop assessment.

In order to define the EIS, PEMC and DEMC, a study undertaken by Kleynhans (1999) helped define the quaternary catchment of concern (W45A, refer to Figure 1). The findings by Kleynhans (1999) formed part of a project entitled “A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers”.
The results of the assessment are summarised in the table below.

**Table 5: Quaternary catchment information.**

| Catchment | Resource | EIS | PES | DEMC |
|---|---|---|---|---|
| W45A | Pongola | Very high | Class B: Largely natural | Class A: Highly sensitive |

EIS = Ecological Importance and Sensitivity
PESC = Present Ecological Sensitivity Class
DEMC = Desired Ecological Management Class

The database results indicate a highly sensitive system which is in accordance with the desired ecological management class. The present ecological state indicates largely natural conditions.

**Table 6: Summary of EIS criteria classifications (Kleynhans 1999)**

| EISC criterion | Quaternary catchment | |
|---|---|---|
| | W45A | Comments |
| Diversity of types | Very high | Floodplain pans, riparian vegetation, sand bed runs, cobble beds. |
| Importance of conservation & natural areas | Very high | Not formally conserved. |
| Intolerant (flow & flow related water quality) | High | *Chiloglanis swierstrai* (Lowveld suckermouth) |
| Migration route/corridor (instream & riparian) | High | Fish and birds. |
| Rare & endangered | Very high | *Redogobius dewaali* (checked goby). |
| Refugia | Very high | Floodplain pans. |
| Sensitivity to water quality changes | High | - |
| Sensitivity to flow changes | High | - |
| Species/taxon richness | Very high | - |
| Unique (endemic, isolated, etc.) | High | Southern limit of a number of species, including *Hydrocynus vittatus* (tigerfish). |

**Table 7: Summary of PESC impact criteria classifications (Kleynhans 1999)**

| Impact | Quaternary catchment | |
|---|---|---|
| | W45A | Comments |
| Bed modification | Low | Potentially also affects flow. |
| Flow modification | High | Pongolapoort Dam regulation and operation. |
| Introduced instream biota | Low | *Cyprinus carpio* (carp). |
| Inundation | Very low | - |
| Riparian/bank condition | High | Traditional vegetable gardens on river banks. |
| Water quality modification | Very low | - |

### 2.2.4 Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database

The PES/EIS database, as developed by the DWS RQIS department, was utilised to obtain additional background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014. The information from this database is based on information at a sub-quaternary catchment reach (subquat reach) level with the descriptions of the aquatic ecology based on the information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, EWR sites and Hydro WMS sites. In this regard Information for the following sub-quaternary catchment reach (SQR) is applicable:

- The proposed bridge crossing point located on the Pongola River at the proposed bridge construction: **W45A-02246 (Pongola River);**

Key information on background conditions within the study area, as contained in this database and pertaining to the PES and EIS for the Pongola River, are tabulated in Table 8. From the assessment of the PES/EIS data the following points are highlighted which summarise the data:

The Ecological Importance (EI) data for SQR W45A-02246 (Pongola River) indicate that the following fish species are expected to potentially occur at site Mboza 1:

*Acanthopagrus berda* (Forsskal,1775)
*Anguilla bicolor bicolor*, McClelland, 1844
*Aplocheilichthys johnstoni,* (Günther, 1893)
*Aplocheilichthys katangae* (Boulenger, 1912)
*Aplocheilichthys myaposae* (Boulenger, 1908)
*Anguilla bengalensis* labiata Peters, 1852
*Anguilla marmorata* Quoy & Gaimard, 1824
*Anguilla mossambica* Peters,1852
*Awaous aeneofuscus* (Peters 1852)
*Barbus annectens* Gilchrist & Thomson, 1917
*Barbus paludinosus* Peters, 1852
*Barbus radiatus*, Peters, 1853
*Barbus toppini,* Boulenger, 1916
*Barbus trimaculatus* Peters, 1852
*Barbus unitaeniatus* Günther, 1866
*Barbus viviparous* Weber, 1897
*Clarias gariepinus* (Burchell, 1822)
*Ctenopoma multispine,* Peters, 1844
*Glossogobius callidus* Smith, 1937
*Hydrocynus vittatus*, Castelnau, 1861

*Labeobarbus marequensis* Smith, 1841
*Labeo congoro* Peters, 1852
*Labeo cylindricus* Peters, 1852
*Labeo molybdinus* Du Plessis, 1963
*Labeo rosae* Steindachner, 1894
*Liza macrolepis* (Smith, 1846)
*Marcusenius macrolepidotus* (Peters, 1852)
*Mesobola brevianalis* (Boulenger, 1908)
*Micralestes acutidens* (Peters, 1852)
*Megalops cyprinoides* (Broussonet, 1782)
*Myxus capensis* (Valenciennes, 1836)
*Nothobranchius orthonotus* (Peters, 1844)
*Oreochromis mossambicus* (Peters, 1852)
*Petrocephalus catostoma* (Günther, 1866)
*Pseudocrenilabrus philander* (Weber, 1897)
*Redigobius dewaali* (Weber, 1897)
*Schilbe intermedius* Rüppel, 1832
*Synodontis zambezensis* Peters, 1852
*Tilapia rendalli* (Boulenger, 1896)
*Tilapia sparrmanii* Smith, 1840

The Ecological Importance (EI) data for SQR W45A-02246 (Pongola River) indicate that the following macro-invertebrate taxa (families) are expected to occur at site Mboza 1:

| | | |
|---|---|---|
| Atyidae | Gyrinidae | Oligochaeta |
| Aeshnidae | Gomphidae | Oligoneuridae |
| Ancylidae | Gerridae | Psephenidae |
| Bulininae | Hydracarina | Potamonautidae |
| Baetidae 1 sp. | Hydroptilidae | Pleidae |
| Belostomatidae | Hydropsychidae 1 sp. | Planorbinae |
| Caenidae | Libellulidae | Simuliidae |
| Coenagrionidae | Leptophlebiidae | Sphaeriidae |
| Corixidae | Lymnaeidae | Veliidae/Mesoveliidae |
| Ceratopogonidae | Leptoceridae | Naucoridae |
| Chironomidae | Dytiscidae | Notonectidae |
| Culicidae | Dixidae | Nepidae |
| Ecnomidae | Elmidae/Dryopidae | |

**Table 8: Summary of the ecological status of the sub-quaternary catchment (SQ) reach SQR W45A-02246 (Pongola River) based on the DWS RQIS PES/EIS database**

<table>
<tr><th colspan="6">Synopsis (SQ reach W45A-02246 Pongola River)</th></tr>
<tr><th>PES[1] category median</th><th>Mean EI[2] class</th><th>Mean ES[3] class</th><th>Length</th><th>Stream order</th><th>Default EC[4]</th></tr>
<tr><td>D</td><td>Moderate</td><td>Very high</td><td>10.23</td><td>4</td><td>A</td></tr>
<tr><th colspan="6">PES details</th></tr>
<tr><td colspan="2">Instream habitat continuity MOD</td><td>Small</td><td colspan="2">Riparian/wetland zone MOD</td><td>Serious</td></tr>
<tr><td colspan="2">RIP/wetland zone continuity MOD</td><td>Large</td><td colspan="2">Potential flow MOD activities</td><td>Serious</td></tr>
<tr><td colspan="2">Potential instream habitat MOD activities</td><td>Large</td><td colspan="2">Potential physico-chemical MOD activities</td><td>Moderate</td></tr>
<tr><th colspan="6">EI details</th></tr>
<tr><td colspan="2">Fish spp/SQ</td><td>41</td><td colspan="2">Fish average confidence</td><td>4.02</td></tr>
<tr><td colspan="2">Fish representivity per secondary class</td><td>High</td><td colspan="2">Fish rarity per secondary class</td><td>Very high</td></tr>
<tr><td colspan="2">Invertebrate taxa/SQ</td><td>39</td><td colspan="2">Invertebrate average confidence</td><td>1.82</td></tr>
<tr><td colspan="2">Invertebrate representivity per secondary class</td><td>High</td><td colspan="2">Invertebrate rarity per secondary class</td><td>High</td></tr>
<tr><td colspan="2">EI importance: riparian-wetland-instream vertebrates (excluding fish) rating</td><td>-</td><td colspan="2">Habitat diversity class</td><td>Low</td></tr>
<tr><td colspan="2">Habitat size (length) class</td><td>Low</td><td colspan="2">Instream migration link class</td><td>Very high</td></tr>
<tr><td colspan="2">Riparian-wetland zone migration link</td><td>Moderate</td><td colspan="2">Riparian-wetland zone habitat integrity class</td><td>Low</td></tr>
<tr><td colspan="2">Instream habitat integrity class</td><td>Moderate</td><td colspan="2">Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m</td><td>High</td></tr>
<tr><td colspan="5">Riparian-wetland natural vegetation rating based on expert rating</td><td>Very high</td></tr>
<tr><th colspan="6">ES details</th></tr>
<tr><td colspan="2">Fish physical-chemical sensitivity description</td><td>Very high</td><td colspan="2">Fish no-flow sensitivity</td><td>High</td></tr>
<tr><td colspan="2">Invertebrates physical-chemical sensitivity description</td><td>Very high</td><td colspan="2">Invertebrates velocity sensitivity</td><td>Very high</td></tr>
<tr><td colspan="5">Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description</td><td>-</td></tr>
<tr><td colspan="5">Stream size sensitivity to modified flow/water level changes description</td><td>Very high</td></tr>
<tr><td colspan="5">Riparian-wetland vegetation intolerance to water level changes description</td><td>Low</td></tr>
</table>

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.

The **Present Ecological State (PES)** of the Pongola River (SQR W45A-02246) is categorised as Class D: Largely modified.

- The instream habitat continuity modification has a small impact rating, meaning that the modifications are only present at a small number of localities and the impact on the habitat quality, diversity, size and variability are also very small;
- The potential physico-chemical modification levels has a moderate impact rating, meaning that the modifications are only present at a small number of localities and the impact on the habitat quality, diversity, size and variability are limited;
- The riparian/wetland zone habitat continuity modification, and the potential instream habitat modification has a large impact rating, meaning that the modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability limited to a few localities and the impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced;
- The riparian/wetland zone modification and potential instream flow modification has a serious impact rating, meaning that 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;

The **Ecological Importance (EI)** is considered moderate.

- The number of fish species estimated per sub quaternary reach is 41;
- The fish representivity per secondary class (FREP) is considered high;
- The fish rarity per secondary class (IRAR) is considered very high;
- The riparian-wetland natural vegetation importance, which is based on the percentage of natural vegetation within 500m is considered high;
- The riparian-wetland natural vegetation importance based on expert rating is considered very high;
- The number of invertebrate taxa per sub quaternary reach is 39;
- The invertebrate representivity per secondary class (IREP) is considered high;
- The invertebrate rarity per secondary class (IRAR) is considered high;
- The habitat diversity class is considered low;
- The habitat size (Length) class is considered low;
- The instream migration link class is very high;
- The riparian-wetland zone migration link is moderate;
- The riparian-wetland zone habitat integrity class is low;
- The instream habitat integrity class is moderate.

The **Ecological Sensitivity (ES)** is considered very high.

- Both the fish and invertebrate physico-chemical sensitivity descriptions are very high. Fish and macro-invertebrate species are thus intolerant, with species being able to survive and breed only under largely unmodified physico-chemical conditions;
- The fish no-flow sensitivity description is high. These species generally requires flow during certain phases of the life cycle for breeding purposes (often fast flows) or for creation of nursing areas with adequate cover. Generally increased habitat suitability and availability resulting from increased flow can be expected to benefit such species. For the majority of these species increased flow may also stimulate breeding activities and/or migration;
- The invertebrate velocity sensitivity description is very high. Such species generally require flow during all phases of the life cycle for breeding purposes. Generally fast flows and clear water conditions are required;
- The stream size sensitivity to modified flow/water level changes description is very high;
- The riparian-wetland vegetation intolerance to water level changes is low;

### PES/EIS summary

A summary of the PES/EIS data, as obtained from the databases consulted, is tabulated below.

**Table 9: Summary of the ecological status of the catchment as well as selected sub-quaternary catchment (SQ) reach**

<table>
<tr><th colspan="5">Quaternary catchment (Kleynhans 1999)</th></tr>
<tr><th>Catchment</th><th>EIS[1]</th><th colspan="2">PES[2]</th><th>DEMC[3]</th></tr>
<tr><td>W45A</td><td>Very high</td><td colspan="2">Class B: Largely natural</td><td>Class A: Highly sensitive</td></tr>
<tr><th colspan="5">Sub-quaternary catchment reach (Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database; accessed 21 August 2015)</th></tr>
<tr><th>SQRs</th><th>PES[4]</th><th>Mean EI[5]</th><th>Mean ES[6]</th><th>Default EC[7]</th></tr>
<tr><td>W45A-02246 (Pongola River)[5]</td><td>D</td><td>Moderate</td><td>Very high</td><td>A</td></tr>
<tr><td colspan="5">[1] EIS = Ecological Importance and Sensitivity<br>[2] PESC = Present Ecological Sensitivity Class<br>[3] DEMC = Desired Ecological Management Class<br>[4] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;<br>[5] EI = Ecological Importance;<br>[6] ES = Ecological Sensitivity<br>[7] EC = Ecological Category; default based on median PES and highest of EI or ES means.</td></tr>
</table>

The Kleynhans (1999) database indicate more natural conditions for the PES for the catchment as a whole, when compared to that obtained from the DWS RQIS database for the specific SQR in question.

With reference to the latter, it is clear that the system is already facing moderate to large impacts with the PES being far removed from the desired/default ecological state.

Both fish and invertebrate fauna are of high importance, with specific reference to *Chiloglanis swierstrai* (Lowveld suckermouth) and *Redogobius dewaali* (checked goby) on a catchment-wide scale.

# 3. WETLAND ECOLOGICAL DESCRIPTION

The following sections contain data accessed as part of the desktop assessment. It is important to note, that although all data sources used provide useful and often verifiable high quality data, the various databases used not always provide an entirely accurate indication of the ecological characteristics in the vicinity of the project footprint. This information is, however, considered to be useful as background information to the study. Thus, this data was used as a guideline to inform the assessment and areas where increased conservation importance is indicated were paid attention to.

## *3.1 National Freshwater Ecosystem Priority Areas (NFEPA; 2011)*

The NFEPA, database was consulted to define the aquatic ecology of the wetland feature systems close to or being traversed by the proposed bridge and road infrastructure that may be of ecological importance. Aspects applicable to the proposed bridge infrastructure and surroundings are discussed below:

- The proposed bridge infrastructure falls within the Usutu to Mhlathuze Water Management Area (WMA). Each Water Management Area is divided into several sub-Water Management Areas (subWMA), where catchment or watershed is defined as a topographically represented area which is drained by a stream or River network. The Sub-Water management unit indicated for the project footprint is the Pongola subWMA;
- The subWMA is not regarded important in terms of fish rehabilitation, translocation and relocation zones for fish, however it is considered as an important fish sanctuary for *Hydrocynus vittatus*. The subWMA is further classified as a fish support area (FEPACODE 2; Figure 8);
- The proposed infrastructure intersects with the Pongola River (Figure 9) which is indicated as a perennial system in a Class C condition (moderately modified). The Pongola River classified as a Fish support area;
- According to the NFEPA database, the proposed bridge and road infrastructure are located within a natural floodplain wetland (Figure 10).
- The wetland features are indicated to fall within Category C (percentage natural land cover 25-75%; PES equivalent: moderately modified).
- The wetland feature is further classified as a WETFEPA, with particular importance of being located within 500m of an important waterbird point locality (Figure 11), as well as a RAMSAR wetland (Figure 12); and
- The wetveg type is identified as Lowveld Group 10, listed as endangered.

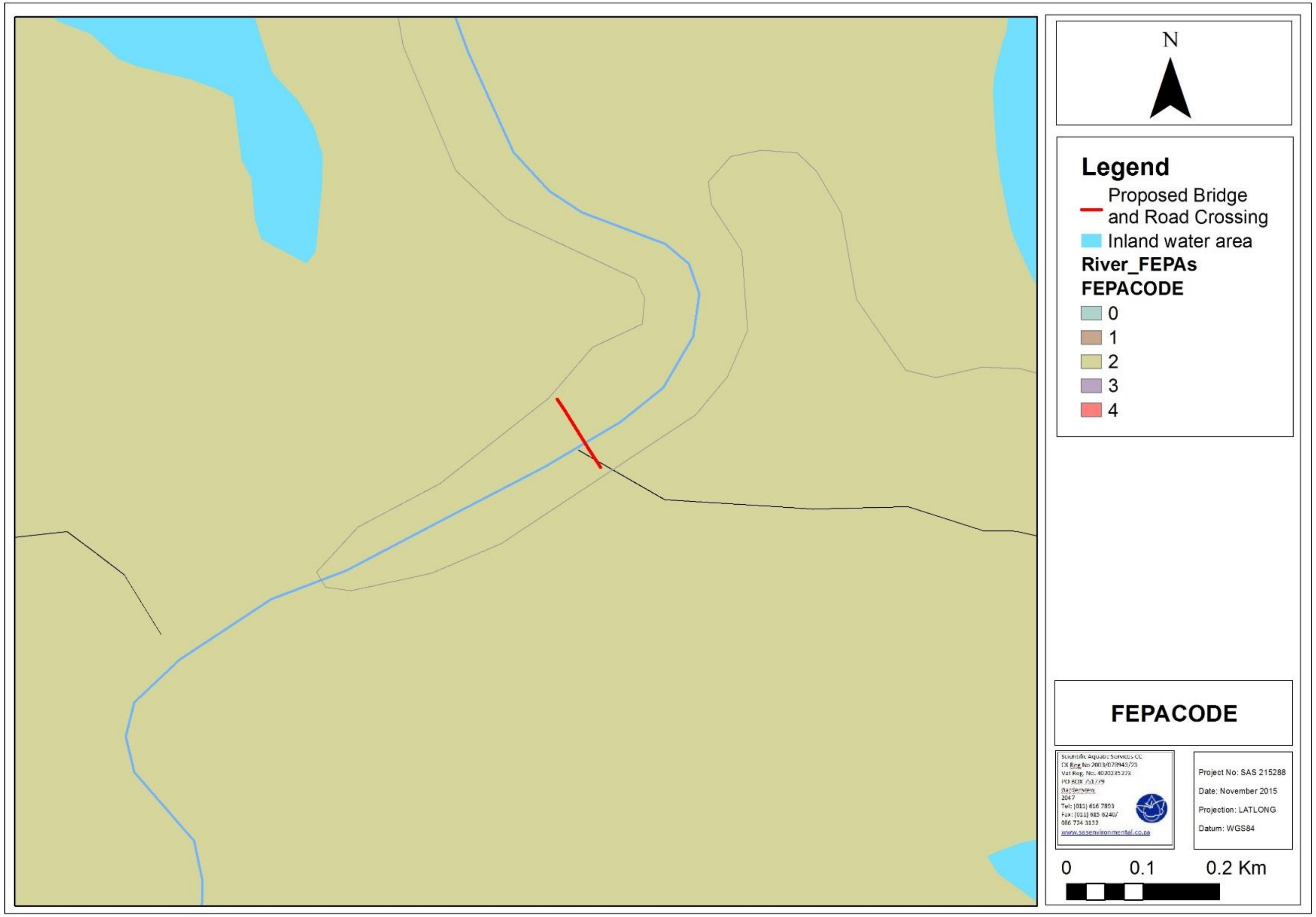


**Figure 8: The subWMA associated with the proposed bridge infrastructure are classified by the NFEPA database as a Fish support area (FEPACODE 2)**

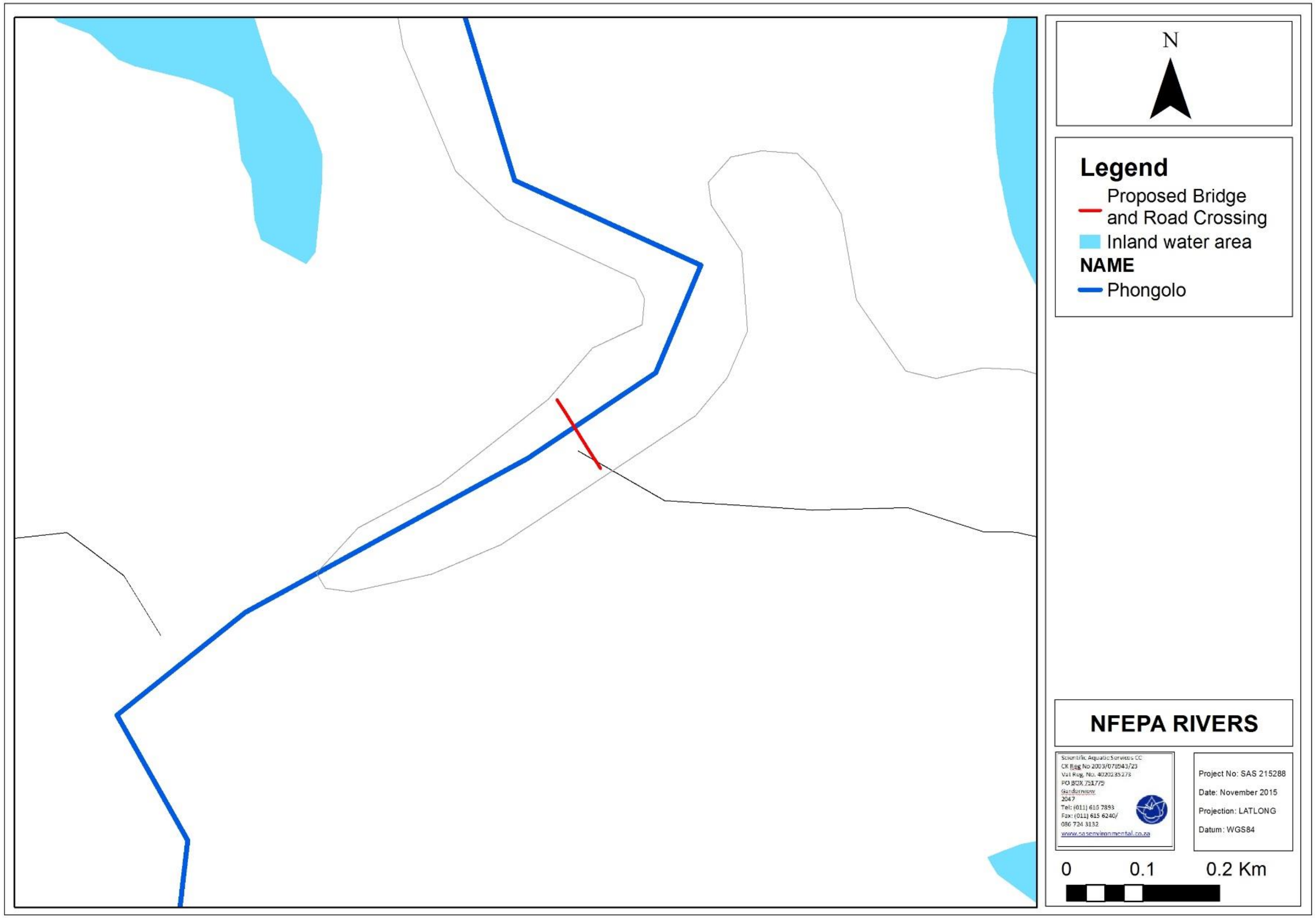


**Figure 9: The proposed bridge infrastructure intersect the Pongola River according to the NFEPA database**

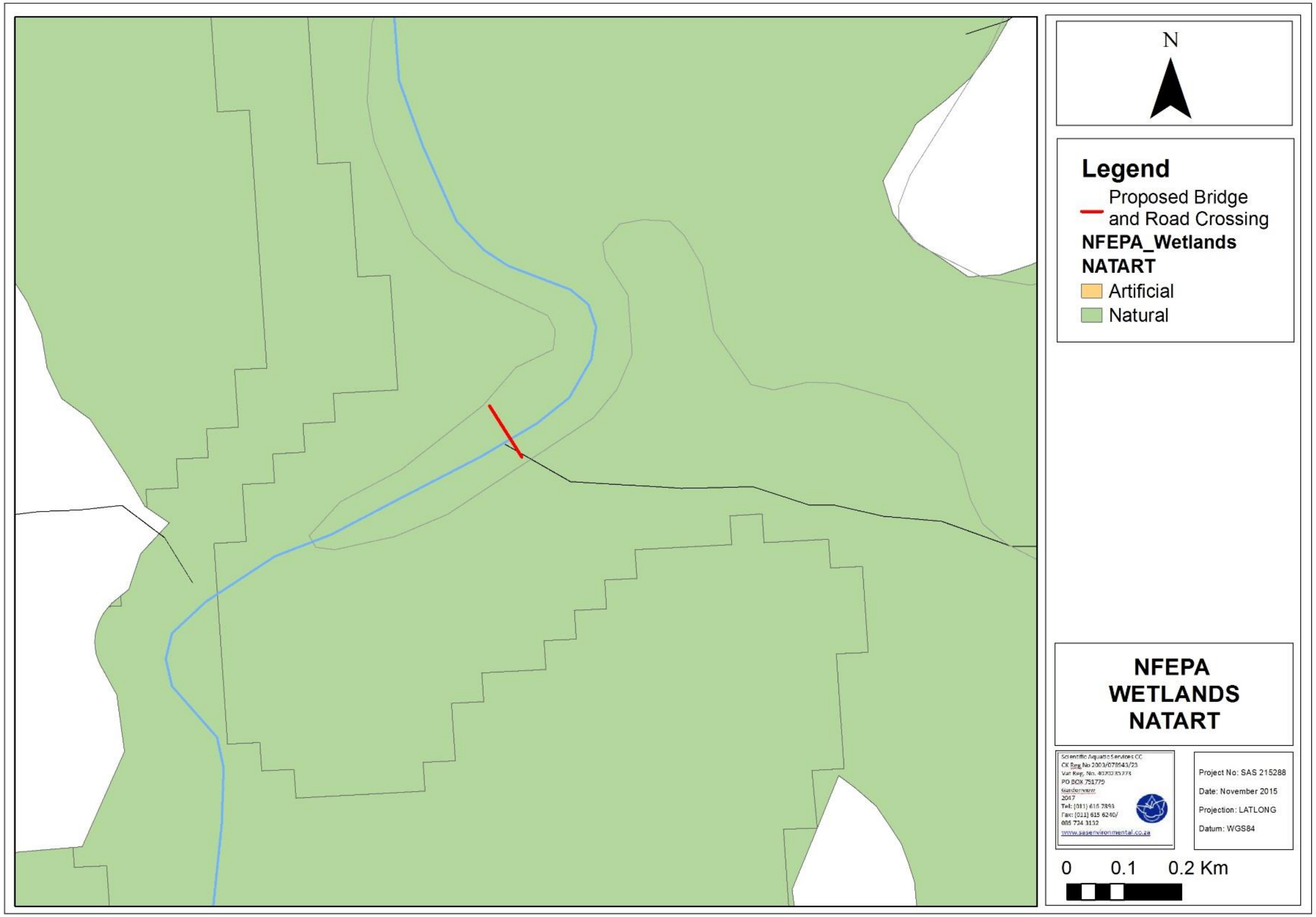


**Figure 10: Natural wetlands associated with the proposed infrastructure according to the NFEPA database**

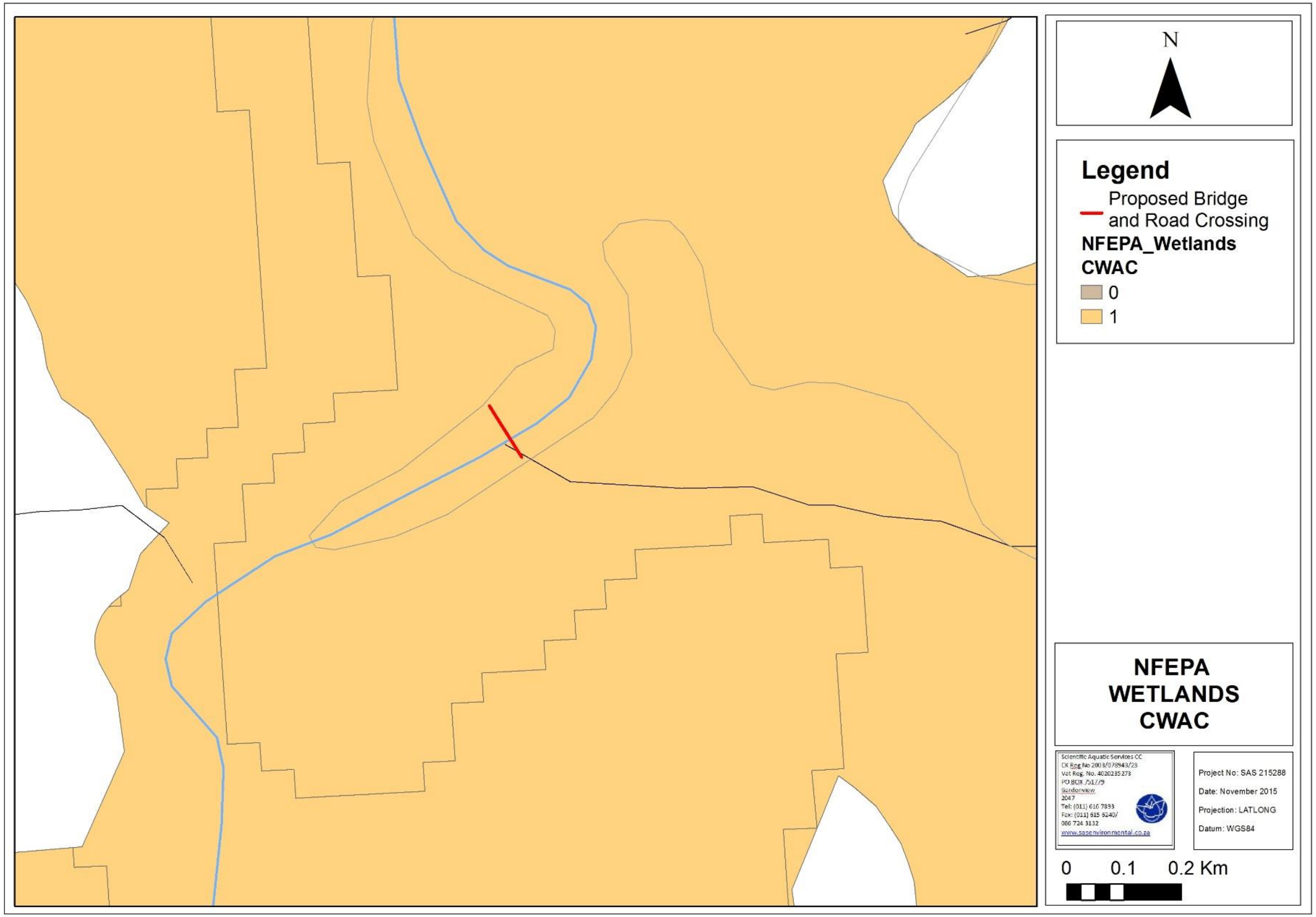


**Figure 11: The wetland associated with the proposed bridge infrastructure are classified as located within 500m of an important bird point locality**

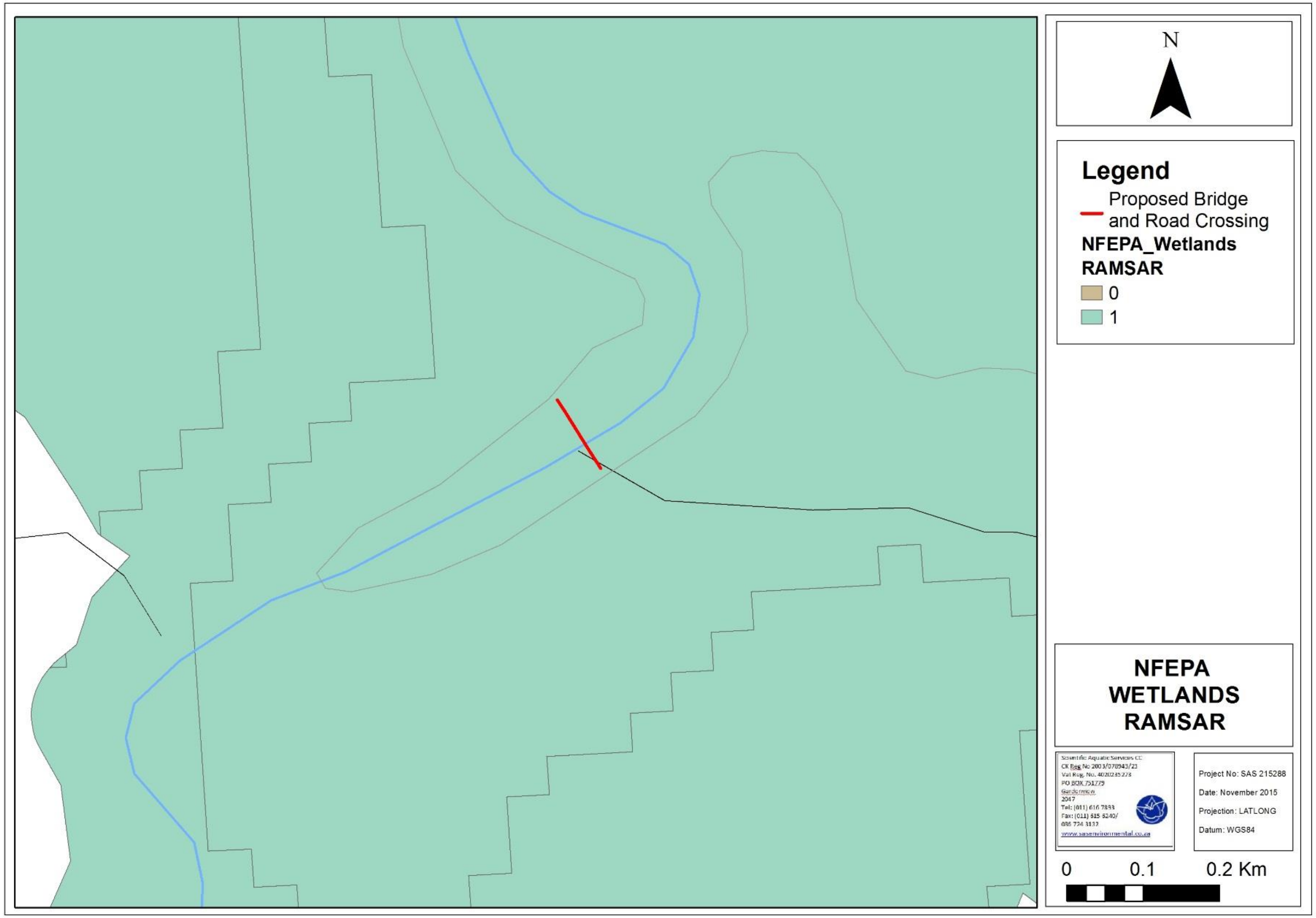


**Figure 12: The wetlands surrounding the proposed bridge infrastructure are classified as RAMSAR wetlands**

## 3.2 KwaZulu Natal Terrestrial Conservation Plan (2010)

According to the KwaZulu-Natal Terrestrial Conservation Plan (Figure 13) the proposed infrastructure falls within an area that is classified as a Biodiversity Area. Biodiversity areas represent the natural and/or near natural environmental areas not indicated to be 'choice' area from a biodiversity point of view. This, however, does not mean that these are areas with no biodiversity value. Important species are still located within these areas and should be accounted for.

## 3.3 Land Cover of KwaZulu Natal (2008) Version 1

In order to appropriately monitor development and derive useful conservation plans, appropriate measures of the state of the landscape and extent of transformation are needed. The KwaZulu-Natal (KZN) Land Cover Dataset is a single, contiguous land-cover dataset covering the entire KZN Province that has been generated from single date SPOT5 imagery acquired primarily in 2008, and represents the final 2008 KZN Province Land-Cover product. The 2008 KZN Land-Cover dataset represents an update of the previously released 2005 KZN Provincial Land-Cover dataset. The updated dataset contains the same information classes as the previous 2005 dataset, although several new sub-classes have been included in the legend structure.

According to the KZN Land-Cover Dataset the land cover associated with the location of the proposed bridge infrastructure is a combination of wetland, natural freshwater, grassland, rural subsistence and degraded bushland, (SANBI BGIS) (Figure 14).

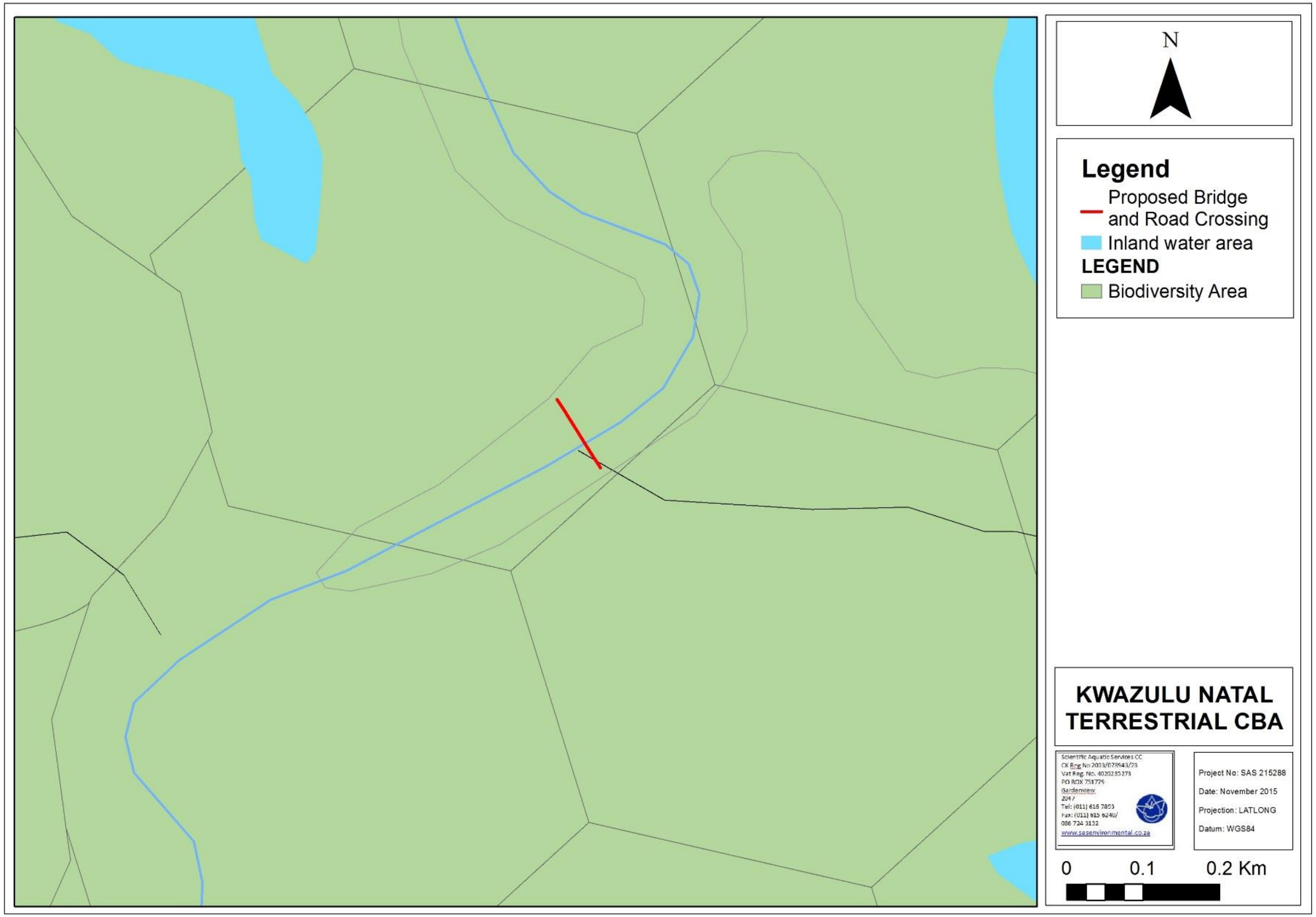


**Figure 13: KZN Terrestrial Conservation Plan (2010) indicating the Biodiversity area associated with the proposed bridge infrastructure.**

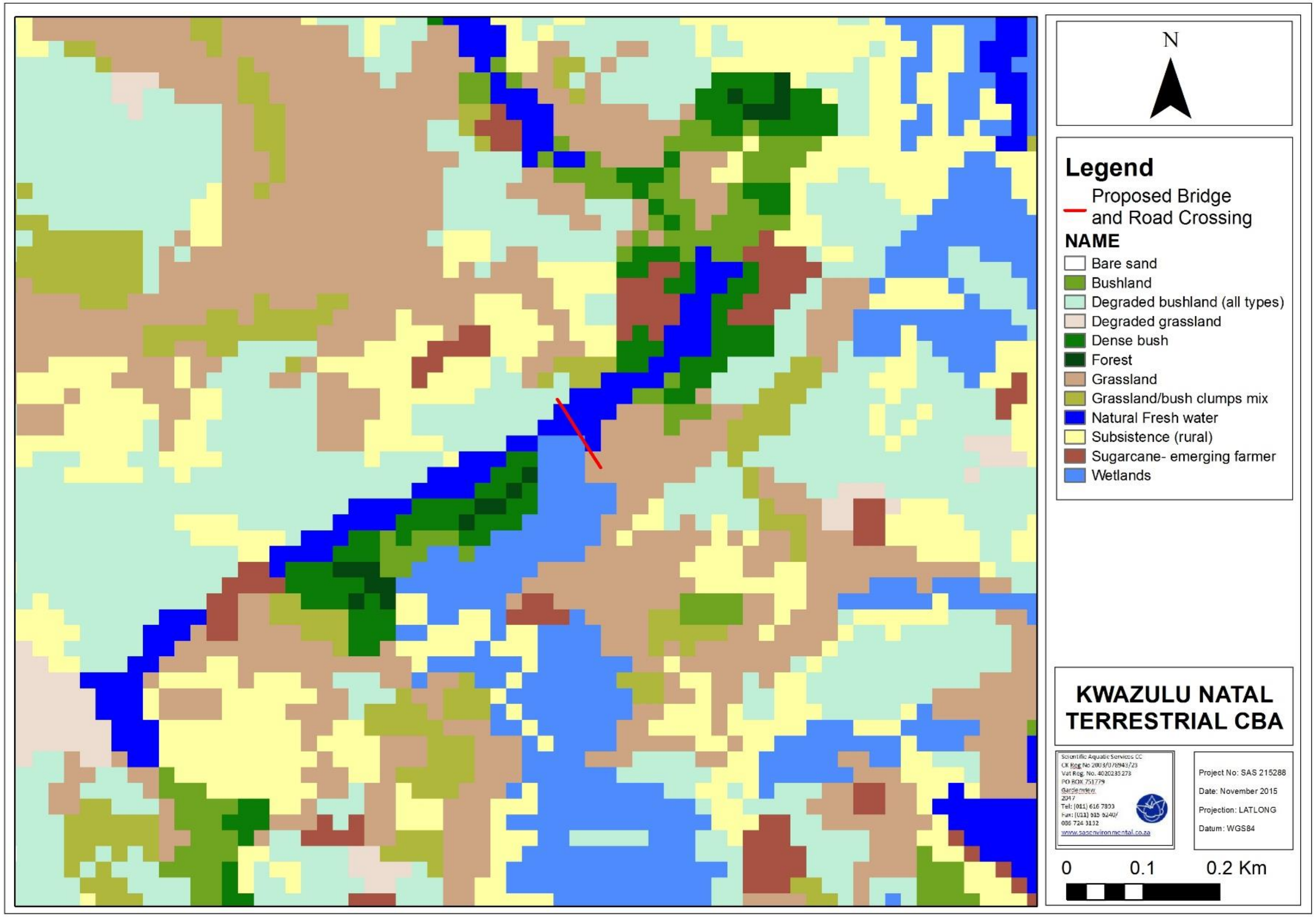


**Figure 14: KZN Land-Cover (2008) associated with the proposed bridge infrastructure.**

# 4. METHOD OF INVESTIGATION

The assessment of the PES of the system, as well as possible impacts due to the proposed development, was based on comparisons between observed conditions and the theoretical reference conditions based on desktop information reviews, and from historical data for the area from the Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS), which presents data available on a subquat reach level and with some filed, verified background information available.

The sections below describe the methodology used to assess the aquatic ecological integrity of the various sites. The methods are described in detail in the Appendices 1 (aquatic assessment methods indices) and 2 (wetland assessment methods and indices) indicated.

## *4.1 Aquatic assessment methods and indices employed*

The following methodologies were employed to assess the aquatic ecological integrity of the crossing site based on water quality, instream and riparian habitat condition and biological impacts and integrity.

- Visual assessment;
- Physico-chemical water quality data;
- Vegetation Response Assessment Index (VEGRAI);
- Invertebrate Habitat Assessment (IHAS);
- Intermediate Habitat Integrity Assessment (IHIA);
- South African Scoring System Version 5 (SASS5);
- Macro-Invertebrate Response Assessment Index (MIRAI);
- Fish Habitat Cover Rating (HCR);
- Fish Response Assessment Index (FRAI).

Refer to Appendix 1 for details.

## *4.2 Wetland assessment methods and indices employed*

- All wetland or riparian features encountered within the linear development were assessed using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems, hereafter referred to as the "Classification System" (Ollis *et. al*., 2013).
- The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et. al.* (2009).

- To assess the PES of the wetland and riparian features, the IHI for South African floodplain and channelled valley bottom wetland types (Department of Water Affairs and Forestry Resource Quality Services, 2007) was used.
- The method used for the EIS determination was adapted from the method as provided by DWA (1999) for wetlands.
- The Recommended Ecological Category (REC) was determined based on the results obtained from the PES, reference conditions and EIS of the resource (sections above), and is followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.
- The wetland and riparian zone delineation took place according to the method presented in the final draft of "A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas" published by the DWAF in February 2005. An updated draft version of this report is also available and was therefore also considered during the riparian delineation (DWAF, 2008).

Refer to Appendix 2 for details.

## *4.3 Impact Assessment*

The following parameters are used to describe the impact/issues in this assessment:

- Nature
- Extent (E)
- Duration (D)
- Intensity (I)
- Probability (P)
- Cumulative (C)
- Significance (S)

Details on methodology employed are provided in Appendix 3.

# 5. AQUATIC RESULTS AND INTERPRETATION

The sections below describe the results obtained for the aquatic ecological integrity of the site based on water quality, instream and riparian habitat condition and biological impacts and integrity. Consideration was given to the position of the aquatic site during selection in order to assist in defining the PES and any impacts in this area. The aquatic assessment results are presented below and cover the aquatic resources in the vicinity of the proposed bridge construction area (refer to Figures 1 and 2).

## *5.1 Site Mboza 1 (Pongola River)*

### 5.1.1 Visual assessment

A photographic record of each assessment site was captured in order to provide visual record of condition, as observed during the field assessments. The photographs taken at the Mboza 1 site are presented below. These are representative of conditions encountered during a single field site visit performed during summer (October 2015, Figures15 and 16). The table that follows summarises the observations for the various criteria made during the visual assessment undertaken on the site.

**Figure 15: Upstream view of the Mboza 1 site indicating low flows at the time of assessment (October 2015)**

**Figure 16: Downstream view of the Mboza 1 site (October 2015)**

**Table 10: Description of the location of the assessment site in the study area**

| SITE | Mboza 1 (Pongola River) |
|---|---|
| **Braiding of the system** | At this point the system mostly consists of one moderately flowing channel, which under low flows consists of largely laminar flow. Under higher flows an increase in turbulence can be expected. |
| **Riparian zone characteristics** | The riparian zone is narrow and the adjacent floodplain has been severely disturbed through tillage and agricultural activities. Some impact on the understorey from alien vegetation encroachment has occurred while the woody component is more intact. The riparian vegetation is in a fair condition. |
| **Algal presence** | No excessive algal proliferation was evident. |
| **Visual indication of an impact on aquatic fauna** | No visual evidence of significant impacts on the aquatic ecology of the system is deemed likely, beyond impacts on the understorey of the riparian zone. |
| **Depth characteristics** | The river at this point consists of shallow glides with depth varying, on average, between 10cm to 50cm deep under low flow conditions. In the area below the proposed crossing point the river consists of slightly deeper pools. |
| **Flow condition** | The river at this point is generally moderately flowing with faster flowing sections on bends and slower flow in the deeper pools. |
| **Water clarity** | Water was clear at the time of assessment |
| **Water odour** | None |
| **Erosion potential** | Under high flow conditions the system will erode rapidly due to the fast flow of the water and the fairly unstable sandy nature of the riparian zone. However deposition of sediments from further upstream ensures a dynamic equilibrium in the system. Some impacts on the hydrology of the system due to impacts of the upstream Jozini impoundment are deemed likely. |

### 5.1.2 Physico-Chemical Water Quality

The table below records the biota specific water quality of the assessment sites.

**Table 11: Biota specific water quality data at site Mboza 1 (Pongola River).**

| SITE | EC (mS/m) | pH | DO (mg/L) | Temp °C |
|---|---|---|---|---|
| Mboza 1 (October 2015) | 41.7 | 7.97 | 6.30 | 25.8 |

- General water quality can be considered largely natural, with the exception of the slightly elevated EC value from what is expected under completely natural conditions. Some variation from the expected natural condition is deemed likely due to return flows and run-offs from agricultural activities;
- The pH is slightly acidic but can be regarded as largely natural (within the 6 to 8 pH value range) and suitable for supporting a diverse and sensitive aquatic community (DWS formerly DWAF, 1996);
- Any impact on the system with reference to pH was limited at the time of assessment with the pH being largely Neutral;
- The DO percentage of saturation was not within the desired 80% to 120% range for aquatic ecosystems (DWS formerly DWAF, 1996). However, the percentage saturation exceeded 75% was still largely capable of supporting a diverse and sensitive aquatic community at the time of assessment (Table 12) although some limitation on more sensitive taxa may occur.

**Table 12: Oxygen measured expressed as percentage of maximum for the site**

| SITE | DO mg/l | Temp °C | Maximum oxygen at that temperature (mg/L) | Oxygen measured expressed as percentage of maximum |
|---|---|---|---|---|
| Mboza 1 (October 2015) | 6.3 | 25.8 | 8.09 | 77.87 |

- Temperature can be regarded as normal for the time of year and time of day when assessment took place.

### 5.1.3 Riparian vegetation assessment using VEGRAI

The VEGRAI assessment result for the Pongola River is presented in the table below. The results of this assessment indicate that the Pongola River falls within Ecostatus Category D, indicating that the vegetation within the system is largely modified. Large changes to the riparian vegetation (mainly the non-marginal zone) of the river due to alien floral invasion and cultivated fields were observed. No deviations as a result of impacted water quality were observed.

**Table 13: Results of the VEGRAI assessment for the Pongola River system**

| LEVEL 3 ASSESSMENT | | | | | |
|---|---|---|---|---|---|
| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
| MARGINAL | 56,3 | 37,5 | 3,3 | 1,0 | 100,0 |
| NON MARGINAL | 20,0 | 6,7 | 0,0 | 2,0 | 50,0 |
| | 2,0 | | | | 150,0 |
| LEVEL 3 VEGRAI (%) | | | | 44,2 | |
| **VEGRAI EC** | | | | **D** | |
| AVERAGE CONFIDENCE | | | | 1,7 | |

### 5.1.4 Invertebrate Habitat Integrity Assessment (IHIA)

From the results of the application of the IHIA to the segment of the Pongola River in the vicinity of the proposed bridge crossing in October 2015, it is evident that there are several small to large impacts on the habitat of the area.

- Small instream impacts at the Pongola River Mboza 1 site included impacts from bed modification, water quality, exotic fauna and solid waste disposal. Moderate impacts included water abstraction and channel modification. A single large instream impact was recorded, namely flow modification. The site achieved 78% score for instream zone integrity;

- Small riparian zone impacts included water quality and water abstraction. Moderate impacts included alien encroachment, bank erosion, flow modification and channel modification. Vegetation removal was the only rage riparian zone impact recorded. The site achieved a 71% score for riparian zone integrity; and
- Overall the site obtained an IHIA rating of 74%, which is indicative of moderately modified (Category C) conditions (refer to Appendix 6). This classification is in agreement with the PES classification for the larger catchment (Kleynhans 1999), but improved from the Category D classification allocated to the relevant SQR (DWS RQIS PES/EIS database).

### 5.1.5 Invertebrate Habitat Assessment System (IHAS)

Table 14 summarizes of the results obtained from the application of the Intermediate Habitat Assessment Index (IHAS) to the bio-monitoring site. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in defining the habitat condition and interpreting SASS5 results (Appendix 4).

From the results of the application of the IHAS index it is evident that the Pongola River in the area provided inadequate habitat conditions for sustaining a diverse macro-invertebrate community at the time of assessment.

This is largely due to a lack of rocky substrate in the system and the dominance of laminar flow over sandy substrate with limited niche habitat for aquatic biota. In addition the sandy substrate is unstable and does not provide cover for any except the most highly adapted aquatic macro-invertebrate taxa. The lack of leafy marginal vegetation and the absence of aquatic macrophytes also limits the availability of suitable cover for aquatic macro-invertebrates. Considering the above, a macro-invertebrate community of limited diversity and abundance can thus be expected (McMillan, 1998).

**Table 14: Biotope specific summary of the results obtained from the application of the IHAS index to the Pongola River at site Mboza 1.**

| SITE | Mboza 1 (Pongola River) Summer (October 2015) |
|---|---|
| IHAS Habitat score | 51 |
| Habitat adjustment score (illustrative purposes only) | +34 |
| McMillan, 1998 Habitat description | Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community |
| Stones habitat characteristics | A lack of diverse substrate is present in the river segment with the river reach dominated by sand habitat with no rocky habitat present. |
| Vegetation habitat characteristics | Marginal vegetation was present out of current but had a limited amount (1% to 25%) of leafy material present to provide habitat and cover for suitably adapted macro-invertebrate families. Aquatic vegetation was absent. |
| Other habitat characteristics | Habitat such as stones, bedrock, gravel and muddy substrate was absent at the site with only sand substrate available for colonisation by suitable adapted macro-invertebrates. The absence of this habitat may limit the diversity of suitably macro-invertebrates possibly supported by the system |
| IHAS general Stream characteristics | The river at this point is wide (>10 m) and on average shallow (1/2 m) and there is limited diversity in depth and flow at the site (shallow run only under conditions at the time of assessment). The surrounding vegetation consisted of a mix of grasses and shrubs. The dominant activity in the area is agriculture (crops). |

### 5.1.6 Aquatic Macro-invertebrates: SASS

The results of the aquatic macro-invertebrate assessment according to the SASS5 index are summarised in the tables below. Table 15 indicates the results obtained at the site per biotope sampled. Table 16 summarises the findings of the SASS assessment based on the analyses of the data for the site, as well as interpretation of the data. SASS score sheets are presented in Appendix 5.

**Table 15: Biotope specific summary of the results obtained from the application of the SASS5 index to the Pongola River site.**

| PARAMETER | SITE | STONES | VEGETATION | GRAVEL, SAND AND MUD | TOTAL |
|---|---|---|---|---|---|
| SASS5 SCORE | Mboza 1 (September 2015) | 0 | 82 | 22 | 85 |
| Number of taxa | | 0 | 13 | 3 | 14 |
| ASPT | | 0 | 6.3 | 7.0 | 6.1 |

**Table 16: Summary of the results obtained from the application of the SASS5 index at the Mboza 1 site during summer (October 2015).**

| Type of Result | Mboza 1 |
|---|---|
| **Biotopes sampled** | Fringing vegetation; Sand. |
| **Sensitive taxa present** | *Atyidae; Hydracarina;Heptageniidae; Calopterygidae; Lepoceridae.* |
| **Sensitive taxa absent** | *Caenidae; Leptophlebiidae; Oligoneuridae; Aeshnidae; Gomphidae; Naucoridae; Ecnomidae; Hydroptilidae; Elmidae; Psephenidae; Dixidae; Ancylidae.* |
| **SASS5 score** | 85 |
| **Adjusted SASS5 score** | 119 |
| **SASS5 % of theoretical reference score*** | 45.9 |
| **ASPT score** | 6.1 |
| **ASPT % of theoretical reference score**** | 87.1 |
| **Dickens & Graham, 2001 SASS5 classification** | Class D (largely impaired) |
| **Dallas 2007 classification** | Class C (moderately impaired) |

***SASS5 reference score = 185; **ASPT reference score = 7.0**

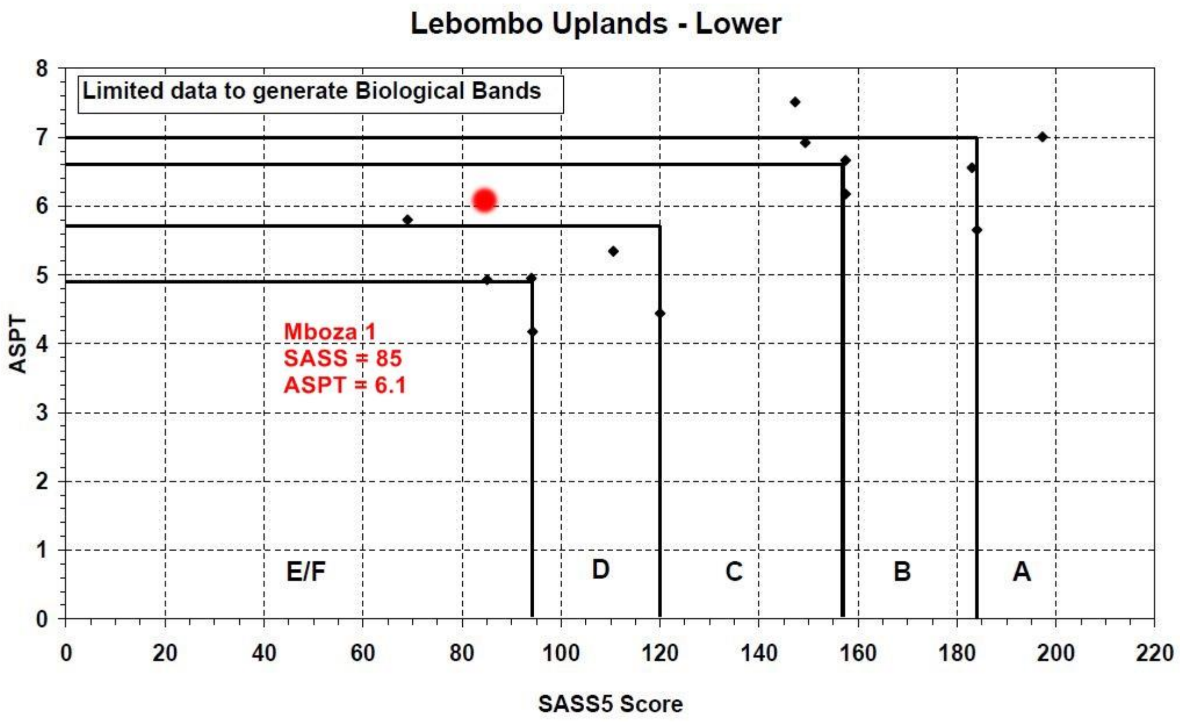


**Figure 17: Scatterplot of historical SASS data (black) and data from the summer (October 2015) assessment (Dallas 2007)**

- SASS scores indicated Category D (largely impaired) conditions at site Mboza 1 according to the Dickens and Graham (2001) classification system;
- According to the Dallas (2007) classification system, a Category C (moderately impaired) classification was obtained for site Mboza 1;

- The apparent discrepancy in results obtained for site Mboza 1 is due to the Dallas (2007) classification system being more sensitive to changes in ASPT compared to the Dickens and Graham (2001) classification system. It must also be noted that no data for the local aquatic region was available for the Dallas (2007) system and the adjacent most applicable ecoregion data was used for interpretation. For the purpose of this assessment both classification systems are deemed relevant.
- However, results employing the Dickens and Graham (2001) classification system are in agreement with the PES for the SQR in which the proposed river crossing is planned (DWS RQIS PES/EIS database, PES classified as Class D). As a result this classification system is deemed most applicable and representative of conditions at the time of assessment. Furthermore the Dallas (2007) indicate limited data from which to make inferences, confirming that the Dickens and Graham (2001) classification system may be better suited to meet the assessment objectives;
- The SASS data indicates that the aquatic macro-invertebrate community of this system, prior to any of the proposed developments taking place, supports an aquatic community of limited abundance and diversity when compared to the reference score for a Lebombo Uplands Lower aquatic ecoregion stream;
- As observed in the IHAS index, this limited community diversity can partially ascribed to natural limitations posed in the system by the lack of suitable habitat and cover for aquatic macro-invertebrates;
- However, other factors such as impacts resulting from agricultural return flows or run off, as well as the potential for other unidentified point and diffuse sources of pollution in the larger catchment resulting from other anthropogenic activities (for example informal rural settlements with associated water quality impacts), may also contribute to the observed trend (impaired macro-invertebrate community);
- Future SASS5 and ASPT results should be monitored and any alterations in the scores should be identified, with particular reference to potential seasonal/annual variations in SASS score which seem relatively stable in the data collected to date scores;
- Considering the proposed bridge crossing construction activities, three potential impacts that may affect the aquatic community have been identified. These are impacts on instream flow and hydrological function, changes to instream habitat and impacts on instream biota;
- Such impacts can have a negative effect on both macro-invertebrate diversity and sensitivity which, based on the PES EIS database, is known to be sensitive to changes in flow. Such potential impacts should be mitigated and close monitoring of trends must take place.

### 5.1.7 Aquatic Macro-invertebrates: MIRAI

The calculated percentage contribution of taxa actually present for each of the preference criteria are tabulated in Table 17 for the October 2015 assessment. Calculations were performed by dividing number of taxa actually present, dividing it by number of taxa expected to occur and multiplying by 100 to express the ratio as a percentage.

**Table 17: Percentage of taxa represented for each preference criterion listed per site in the Pongola River for the October 2015 assessment.**

| Variable | Criteria | Percentage occurrence of taxa showing preferences at each of the sites |
|---|---|---|
| | | Mboza 1 |
| Flow | Very Fast (>0.6 m/s) | 0.00 |
| | Moderately Fast (0.3-0.6 m/s) | 50.00 |
| | Slow (0.1-0.3 m/s) | 20.00 |
| | Very Slow (<0.1 m/s) | 31.25 |
| Habitat | Bedrock | 0.00 |
| | Cobbles | 21.43 |
| | Vegetation | 58.33 |
| | Gravel, Sand, Mud | 20.00 |
| | Water | 12.50 |
| Water quality | High | 50.00 |
| | Moderate | 36.36 |
| | Low | 20.00 |
| | Very Low | 33.33 |

**Table 18: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment site on the Pongola River. For ease of comparison the SASS5 classifications are also provided in this table.**

| Index | Ecological category obtained for site Mboza 1 |
|---|---|
| MIRAI category (score) | D (57.34) |
| SASS5 (Dickens and Graham 2001) | D |
| SASS5 (Dallas 2007) | C |

In terms of ecological category classification, the MIRAI Ecostatus tool revealed an ecostatus category classification Category D for site Mboza 1. This is in agreement with SASS5 results obtained using the Dickens and Graham (2001) classification system and also the PES for the SQR in question (DWS RQIS PES/EIS database).

All macro-invertebrate indices confirm a macro-invertebrate community deteriorated from what is expected based on diversity and sensitivity, when compared to what is expected for a pristine stream in the ecoregion. As discussed previously the reasons for this appears to be a combination of current anthropogenic impacts, most notably return flow and run-off from agricultural activities, combined with inadequate habitat conditions (lack of stone habitat, limited vegetation habitats and lack of depth and flow diversity) unable to support a diverse macro-invertebrate community. Long term, natural variation of biological activities within the system may also affect macro-invertebrate community dynamics. Future monitoring efforts will help to identify and elucidate potential seasonal variation.

### 5.1.8 Fish Community Integrity

The HCR (Habitat Cover Rating) results for the Mboza 1 site on the Pongola River are provided below:

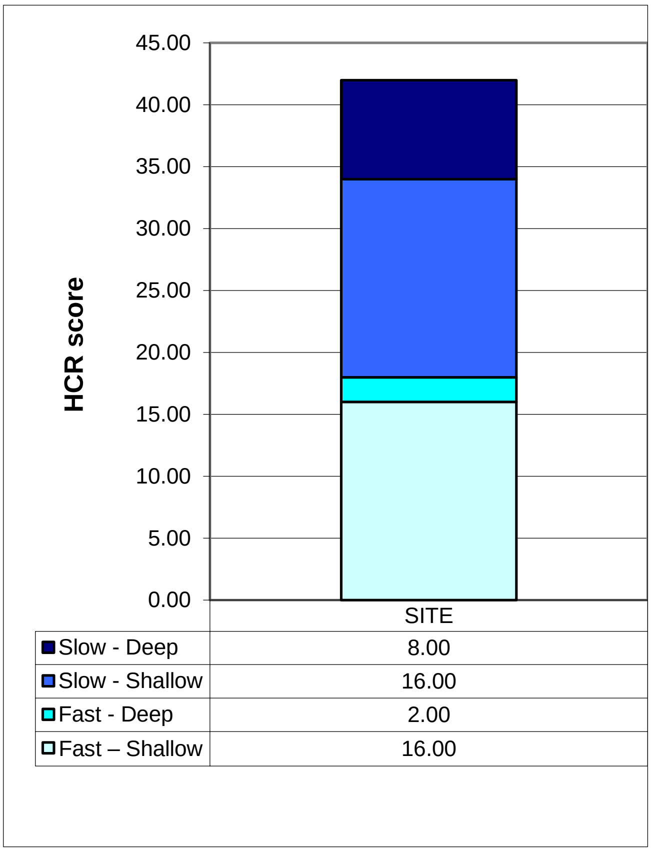


**Figure 18: HCR scores for the Pongola River at site Mboza 1**

It is clear that under low flows resulting in shallow conditions, a combination of slow and fast flows dominate the system. Cover feature availability is limited, with fish demonstrating a preference for deep conditions, rocky substrate or dense vegetation cover expected not to occur at the proposed crossing point.

Sampling for fish was conducted within the Pongola River (site Mboza 1) over a 1 hour period using electronarcosis methods as well as cast netting and using a hand held sweep net. No fish species were observed or captured during the assessments:

- The most likely reasons for the absence of fish in the system is
  - limited habitat and cover;
  - limited flow and depth diversity;
  - anthropogenic activity around the assessment site as the river here is often used by the local community for recreational activities such as swimming (personal observation at time of assessment); and
  - Potential impacts from overutilization of fish stocks in the system and impacts from changes on instream flows as a result of the Jozini Dam operation.
- Fish migration, with specific reference to eel species, is likely to occur within a free flowing river system such as the Pongola River and some seasonal variation in fish community assemblage is deemed likely. In addition such migratory patterns are likely to be affected by impoundments upstream of the assessment site, most notably the Pongolapoort Dam;
- The results of the survey thus did not support the findings of survey data in the DWS RQIS PER/EIS database, where a large variety of expected fish species were listed;
- Due to the high integrity, diversity and sensitivity of the fish community based on the desktop assessment, it is evident that the specific site of the crossing is of reduced sensitivity and can be considered a good point for crossing from a fish community conservation point of view;
- Because no fish were collected during the assessments, the FRAI score was defined as Class F when compared to the expected fish assemblage.

## *5.2 Aquatic Ecological Importance and Sensitivity*

The EIS method was applied to the Pongola River in order to ascertain the current sensitivity and importance of the systems. The results of the assessment are presented in the table below.

**Table 19: Results of the EIS assessment for the Pongola River (site Mboza 1)**

| Biotic Determinants | Pongola River |
|---|---|
| Rare and endangered biota | 2 |
| Unique biota | 2 |
| Intolerant biota | 3 |
| Species/taxon richness | 2 |
| **Aquatic Habitat Determinants** | |
| Diversity of aquatic habitat types or features | 1 |
| Refuge value of habitat type | 2 |
| Sensitivity of habitat to flow changes | 3 |
| Sensitivity of flow-related water quality changes | 3 |
| Migration route/corridor for instream and riparian biota | 3 |
| Nature Reserves, Natural Heritage sites, Natural areas, PNEs | 2 |
| **RATING AVERAGE** | **2.3** |
| **EIS CATEGORY** | **High** |

The Ecological Importance and Sensitivity Assessment analysis of the Pongola River provided a score of 2.3 which is regarded as highly important and sensitive despite the low PES of the system as a result of local and regional impacts. The increased importance and sensitivity of the stream is mainly as a result of high diversity and sensitivity of aquatic biota in the Pongola river system. The system also has some importance with regards to use as a migration corridor with specific reference to eels and the provision of refugia for species relying on the system. Despite the system having a poor diversity of habitat features on a local scale the habitats provided by the system are diverse on a reach scale which increases the EIS of the system. The systems is considered moderately sensitive to alterations in flow and flow-related water quality changes with year round water required in the system to support the sensitive aquatic biota. The EIS classification corresponds with that provided in the databases provided (Kleynhans 1999 as well as DWS RQIS PES/EIS database).

# 6. WETLAND RESULTS AND INTERPRETATION

## *6.1 Wetland Characterisation*

The wetland features within the project footprint was categorised with the use of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, *et. al.* 2013). Upon assessment single HGM Units, namely a floodplain wetland, was identified and will be assessed accordingly:

**Table 20: Classification for the Floodplain Wetland (SANBI 2013).**

| Level 1: Inland System | Level 2: Regional Setting | Level 3: Landscape unit | Level 4: HGM Unit |
|---|---|---|---|
| An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically. | The project footprint falls within the Lowveld Ecoregion and within the Lowveld Group 10 (endangered) (NFEPA WetVeg). | **Plain:** An extensive area of low relief, characterised by relatively level, gently undulating or uniformly sloping land with a very gentle gradient that is not located within. | River: a linear landform with clearly discernible bed and banks, which are permanently or periodically carries a concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit. |

## 6.2 General Wetland Assessment Results

During the field assessment it was evident that the floodplain wetland is in a moderately degraded state due to the high levels of historical and current agricultural practices within the wetland system. It should be noted that the assessment was largely restricted to the portion of the Floodplain wetland and Pongola River in the immediate vicinity of the proposed road and bridge infrastructure, although cumulative impacts from the surroundings were also considered, where applicable.These areas are discussed in detail below. For the purposes of this investigation, a wetland and a riparian habitat are defined in the national water Act (1998) as stated below:

- A wetland is a land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.
- Riparian habitat is defined as including the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized 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.

The banks of the Pongola River where mainly associated with riparian habitat and included species such as *Ficus sycomorus* (Sycamore fig), *Trichilia emetica* (Natal mahogany), *Vachellia xanthophloea* (Fever Tree), *Sclerocarya birrea* (Maroela), *Vachellia kraussiana* (Scented-pod Thorn) and *Mangifera indica* (Mango) with  alien vegetation comprising mainly of *Lantana camara* (Tickberry), The remainder of the floodplain vegetation has been severely altered as a result of current and historic agricultural practices, and where mainly associated with agricultural crops such as *Zea* Mays (Corn), as well as alien vegetation associated with agricultural crop lands namely *Datura ferox* (Large thorn apple), *Tagetus minuta* (Tall khaki weed), *Argemone mexicana* (Yellow-flower Mexican poppy) and *Xanthium strumarium* (Large cocklebur). Although transformation of the wetland vegetation has occurred, the Pongola River is still considered to be of importance in terms of the provision of an ecological corridor through a largely transformed area. Furthermore, the system is likely to provide important ecosystem services and function and may provide the habitat to support an increased abundance of fish species. Being classified by the NFEPA database (2011) as a RAMSAR wetland as well as a WETFEPA with particular importance in being located within 500m of a threatened waterbird point locality, the wetland plays an important role in delivering ecosystem services, despite being in a moderately degraded condition.

**Figure 19: The Pongola River (left) and the cultivated crop lands associated with the floodplain wetland (right).**

## *6.3 Wetland Function Assessment*

The function and service provision of the floodplain wetland near the proposed bridge and road infrastructure was assessed based on Kotze *et. al*., (2009). The characteristics of the wetland were used to quantitatively determine the value, and by extension sensitivity, of the wetland. Each characteristic was scored to give the likelihood that the service is being provided.

The scores for each service were then averaged to give an overall score to each feature, presented in the table below. Scores for the various ecosystem services are graphically presented in the radar plot to follow.

**Table 21: Wetland functions and service provision.**

| Ecosystem service | Floodplain wetland |
|---|---|
| Flood attenuation | 1.7 |
| Streamflow regulation | 1.8 |
| Sediment trapping | 2.4 |
| Phosphate assimilation | 2.0 |
| Nitrate assimilation | 2.0 |
| Toxicant assimilation | 2.0 |
| Erosion control | 2.1 |
| Biodiversity maintenance | 1.9 |
| Carbon Storage | 1.7 |
| Water Supply | 3.3 |
| Harvestable resources | 3.4 |
| Cultivated foods | 3.6 |
| Cultural significance | 1.5 |
| Tourism and recreation | 1.1 |
| Education and research | 1.0 |
| **SUM** | **31.5** |
| **Average score** | **2.1** |

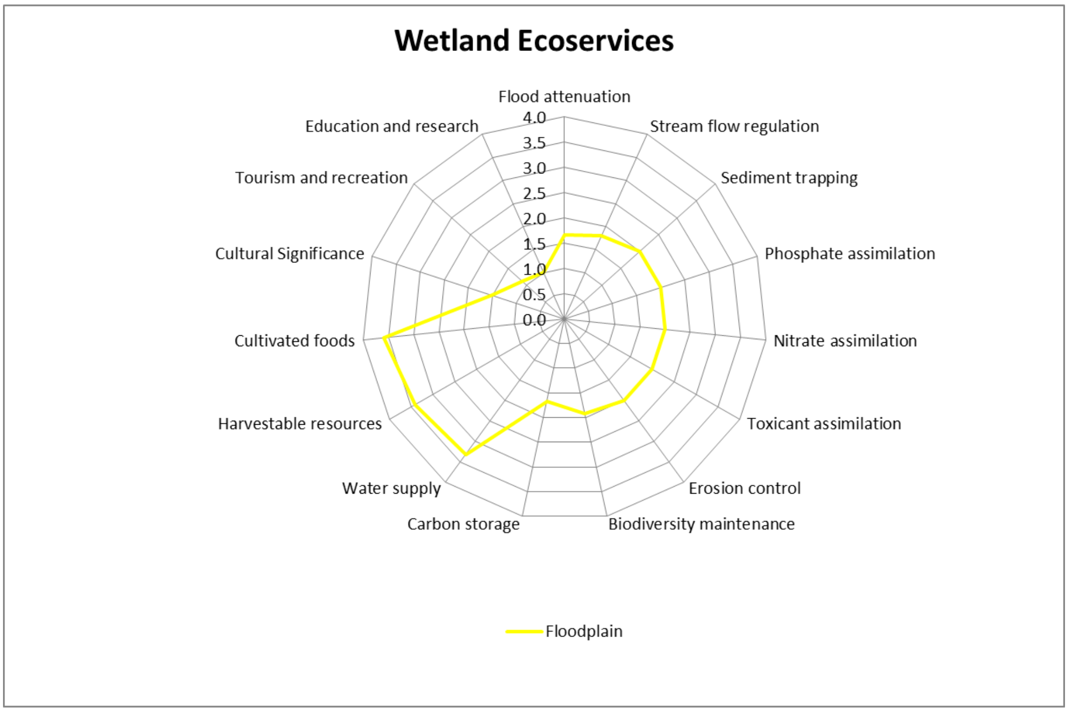


**Figure 20: Radar plot of wetland services provided by the features associated with the proposed bridge infrastructure.**

From the results of the assessment it is evident that the Floodplain wetland has a moderately high importance in terms of function and service provision. This is mainly due to the socio-cultural level of service provision being high, despite the ecological services being of intermediate levels.

In terms of ecological service provision, the wetland plays a moderately high role in sediment trapping and erosion control, although dams upstream affect its natural flow regime and sediment supply. However runoff intensity has likely increased as a result of agricultural practices within the catchment which may significantly reduce the features effectiveness in controlling erosion.

The significant disturbance of soils due to agricultural practices within the wetland, coupled with the absence of diverse indigenous obligate and facultative species is likely to reduce the wetlands ability to assimilate chemical substances. The wetland plays an intermediate role in biodiversity maintenance due to the significant level of disturbance that affected its hydrological regime and natural vegetation community assemblage.

During the field assessment it was evident that the wetland plays an important role in service provision for the local community, with specific emphasis on water-supply, harvestable resources and cultivated foods. The resource is widely used by the rural community for small scale agricultural practices. Loss of the floodplain wetland from the area would therefore be detrimental from a community perspective, and care should be taken during the construction of the bridge and associated road, to ensure stream continuity of the wetland feature is ensured, as well as to prevent unnecessary wetland damage due to poor management.

## *6.4 Wetland PES*

To assess the Present Ecological State (PES) of the Floodplain wetland the protocol "IHI for South African Rivers and channelled valley bottom wetland types*"* (Department of Water Affairs and Forestry Resource Quality Services, 2007) was used. The results for the criteria and attributes used for the calculation of the IHI are presented in the tables below.

**Table 22: PES as determined by the IHI for the Berg River.**

| OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE | | | | | |
|---|---|---|---|---|---|
| | Ranking | Weighting | Score | *Confidence Rating* | PES Category |
| **DRIVING PROCESSES:** | | **100** | **1.8** | | |
| Hydrology | 1 | 100 | 2.4 | *2.2* | **D** |
| Geomorphology | 2 | 80 | 1.5 | *3.4* | **C** |
| Water Quality | 3 | 30 | 0.2 | *1.7* | **A** |
| **WETLAND LANDUSE ACTIVITIES:** | | **80** | **2.2** | ***4.6*** | |
| Vegetation Alteration Score | 1 | 100 | 2.2 | *4.6* | **D** |
| Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)* | | | | | |
| **OVERALL SCORE:** | | | **2.0** | ***Confidence Rating*** | |
| | **PES %** | | **60.9** | | |
| | **PES Category** | | **C/D** | ***2.0*** | |

The present hydrological state of the Floodplain wetland calculated a score which falls within Category D (largely modified). The hydrological function of the wetland system has been significantly modified due to anthropogenic activities such as agricultural practices associated with the rural community and the upstream Jozini Dam. Without effective catchment management strategies the hydrological state is likely to deteriorate in the following years.

The present geomorphological state of the floodplain wetland calculated a score which falls within Category C (Moderately modified). Significant erosion and incision of the banks of the Pongola River as well as modification of the stream bed has occurred. In addition sediment trapping by dams upstream have changed the sediment balance of the Pongola River system.

The present vegetation state of the Berg River calculated a score which falls within Category D (moderately modified). Surrounding anthropogenic activity related to agricultural and rural development has resulted in the removal of indigenous species and the invasion by alien vegetation, most notably the understorey of the riparian zone.

The present water quality state of the Pongola River associated with the floodplain wetland calculated a score which falls within Category A (natural). Although the onsite water quality testing showing slightly elevated EC values from those expected under pristine conditions the general water quality conditions were considered to be largely natural.

The overall score for the wetland which aggregates the scores for the four modules, namely hydrology, geomorphology, water quality and vegetation, was calculated using the formula [1] as provided by the IHI methodology. The overall score calculated falls within the PES Category C/D (moderately to largely modified): A large loss of natural habitat, biota and basic ecosystem functions has occurred.

## 6.5 EIS Determination

The method used for the EIS determination was adapted from the method as provided by DWA (1999) for floodplains. The method takes into consideration PES scores obtained for IHI as well as function and service provision to enable the assessor to determine the most representative EIS Category for the wetland feature or group being assessed. A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. In addition, the confidence of scores is indicated within the table below (Conf), where 0 indicates a very low confidence and 4 indicates a high confidence. The average of the determinants is used to assign the EIS Category as listed in Table 23 below.

From the results it is evident that the Floodplain wetland has an EIS falling within Category C (moderate sensitivity).

**Table 23: EIS determination.**

| Determinant | Floodplain | |
|---|---|---|
| | Score | Conf |
| **PRIMARY DETERMINANTS** | | |
| 1. Rare & Endangered Species | 1 | 2 |
| 2. Populations of Unique Species | 1 | 3 |
| 3. Species/taxon Richness | 2 | 4 |
| 4. Diversity of Habitat Types or Features | 2 | 4 |
| 5 Migration route/breeding and feeding site for wetland species | 2 | 2 |
| 6. PES as determined by IHI / Wet-health assessment | 2 | 4 |
| 7. Importance in terms of function and service provision | 3 | 4 |
| **MODIFYING DETERMINANTS** | | |
| 8. Protected Status according to NFEPA Wetveg | 3 | 4 |
| 9. Ecological Integrity | 2 | 4 |
| TOTAL | 18 | |
| AVERAGE | 2.0 | |
| **OVERALL EIS** | **C** | |

[1] ((Hydrology score) x 3 + (geomorphology score) x2 + (vegetation score) x 2))/ 7 = PES

The following key aspects were considered for the rating of each determinant:

- No rare or endangered species were encountered within the floodplain wetland;
- The PES calculated for the wetland was low due to the significant hydrological transformation that has taken place;
- The Lowveld Group 10 wetland vegetation type is listed as endangered; and
- The ecological integrity of the wetland was considered to be low.

## 6.6 Recommended Ecological Category

Based on the findings of the assessment it is evident that the floodplain wetland are degraded to a significant degree with a moderate EIS value. Due to the significance of impacts already present within the wetland and due to the disturbance and transformation of the surrounding catchment area, it is doubtful that the PES of the features can be significantly increased without an extensive rehabilitation plan. It is therefore deemed important that the PES (C/D) category of the floodplain wetland and the river itself be maintained and that additional disturbance due to the proposed development be avoided, managed and mitigated. Taking into consideration the PES and EIS values obtained for the wetland feature, the appropriate REC of the floodplain wetland should be a Class C.

## 6.7 Wetland Delineation

The wetlands were delineated according to the guidelines advocated by DWA (2005). The wetland delineation as presented in this report is regarded as a best estimate of the wetland boundaries based on the site conditions present at the time of assessment.

*During the assessment, the following indicators were used in order to determine the wetland boundaries:*

- Terrain units were used to determine in which parts of the landscape the wetland feature was most likely to occur ;
- Surface water was used as a secondary indicator for the wetland boundary;
- For the soil form indicator, the presence of gleyed soils (most of the iron has been leached out of the soil leading to a low chroma greyish/greenish/bluish colour) and mottling (created by a fluctuating water table) were investigated. Sparse mottling of the soil was noted within the first 50cm of the soil layer at various augering points of the floodplain wetland and could be used as an indicator of its temporary zone boundary;
- Vegetation could not be used as an indicator along the majority of the wetland boundaries assessed due to the proliferation of alien invasive species.

## 6.8 Buffer Allocation

For biodiversity protection a buffer between 10 and 25 metres for wetlands with minimal wildlife habitat functions and adjacent low intensity land uses is recommended; 20 to 50 metres for wetlands with moderate habitat functions or adjacent high intensity land uses; and 50 and up to 200 metres to wetlands with high habitat functions (DWA 2013). The entire proposed development will take place within the wetland area however a 32m buffer has been indicated in the figure below for illustrative purposes.

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**Figure 21: Riparian zone delineation of the area immediately surrounding the proposed bridge infrastructure site.**

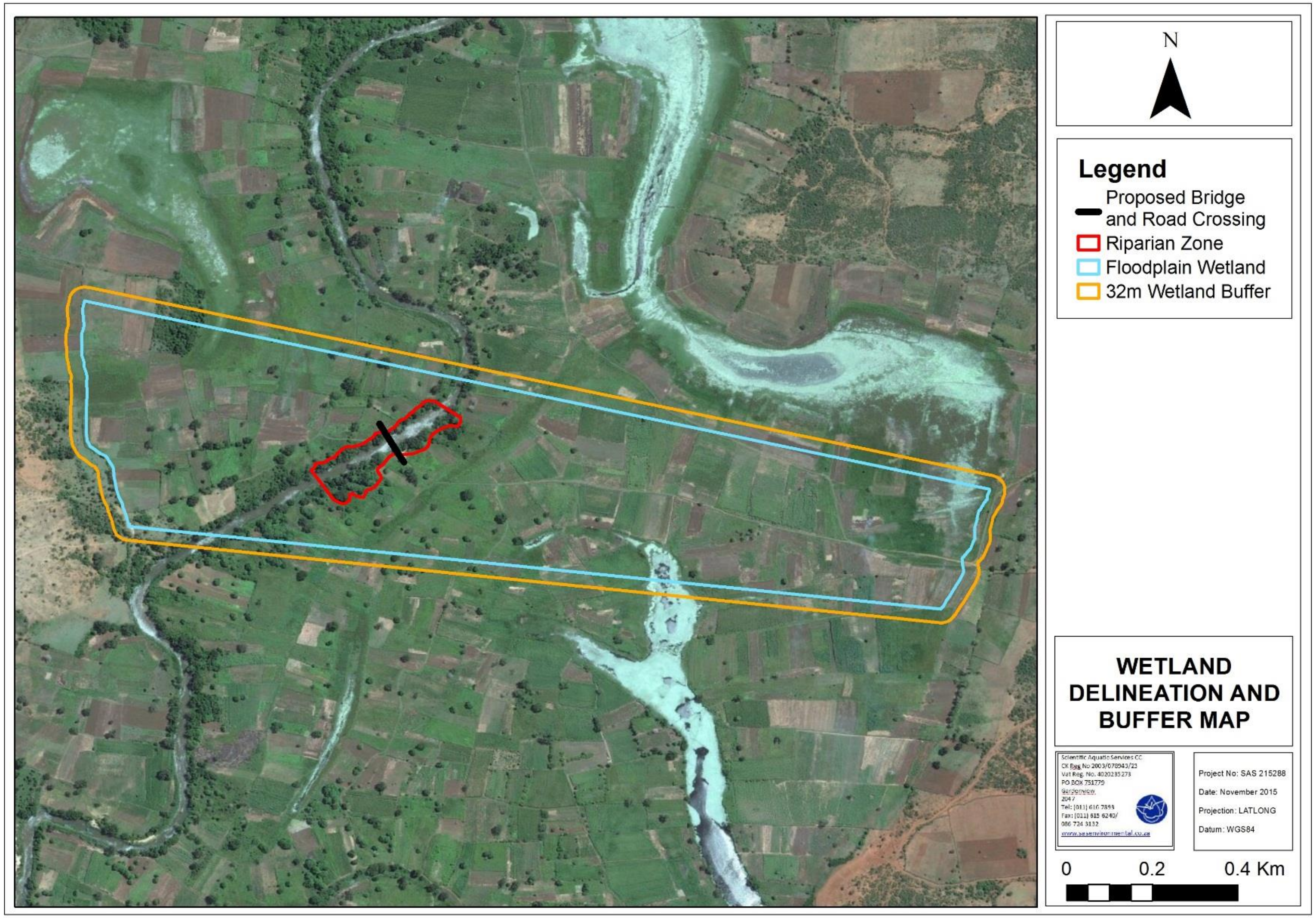


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**Figure 22: Wetland delineations with 32m buffers.**

# 7. IMPACT ASSESSMENT

The impact assessment was undertaken on all aspects of aquatic ecology deemed likely to be affected by the proposed river crossing development. The sections below present the results of the findings for the primary potential impacts identified:

- Impact on instream flow and hydrological function;
- Changes to instream habitat;
- Impacts on instream biota;
- Loss of wetland habitat and ecological structure;
- Changes to ecological and socio-cultural service provision; and
- Impacts on wetland hydrological function and sediment balance.

These potential impacts are considered to potentially have a high to moderate negative effect on the aquatic resources. Mitigation measures will, however, further limit these impacts to a lower impact status, provided all mitigation measures, and especially the instream flow requirements developed as part of the desktop reserve determination, are adhered to.

The significance of the potential impacts was assessed separately for the pre-construction, construction, operational phases. No decommissioning phase is deemed applicable to this the project.

## *7.1 Aquatic Impact Assessment*

### 7.1.1 Impact 1: Impact on instream flow and hydrological function

**Activities and aspects potentially leading to impact**

| Pre-Construction | Construction | Operational |
|---|---|---|
| Poor planning of the construction methods could lead to severe impacts on the system during the construction phase of the development. | Vehicles and equipment accessing area through riparian area and area of natural bankside vegetation leading to altered streamflow patterns with special mention of the creation of turbulent flow and the concentration of flow as well as localised changes to habitat types and abundance and cover availability and types. | Incorrect rehabilitation and reshaping of the stream bed and banks in areas of disturbance leading to ongoing deterioration of stream banks leading to altered streamflow patterns with special mention of the creation of turbulent flow and the concentration of flow as well as potential upstream inundation and ponding. |
| Poor design could potentially lead to impacts on instream flow patterns during the operational phase of the crossing. Based on the crossing designs, as evidenced | Construction of any stream diversions, coffer dams and temporary crossings for construction vehicles leading to upstream ponding and inundation for the duration of construction and | Altered structure of riparian habitat and riparian vegetation assemblages due to altered hydrology and ongoing erosion. |

| | | |
|---|---|---|
| on the existing, this is deemed a definite impact as the proposed bridge structures includes two piers to be located within the active channel. | creation of turbulent flow and the concentration of flow downstream of the crossing. | |
| - | Construction activities will lead to sedimentation and the alteration of instream habitat and the smothering of benthos. | Latent impacts due to inadequate design leading to degrading instream habitat and cover as well as migratory connectivity and riparian habitat and vegetation structures. |
| - | Incorrect rehabilitation and reshaping of the stream bed and banks in areas of disturbance. Inadequate removal of waste construction material from the stream bed. | Proliferation of alien vegetation leading to altered habitat for indigenous riparian fauna and flora. |
| - | Construction activities may lead to altered stream connectivity which in turn can affect fish migration. | Water quality impacts from chemical, cement and fuel spills. |
| - | Construction activity will affect riparian soils and habitats which in turn will affect riparian vegetation cover and assemblage. | |

### Impact assessment: Impact on instream flow and hydrological function

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -2 | -1 | -1 | -2 | -6 Negative low |
| Construction phase | -4 | -2 | -1 | -2 | -9 Negative moderate |
| Operational Phase | -4 | -3 | -4 | -3 | -14 Negative very high |

**Essential mitigation measures in the construction phase:**

- The pier structure must be designed in such a way as to ensure that turbulent flow is minimised to prevent downstream erosion and scour through the use of streamlined support column shapes;
- The foundations of the pier must ensure that no changes to stream flow direction occur and that minimisation of turbulent flow, erosion and scour is ensured.All crossing construction should be undertaken in the low flow season and must be completed within 6 months;
- The duration of construction works needs to be kept to the absolute minimum and all project planning must be very well orchestrated to reach this goal;
- The construction infrastructure and coffer dams and stream diversions must at no time lead to upstream ponding and inundation or lead to the constriction of flow and downstream erosion;
- Minimise disturbance of instream and bankside areas and minimise activities in these areas;
- As far as possible keep all instream areas and stream banks off limits to general activity during the construction phase;
- Any construction-related waste must not be placed in the vicinity of any riparian areas;
- Ensure that on-site camp fires are forbidden;
- Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing;
- During construction, drift fences constructed from hessian sheets should be installed at erodible areas to minimise erosion. Silt traps should also be provided to remove sand/silt particles from runoff;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise environmental damage;
- Riparian areas that may have been disturbed during construction should be rehabilitated through reprofiling and revegetation upon completion of the construction phase;

**Recommended mitigation measures for the construction phase**

- Desilt all riparian areas affected by construction activities;
- Reprofiling of the banks of disturbed drainage areas to a maximum gradient of 1:3 to ensure bank stability if necessary;
- Reinforce banks and drainage features where necessary with gabions, reno mattresses and geotextiles;

**Essential mitigation measures in the operational phase:**

- Sheet runoff from access roads and the final road structure needs to be curtailed and slowed down by the strategic placement of energy dissipation structures;
- Adequate stormwater management must be incorporated into the design of the proposed structure in order to prevent erosion and the associated sedimentation of the system for the life of the structure; and
- As far as possible, all construction activities should occur in the low flow season, during the drier summer months;
- Ongoing aquatic biomonitoring on a minimum of a quarterly basis must take place from 6 months prior to construction till 1 year after construction to determine trends in ecology and define any impacts requiring mitigation.

**Recommended mitigation measures for the operational phase**

- During the operational phase an annual assessment should be undertaken to determine if any excessive erosion of the structure is occurring. Photographic records should be maintained and any necessary maintenance and rehabilitation implemented.

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -1 | -1 | -1 | -1 | -4 Negative low |
| Construction phase | -2 | -1 | -1 | -2 | -6 Negative low |
| Operational Phase | -3 | -2 | -3 | -1 | -9 Negative moderate |

**Probable latent impacts**

- Localised erosion (not significant);
- Localised changes to instream and riparian habitat (not significant);
- Localised sedimentation of the system may lead to altered instream habitat (potentially significant);
- Some changes to the hydrology of the system may occur altering instream habitats on a localised scale (not significant).

### 7.1.2 Impact 2: Changes to instream habitat

#### Activities and aspects leading to impact

| Pre-Construction | Construction | Operational |
|---|---|---|
| Poor planning leading to an increased footprint in the vicinity of the active stream channel leading to excessive alteration of the instream habitat | Direct impact on instream habitat and the associated impact on instream biota due to construction activity | Ongoing erosion of the stream channel and potential incision of the river system |
| Poor planning leading to an ongoing erosion and altered instream habitats | Earthworks in the vicinity of the channel leading removal of riparian vegetation and the disturbance of soils to increased runoff and erosion and altered runoff patterns | Sedimentation due to erosion from the activities associated with the development |
| Inadequate planning of rehabilitation leading to permanent impacts on instream habitat | Construction activities and disturbances leading to altered stream substrate and flows leading to altered flow and depth cover classes | Ineffective rehabilitation may lead to instream habitat transformation leading to lower abilities to support aquatic biota |
| - | Construction activities with special mention of temporary access roads leading to inundated areas upstream of the bridge and ponding | Altered riparian vegetation and instream community structures |
| - | Dumping of construction material within or near the channel and the compaction of riparian soils | Loss of stream connectivity and migratory connectivity |

| Pre-Construction | Construction | Operational |
|---|---|---|
| - | Potential contamination of soil and water from the fuel of construction vehicles | Contamination of water and sediment within the channel resulting in algal proliferation if any road users spill hazardous materials in the vicinity of the river crossing |
| - | - | Ongoing disturbance as a result of maintenance activities in the road reserve leading to altered riparian vegetation community structures |

## Impact assessment: Changes to instream habitat

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -3 | -2 | -3 | -2 | -10 Negative high |
| Construction phase | -4 | -1 | -2 | -3 | -10 Negative high |
| Operational Phase | -4 | -1 | -3 | -3 | -11 Negative high |

**Essential mitigation measures for construction phase:**

- Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing;
- As far as possible, all construction activities should occur in the low flow season, during the drier winter months;
- All waste rock and other construction material should be removed from the stream bed and banks upon completion of construction;
- Please refer to the mitigation measures presented in impact 1 above.

**Recommended mitigation measures**

- Implement an alien vegetation control program within riparian areas (as above);
- All sharp edged rocks and material should be removed from the stream bed and banks;
- Please refer to the mitigation measures presented in impact 1 above.

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -1 | -1 | -1 | -1 | -4 Negative low |
| Construction phase | -2 | -1 | -1 | -2 | -6 Negative low |
| Operational Phase | -3 | -1 | -4 | -1 | -9 Negative moderate |

- Localised changes to instream and riparian habitat (not significant);
- Some localised changes to aquatic and riparian zone community assemblages (not significant).

### 7.1.3 Impact 3: Impacts on instream biota

#### Activities leading to impact

| Pre-Construction | Construction | Operational |
|---|---|---|
| Poor planning leading to an increased footprint in the vicinity the active stream channel and thereby increasing the loss of aquatic biota and their associated habitat | Direct impact on instream habitat and the associated impact on instream biota | Ongoing erosion of the stream channel and potential incision of the river system leading to reduced instream and riparian community diversity, abundance and structure with special mention of more sensitive taxa |
| Poor planning leading to potential impacts on migratory movement of more mobile aquatic taxa | reduced instream and riparian community diversity, abundance and structure with special mention of more sensitive taxa | Capturing of biota from the system with special mention of fish due to increased accessibility of the area |
| - | Capturing of biota from the system with special mention of fish by construction personnel. | An impact on migratory fish species due to possible impacts on instream flow and connectivity |
| - | An impact on migratory fish species due to temporary structures affecting stream connectivity | Ongoing disturbance as a result of maintenance activities in the road reserve leading to altered riparian vegetation community structures |
| - | Sedimentation leading to the smothering of benthos and their associated habitat | - |

#### Impact assessment: Aquatic biodiversity

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -2 | -1 | -3 | -2 | -8<br>Negative moderate |
| Construction phase | -4 | -3 | -1 | -2 | -10<br>Negative high |
| Operational Phase | -4 | -2 | -4 | -2 | -12<br>Negative high |

**Essential mitigation measures for construction phase:**

- Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing;
- As far as possible, all construction activities should occur in the low flow season, during the drier winter months;
- It must be ensured that migratory connectivity and stream continuity is maintained throughout the construction phase of the project;
- Ongoing aquatic biomonitoring commencing at least 6 months before construction and for at least year after construction is to take place to monitor the impacts on aquatic biota and in order to allow the identification of required impact minimisation measures for each system;
- Please refer to the mitigation measures presented in impact 1 and 2 above for recommendations pertaining to hydrological and habitat management controls which will minimise the impact on biota.

**Recommended mitigation measures**

- Implement an alien vegetation control program within riparian areas;
- All sharp edged rocks and material should be removed from the stream bed and banks;
- Please refer to the mitigation measures presented in impact 1 and 2 above.

**Essential mitigation measures for operational phase:**

- It must be ensured that migratory connectivity and stream continuity is maintained throughout the construction phase of the project;
- Removal of alien vegetation and good housekeeping within the road reserve must take place at all times;

- Any spills by maintenance teams or road users should be cleaned up immediately and all work overseen by a suitably qualified professional.

**Recommended mitigation measures**

NA

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -1 | -1 | -2 | -1 | -5 Negative low |
| Construction phase | -2 | -2 | -1 | -1 | -6 Negative low |
| Operational Phase | -3 | -1 | -3 | -1 | -8 Negative moderate |

**Probable latent impacts**

- Localised changes to instream and riparian habitat and cover types (not significant);
- Some localised changes to aquatic and riparian zone community assemblages (not significant).

## 7.2 Wetland Impact Assessment

### 7.2.1 Impact 1: Loss of Wetland Habitat and Ecological Structure

**Activities and aspects leading to impact**

| Pre-Construction | Construction | Operational |
|---|---|---|
| Planning of infrastructure within wetland areas, such as the tailings dam | Site clearing and the removal of vegetation leading to increased runoff and erosion | Ongoing disturbance of soils with general operational activities |
| Inadequate design of infrastructure leading to risks of pollution | Site clearing and the disturbance of soils leading to increased erosion | Erosion and sedimentation of wetlands leading to loss of wetland habitat |
| Inadequate design of infrastructure leading to changes to wetland habitat | Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns | Sedimentation and incision leading to altered habitats |
| | Construction of stream crossings altering stream and base flow patterns and water velocities | Loss of wetland floral biodiversity |
| | Topsoil stockpiling adjacent to wetlands and runoff from stockpiles | |
| | Movement of construction vehicles within wetlands | |
| | Dumping of hazardous and non-hazardous waste into the wetland areas | |
| | Waste material spills and waste refuse deposits into the wetland features | |
| | Site clearing and the disturbance of soil | |
| | Inadequate management of edge effects during construction | |

### Impact assessment: Loss of Wetland Habitat and Ecological Structure

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Construction phase | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Operational Phase | -2 | -1 | -1 | -2 | -6 Negative Low |

**Essential mitigation measures during the construction phase**

- Create permanent roadside swales in places where runoff from the roads is not collected in a stormwater system to allow it to be biologically cleansed prior to seeping into wetland areas;
- Incorporate adequate erosion and stormwater management measures in order to prevent erosion and the associated sedimentation of the wetland areas. Management measures may include berms, silt fences, hessian curtains, stormwater diversion away from areas susceptible to erosion and stormwater attenuation. Care should however be taken so as to avoid additional disturbance during the implementation of these measures In this regard specific attention should be given to the attenuation of stormwater in order to prevent erosion;
- Maintain habitat connectivity, especially where the road crosses wetlands;
- Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the wetland crossing;
- Construct underpasses so that they are sufficiently high to allow for the movement of local fauna and sufficiently wide to include a buffer along the margins of the wetland habitat;
- Avoid culverts and drainage features that have vertical walls that create a pit or narrow pipes; and
- Rescue and relocate amphibian species to nearby wetland areas, if encountered.

**Recommended mitigation measures**

- Restrict construction to the drier winter months, if possible, to avoid erosion of exposed soils and sedimentation of wetland habitats associated with the project footprint.

**Essential mitigation measures during the operational phase**

- Limit mowing in the road reserve to areas where sight distance is impeded by vegetation in the road reserve. Leave the remainder of the vegetation untouched with special mention of vegetation associated with wetland areas;
- Maintain vegetation in the road reserve where possible to intercept polluting particles such as dust emanating from the road during operation;
- Control road maintenance teams operating along the route to ensure environmental damage is limited with special mention of damage to wetland areas falling outside of the road reserve; and
- Clear alien and invasive species from the road reserve for at least 1 years following the completion of the project. Appoint a specialist contractor for this task;
- Rehabilitate disturbed areas including areas where alien vegetation was removed with local indigenous species.

**Recommended mitigation measures**

- N/A

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -2 | -2 | -1 | -1 | -6 Negative Low |
| Construction phase | -2 | -2 | -1 | -1 | -6 Negative Low |
| Operational Phase | -2 | -2 | -1 | -1 | -6 Negative Low |

**Cumulative impacts**

- Alien vegetation proliferation

### 7.2.2 Impact 2: Changes to wetland ecological and socio-cultural service provision

**Activities and aspects leading to impact**

| Pre-Construction | Construction | Operational |
|---|---|---|
| Poor planning leading to the placement of infrastructure within wetland areas | Site clearing and the removal of vegetation leading to increased runoff and erosion | Ongoing disturbance of soils with general operational activities |
| Inadequate design of infrastructure leading to risks of pollution | Site clearing and the disturbance of soils leading to increased erosion | Dumping of hazardous and non-hazardous waste into the wetland areas |
| Inadequate design of infrastructure leading changes to wetland habitat | Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns | Erosion and sedimentation of wetlands leading to loss of wetland habitat |
| Sedimentation of the wetland feature | Construction of stream crossings altering stream and base flow patterns and water velocities | Inadequate removal of alien vegetation |
| Indiscriminate movement of construction vehicles and personnel outside demarcated construction areas | Topsoil stockpiling and runoff from stockpiles may affect adjacent wetlands | Indiscriminate movement of operational vehicles and personnel |
| Spills and leaks from construction vehicles | Movement of construction vehicles within adjacent wetlands | |
| Inadequate management of edge effects during construction | Dumping of hazardous and non-hazardous waste into the wetland areas | |
| Dust generation | Waste material spills and waste refuse deposits into the wetland features | |
| - | Alien vegetation encroachment | |

**Impact assessment: Changes to wetland ecological and socio-cultural service provision**

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Construction phase | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Operational Phase | -3 | -1 | -1 | -2 | -7 Negative Moderate |

**Essential mitigation measures during the construction phase:**

- Ensure that all areas containing hazardous waste are bunded to ensure that no oil or other waste material contaminate the soils, groundwater or surface water of surrounding wetlands;
- Incorporate adequate erosion and stormwater management measures in order to prevent erosion and the associated sedimentation of the wetland areas. Management measures may include berms, silt fences, hessian curtains, stormwater diversion away from areas susceptible to erosion and stormwater attenuation. Care should however be taken so as to avoid additional disturbance during the implementation of these measures In this regard specific attention should be given to the attenuation of stormwater in order to prevent erosion;

- Carry out all servicing and refuelling of construction vehicles on a concrete platform with runoff traps and containment. If refuelling takes place in the field use drip trays at all times;
- Treat contaminated soils with appropriate product; and
- Remove and appropriately dispose of any contaminated soil and water to a designated dump site as rapidly as possible following contamination.

**Recommended mitigation measures during the construction phase:**

- Restrict activities to winter months in order to limit impact from sedimentation and erosion;
- Implement a Pongola River alien vegetation control plan in association with the neighbouring farmers in order to curb their proliferation

**Essential mitigation measures during the operational phase:**

- Limit mowing in the road reserve to areas where sight distance is impeded by vegetation in the road reserve. Leave the remainder of the vegetation untouched with special mention of vegetation associated with wetland areas; and
- Maintain vegetation in the road reserve where possible to intercept polluting particles such as dust emanating from the road during operation.

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -2 | -2 | -1 | -1 | -6 Negative Low |
| Construction phase | -3 | -2 | -1 | -1 | -7 Negative Moderate |
| Operational Phase | -2 | -2 | -1 | -1 | -6 Negative Low |

**Cumulative impacts**

- NA

### 7.2.3 Impact 3: Impacts on wetland hydrological function and sediment balance

**Construction Phase**

**Activities and aspects leading to impact**

| Pre-Construction | Construction | Operational |
|---|---|---|
| Poor planning leading to the placement of infrastructure within wetland areas | Site clearing and the removal of vegetation leading to increased runoff and erosion | Ongoing disturbance of soils with general operational activities |
| Inadequate design of infrastructure leading to risks of pollution | Site clearing and the disturbance of soils leading to increased erosion | Dumping of hazardous and non-hazardous waste into the wetland areas |
| Inadequate design of infrastructure leading changes to wetland habitat | Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns | Erosion and sedimentation of wetlands leading to loss of wetland habitat |
| Lack of erosion management strategies leading to sedimentation | Construction of stream crossings altering stream and base flow patterns and water velocities | Alien and invasive vegetation maintenance |
| | Topsoil stockpiling and runoff from stockpiles may affect adjacent wetlands | |
| | Movement of construction vehicles within adjacent wetlands | |

| Pre-Construction | Construction | Operational |
|---|---|---|
| | Dumping of hazardous and non-hazardous waste into the wetland areas | |
| | Waste material spills and waste refuse deposits into the wetland features | |

### Impact assessment: Impacts on wetland hydrological function and sediment balance

| Without Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Construction phase | -3 | -2 | -1 | -3 | -9 Negative Moderate |
| Operational Phase | -3 | -2 | -1 | -2 | -6 Negative Low |

**Essential mitigation measures during the construction phase:**

- Ensure that hydraulic connectivity of the wetland areas is maintained between the areas upstream and downstream of the crossing;
- During construction, drift fences constructed from hessian sheets should be installed at erodible areas to minimise erosion. Silt traps should also be provided to remove sand/silt particles from runoff;
- The bridge crossing design must ensure that the soils in the Pongola River remain inundated with water after heavy rainfall events. In order to achieve this the following should be implemented:
  - The pioneer layer should be constructed out of a porous material or from material which is coarse enough to assist with the movement of water through the structure to allow wetting of the soils to occur on the downstream side of the crossing and prevent excessive upstream inundation;
  - The extent to which culverts are used in the system should reach as far as possible to ensure that during freshets the broadest possible area becomes inundated allowing for recharge of the wetland soils across the width of the wetland;
  - The design should ensure that the permanent wetland zone should have inundated soil conditions throughout the year extending to the soil surface;
  - The design should ensure that the seasonal wetland zone should have water logged soils within 300mm of the soil surface for at least the high flow season (November to January);
  - Temporary wetland zone areas should have waterlogged soil conditions occurring to within 300m of the land surface during the wettest part of the summer season;
  - Ensure that no incision and canalisation of the Pongola River takes place as a result of the construction of the bridge:
  - The crossing structure must allow for sufficient dispersion of water through the wetland area to prevent the concentration of flow in the permanent zone or the active channel which could lead to scouring and incision of the system.
- The following key design criteria should be considered for the instream piers:
  - The pier structures must be designed in such a way as to ensure that turbulent flow is minimised through the use of streamlined support column shapes;
  - The foundations of the piers must ensure that no changes to stream flow direction occur and that minimisation of turbulent flow is ensured.
  - The bridge should cross the river at a 90 degree angle to minimise the damage to the riparian area.
- Use of culverts should be made in the area between the active channel bank and to the edge of the macro-channel bank or 1:100 year floodline, whichever is the greater to ensure that the hydraulic function of the system is maintained and to ensure that wetting frequencies and patterns are maintained in the pre-development condition;
- Culvert and bridge design must ensure that no upstream ponding and no downstream erosion and scouring occur;
- Culvert and bridge design must ensure that no hindrance to terrestrial, wetland/riparian and aquatic fauna occurs;
- All areas where soils are exposed or destabilised need to be stabilised taking into account the following:

- o As far as possible soft engineering and earthworks should be used, with special mention of resloping of banks, revegetation of banks and stabilisation using products such as hessian sheets and socks;
- o Hard engineering techniques should only be implemented in areas where engineering and hydraulic constraints require such interventions. In particular mention is made of gabions, reno mattresses and reinforced walls.
- Incorporate adequate erosion and stormwater management measures in order to prevent erosion and the associated sedimentation of the wetland areas. Management measures may include berms, silt fences, hessian curtains, stormwater diversion away from areas susceptible to erosion and stormwater attenuation. Care should however be taken so as to avoid additional disturbance during the implementation of these measures. In this regard, specific attention should be given to the attenuation of stormwater in order to prevent erosion;
- Sheet runoff from cleared areas and access roads must be curtailed;
- Any discharge of runoff into wetland features must be done in such a way as to prevent erosion. In this regard, special mention is made of the use of energy dissipating structures in stormwater discharge.

**Recommended mitigation measures during the construction phase:**

- Restrict activities to winter months in order to limit impact from sedimentation and erosion.

**Essential mitigation measures during the operational phase:**

- Control road maintenance teams operating along the route to ensure environmental damage is limited with special mention of damage to wetland areas falling outside of the road reserve;
- Implement an alien vegetation control plan in association with the neighbouring farmers in order to curb their proliferation;
- Rehabilitate the disturbed riparian zone in the vicinity of the project footprint with local indigenous riparian species to ensure the sediment balance of the Pongola River system.

**Recommended mitigation measures during the operational phase:**

- During the operational phase an annual assessment should be undertaken to determine if any excessive erosion is occurring. Photographic records should be maintained and any necessary maintenance and rehabilitation implemented.

| With Management | Probability | Extent | Duration | Intensity | Significance |
|---|---|---|---|---|---|
| Pre-construction | -2 | -1 | -1 | -2 | -6 Negative Low |
| Construction phase | -2 | -2 | -1 | -2 | -7 Negative Moderate |
| Operational Phase | -2 | -2 | -1 | -1 | -6 Negative Low |

**Cumulative impacts**

- N/A

## 7.3 No Go Alternative

The proposed bridge infrastructure is located within an area where extensive agriculture has resulted in loss of indigenous vegetation communities as well as wetland habitat. Therefore, very little intact terrestrial or wetland vegetation presently occurs within the project footprint.

## 7.4 Cumulative Impacts

Rivers and wetlands within the region are under continued threat due to ongoing agricultural activities. The loss of wetland habitat associated with the proposed bridge infrastructure may therefore add to the cumulative effect on the loss of riparian and wetland areas within the region. However, the majority of the wetland habitat associated with the project footprint is considered to be in a significantly disturbed and transformed state and is therefore not likely to add to the conservation of intact wetland habitat in the region.

All vegetation associated with the project footprint has been significantly transformed and is no longer considered representative of the Lowveld Group 10 wetland vegetation type. The vegetation is therefore not likely to add to the conservation target of this vegetation type in the region and its loss from the project footprint is therefore not considered to contribute to any cumulative impacts.

Cumulative impacts on the Pongola River are significant with impacts from agriculture in the floodplain and the upstream Jozini dam. In addition, other bridge crossings in the area also occur. If the proposed bridge crossing development is undertaken in such a way as to ensure an ecologically sensitive design and ecologically sensitive implementation and construction management the risk of significant additional impact to the system is limited.

# 8 CONCLUSION

The following table and associated summary provides the key findings of the study:

**AQUATIC ASSESSMENT**

**Table 24: Summary of aquatic assessment results for the Mboza 1 site as assessed in October 2015**

| Variable | | Site |
|---|---|---|
| | | Mboza 1 |
| VEGRAI | | D |
| IHIA | | C |
| IHAS | | Inadequate |
| SASS5 score | Dickens and Graham (2001) | D |
| | Dallas (2007) | C |
| MIRAI | | D |
| FRAI | | F |
| * Dallas (2007) classification more sensitive to ASPT score. Dickens and Graham (2001) classification considered to be more representative of conditions at the time of assessment. | | |

Based on the findings of this study it is evident that the conditions at the time of assessment are in agreement with the desktop assessment results.

Prior to any impact from the proposed river crossing construction, the system is already significantly impacted upon. Impacts include agricultural run-off and return water flow with associated water quality impact, flow related impacts from the upstream impoundment, vegetation removal and use of the riverine resource by the local population.
Potential impacts identified included impact on instream flow and hydrological function, changes to instream habitat and Impacts on instream biota.

**Table 25: Summary of aquatic impact significance on the Pongola River**

| Pre-Construction phase | | |
|---|---|---|
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative low | Negative low |
| 2: Changes to instream habitat | Negative high | Negative low |
| 3: Impacts on instream biota | Negative moderate | Negative low |
| **Construction phase** | | |
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative moderate | Negative low |
| 2: Changes to instream habitat | Negative high | Negative low |
| 3: Impacts on instream biota | Negative high | Negative low |
| **Operational phase** | | |
| **Impact** | **Unmanaged** | **Managed** |
| 1: Impact on instream flow and hydrological function | Negative very high | Negative moderate |
| 2: Changes to instream habitat | Negative high | Negative moderate |
| 3: Impacts on instream biota | Negative high | Negative moderate |

Therefore, on this basis, should the project proceed it may potentially have an ecological impact of high significance both within and potentially beyond the boundaries of the project if mitigation is not applied. With mitigation, the impact can be limited to a low-level significance impact of low to moderate severity with limited spatial impact. However, due to the duration of the activity, the impact is expected to remain at moderate levels during the operational phase, whilst it can be reduced to low levels during the planning and construction phases.

The objective of this study was to provide sufficient information on the ecology of the area, together with other studies on the physical and socio-cultural environment, in order for the Environmental Assessment Practitioner (EAP) and the relevant authorities to apply the principles of Integrated Environmental Management (IEM) and the concept of sustainable development. The needs for conservation as well as the risks to other spheres of the physical and socio-cultural environment need to be compared and considered, along with the need to ensure economic development of the country.

It is the opinion of the ecologists that this study provides the relevant information required in order to implement IEM and to ensure that the best long term use of the resources on the subject property will be made in support of the principle of sustainable development.

**WETLAND ASSESSMENT**

The following general conclusions were drawn on completion of the wetland assessment:

- Using the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, et. al. 2013), the entire system was classified as a floodplain wetland;
- The wetland is registered as a RAMSAR wetland;
- The floodplain wetland has a moderately high importance in terms of function and service provision. Although transformation of the wetland vegetation has occurred, the wetland is considered to be of high importance from a socio- cultural service provision perspective;
- The floodplain wetland has an EIS falling within Category C (moderate sensitivity);
- The Present Ecological State (PES) of the wetland features was determined using the Integrated Habitat Integrity (IHI) methodology. The overall PES score calculated for the floodplain wetland fall within Category C/D (moderately to largely modified);
- Taking into consideration the PES and EIS values obtained for the wetland feature, the appropriate REC of the floodplain wetland should be a Class C; and

The table below serves to summarise the significance of perceived impacts on the wetland biodiversity associated with the proposed bridge infrastructure.

**Table 26: Summary of impact assessment results.**

| Impact | Phase | Unmanaged | Managed |
|---|---|---|---|
| Loss of wetland habitat and ecological structure | Pre-construction | Negative Moderate | Negative Low |
| | Construction | Negative Moderate | Negative Low |
| | Operation | Negative Low | Negative |
| Changes to wetland ecological and socio-cultural service provision | Pre-construction | Negative Moderate | Negative Low |
| | Construction | Negative Moderate | Negative Moderate |
| | Operation | Negative Moderate | Negative Low |
| Impacts on wetland hydrological function and sediment balance | Pre-construction | Negative Moderate | Negative Low |
| | Construction | Negative Moderate | Negative Moderate |
| | Operation | Negative Low | Negative Low |

It is the opinion of the wetland ecologists that the proposed development activities will have a Negative moderate to Negative low impact on the wetland resources, specifically with regards to impacts on hydrology and sedimentation of the Pongola River floodplain, if mitigation measures are not adhered to. Provided that the management and maintenance recommendations as provided in the impact assessment of this report are strictly adhered to, impacts on the wetland features are likely to Negative low to Negative moderate impacts.

After conclusion of the freshwater assessment, it is the opinion of the ecologists that the proposed development activities be considered favourably, provided that the management and monitoring recommendations as provided in the impact assessment of this report are strictly adhered to.

# 9 REFERENCES

Bromilow, C. 2001. Revised Edition, First Impression. Problem Plants of South Africa. Briza Publications, Pretoria, RSA.

Chutter, F. M. 1998. Research on the rapid biological assessment of water quality impacts in streams and rivers. Report to the water research commission by Environmentek, CSIR, WRC report No 422/1/98. Pretoria: Government printer.

Dallas, H.F. 1997. A preliminary evaluation of aspects of SASS (South African Scoring System) for the rapid bioassessment of water in rivers with particular reference to the incorporation of SASS in a national biomonitoring programme*. South African Journal of Aquatic Science*, 23: 79-94.

Dallas, H.F. 2007. River Health Programme: South African Scoring System (SASS) data interpretation guidelines. The Freshwater Consulting Group / Freshwater Research Unit, University of Cape Town

Davies, B., & Day, J. (1998).*Vanishing Water*. Cape Town: UCT Press.

Department of Water Affairs (DWA), South Africa Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999 [Appendix W3].

Department of Water Affairs and Forestry (1996). South African water quality guidelines vol. 7, Aquatic ecosystems

Department of Water Affairs and Forestry (DWAF) 2005: Final draft: A practical field procedure for identification and delineation of wetlands and Riparian areas.

Department of Water Affairs and Forestry (DWAF). 2007. Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa

Department of Water Affairs and Forestry (DWAF). 2008. Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas, prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Report no. X. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry. 2003. The management of complex waste water discharges, introducing a new approach – Toxicity-based Ecological Hazard Assessment (TEHA). Discussion document, third draft.

Dickens, C. & Graham, M. 2001. South African Scoring System (SASS) version 5. Rapid bio assessment for rivers May 2001. CSIR. http://www.csir.co.za/rhp/sass.html

EKZNW (2007) Freshwater Systematic Conservation Plan: Best Selected Surface (Marxan). Unpublished GIS Coverage [Freshwater_cons_plan_2007], Biodiversity Conservation Planning Division, Ezemvelo KZN Wildlife, P. O. Box 13053, Cascades, Pietermaritzburg, 3202.

Gerber, A. and Gabriel, M.J.M. 2002. Aquatic Invertebrates of South African Rivers. First Edition. Department of Water Affairs: Pretoria, South Africa.

Kemper, N. 1999. Intermediate Habitat Integrity assessment for use in rapid and intermediate assessments. RDM Manual version 1.0.

Kleynhans C.J. 1999. A procedure for the determination of the ecological reserve for the purposes of the national water balance model for South African River. Institute of Water Quality Studies, Department of Water Affairs & Forestry, Pretoria.

Kleynhans C.J., Thirion C. and Moolman J. 2005. A Level 1 Ecoregion Classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria

Kleynhans CJ, Mackenzie J, Louw MD. 2007. Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and DWA and Forestry report. WRC Report No.

Kleynhans, C. J. 2002. Fish Intolerance ratings. Proceedings resulting from the national fish workshop held at the WRC during 2001.

Kleynhans, C. J. 2007. Module D: Fish response assessment index (FRAI). In: River ecoclassification manual for ecostatus determination (Version 2): Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans, C. J., Louw, M.D. and Moolman, J. 2007. Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kotze D.C., Marneweck G.C., Batchelor A.L., Lindley D.S. and Collins N.B. 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No. TT 339/09. Water Research Commission, Pretoria.

McMillan, P.H. (1998). An integrated habitat assessment system (IHAS v2) for the rapid biological assessment of rivers and streams. A CSIR research project. Number ENV-P-I 98132 for the water resources management programme. CSIR. ii +44 pp

Mucina, L. & Rutherford, M.C. (Eds). 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria, RSA.

National Environmental Management Act (NEMA) 107 of 1998

National Water Act 36 of 1998. Section 21(c) and (i).

Nel, JL, Driver, A., Strydom W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J, Nienaber, S., Van Deventer, H., Swartz, E. & Smith-Adao, L.B. 2011. Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. Water Research Commission Report No. TT 500/11, Water Research Commission, Pretoria.

Ollis, D.J., Snaddon, C.D., Job, N.M., & Mbona, N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria

Skelton, P. H. (2001). A complete guide to freshwater fishes of Southern Africa. Southern Book Publishers (Pty) Ltd., Halfway House. 388pp.

The South African National Biodiversity Institute - Biodiversity GIS (BGIS) [online]. URL: http://bgis.sanbi.org as retrieved on 01/10/2015

Thirion C. 2007. Module E: Macro-Invertebrate response assessment index (MIRAI). In: River ecoclassification manual for ecostatus determination (Version 2): Joint Water Research Commission and Department of Water Affairs and Forestry report.

Thirion, C. A; Mocke, A and Woest, R. 1995. Biological Monitoring of Streams and Rivers using SASS4: A User Manual. Final Report, No. N 000/00/REQ/1195. Institute of Water Quality Studies, Department of Water Affairs and Forestry.

United States Environmental Protection Agency (US EPA, 1996). Ecological effects test guidelines. Fish acute toxicity test, Freshwater and marine. OPPTS 850.1075. Report number EPA-712-C-96-118

United States Environmental Protection Agency (US EPA, 2002). Method for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms.

EPA-821-R-02-012, 5th Edition. Office of Research and Development, Washington DC 20460

Van Oudtshoorn, F. 2004. Second Edition, Third Print. Guide to Grasses of South Africa. Briza Publications, Pretoria, RSA.

# APPENDIX 1: AQUATIC ASSESSMENT METHODS AND INDICES EMPLOYED

## Visual Assessment

The assessment sites were investigated in order to identify visible impacts, with specific reference to impacts from surrounding activities and any effects resulting from activities occurring upstream in the catchment. Both natural constraints placed on ecosystem structure and functions, as well as anthropogenic alterations to the system, were identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance and pollution of the area and
- Other life forms reliant on aquatic ecosystems.

## Physico Chemical Water Quality Data

On-site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity (EC), dissolved oxygen (DO) concentration and temperature. Results are discussed against the guideline water quality values for aquatic ecosystems as defined by the Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF, 1996 vol. 7).

In addition the dissolved oxygen concentration was compared to known levels of saturation at specific temperatures, as tabulated by the United States Environmental Protection Agency (US EPA, http://water.epa.gov/type/rsl/monitoring/vms52.cfm), in order to determine the percentage saturation level at the time of sampling.

## Riparian Vegetation Response Assessment Index (VEGRAI)

The Riparian Vegetation Response Assessment Index (VEGRAI) is designed for qualitative assessment of the response of riparian vegetation to impacts, in such a way that qualitative ratings translate into quantitative and defensible results (Kleynhans et al, 2007). Results are defensible because their generation can be traced through an outlined process, a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category.

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: ‘riparian habitat’ includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

**Table 27: Descriptions of the A-F ecological categories.**

| Ecological category | Description | Score (% of total) |
|---|---|---|
| A | Unmodified, natural. | 90-100 |
| B | Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged. | 80-89 |
| C | Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged. | 60-79 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 40-59 |
| E | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20-39 |
| F | Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible | 0-19 |

## Invertebrate Habitat Assessment System (IHAS)

The Invertebrate Habitat Assessment System (IHAS) was applied according to the protocol of McMillan (1998).

This index was used to determine specific habitat suitability for aquatic macro-invertebrates, as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65%: habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community.
- 65%-75%: habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community.
- >75% habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community.

## Intermediate Habitat Integrity Assessment (IHIA)

It is important to assess the habitat of each site, in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration.

The general habitat integrity of the site should be discussed based on the application of the Intermediate Habitat Integrity Assessment (IHIA) for (Kemper, 1999). The IHIA protocol, as described by Kemper (1999), should be used for site specific assessments. The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site should be scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones should be analysed separately, and the final assessment should be made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone are, however, primarily interpreted in terms of the potential impact on the instream component. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings. Analysis of the data should be carried out by weighting each of the criteria according to Kemper (1999). By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score can be obtained for each site. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitats of the site. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

**Table 28: Classification of Present State Classes in terms of Habitat Integrity [Based on Kemper 1999]**

| Class | Description | Score (% of total) |
|---|---|---|
| A | Unmodified, natural. | 90-100 |
| B | Largely natural, with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged. | 80-90 |
| C | Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. | 60-79 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 40-59 |
| E | Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20-39 |
| F | Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible. | <20 |

## South African Scoring System Version 5(SASS5)

Aquatic Macro-invertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System version 5) (Dickens & Graham, 2001). The SASS5 method has been specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998). The assessment was undertaken according to the protocol as defined by Dickens & Graham (2001). All work was done by an accredited SASS5 practitioner. The SASS5 method was designed to incorporate all available biotypes at a given site and to provide an indication of the integrity of the of the aquatic macro-invertebrate community through recording the presence of various macro-invertebrate families at each site, as well as consideration of abundance of various populations, community diversity and community sensitivity. Each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997).

This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net, with a pore size of 1000 micron mounted on a 300 mm square frame, over the churned up area several times. In stony bottomed flowing water biotopes (rapids, riffles, runs, etc.) the net downstream of the assessor and the area immediately upstream of the net is disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net was also swept under the edge of marginal and aquatic vegetation to cover from 1-2 meters. Identification of the organisms was made to family level (Thirion *et al*., 1995; Davies & Day, 1998; Dickens & Graham, 2001; Gerber & Gabriel, 2002).

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et al.*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score, in conjunction with a low habitat score, can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score, together with a high habitat score, would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

Classification of the system took place by comparing the present community status to reference conditions which reflect the best conditions that can be expected in rivers and streams within a specific area and reflect natural variation over time. SASS and ASPT reference conditions were obtained from Dallas (2007), as presented in the figure below. Reference conditions are stated as a SASS score of 185 and an ASPT score of 7.0. Sites were classified according to the classification system for the Lebombo Uplands Lower aquatic ecoregion according to Dallas (2007) since no information for the Lowveld uplands is available, as well as the classification system of Dickens & Graham 2001.

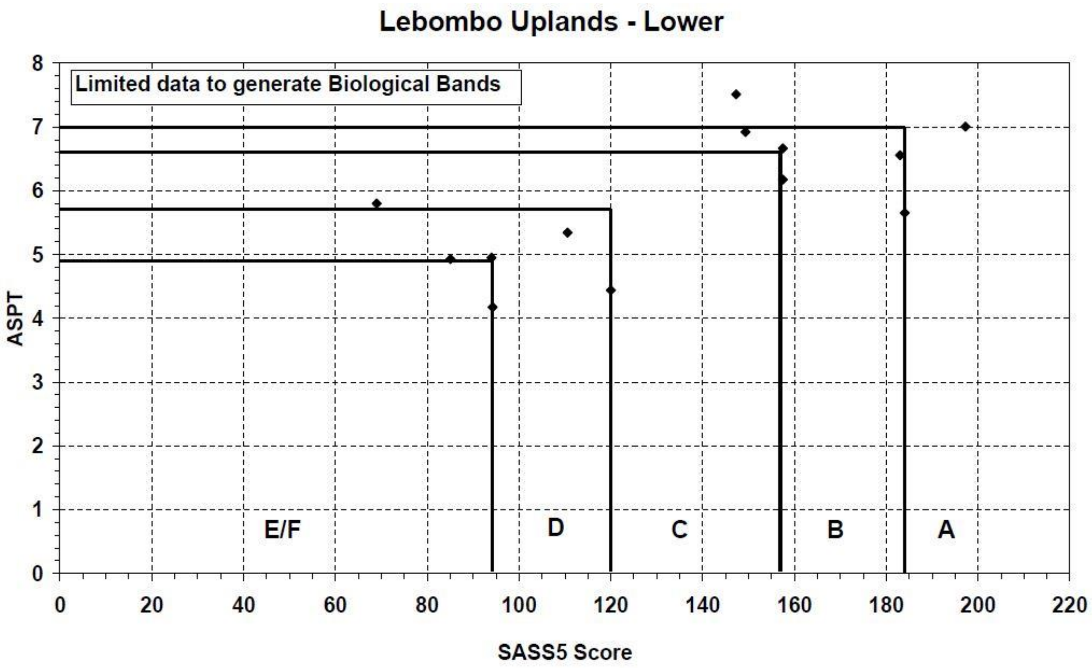


**Figure 23: SASS5 Classification using biological bands calculated form percentiles for the Lowveld Lower Ecoregion, Dallas, 2007**

**Table 29: Definition of Present State Classes in terms of SASS scores as presented in Dickens & Graham (2001)**

| Class | Description | SASS Score% | ASPT |
|---|---|---|---|
| A | Unimpaired. High diversity of taxa with numerous sensitive taxa. | 90-100<br>80-89 | Variable<br>>90 |
| B | Slightly impaired. High diversity of taxa, but with fewer sensitive taxa. | 80-89<br>70-79<br>70-89 | <75<br>>90<br>76-90 |
| C | Moderately impaired. Moderate diversity of taxa. | 60-79<br>50-59<br>50-79 | <60<br>>75<br>60-75 |
| D | Largely impaired. Mostly tolerant taxa present. | 50 - 59<br>40-49 | <60<br>Variable |
| E | Severely impaired. Only tolerant taxa present. | 20-39 | Variable |
| F | Critically impaired. Very few tolerant taxa present. | 0-19 | Variable |

## Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with particular reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs. An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions). To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly habitat preferences and requirements for each taxa present should be obtained. As such reference conditions can be established against which any response to drivers can be measured. Secondly habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result expected and actual patterns can be evaluated to achieve an Ecostatus Category (EC) rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to sites FM1 and FM2 following methodology described by Thirion (2007). Aquatic macro-invertebrates expected at each point were derived both from previous studies of rivers near the area as well as habitat, flow and water parameters (Thirion 2007).

## Fish biota: Habitat Cover Rating (HCR)

This approach was developed to assess habitats according to different attributes that are surmised to satisfy the habitat requirements of various fish species. At each site, the following depth-flow (df) classes are identified, namely:

- Slow (<0.3m/s), shallow (<0.5m) - Shallow pools and backwaters.
- Slow, deep (>0.5m) - Deep pools and backwaters.
- Fast (>0.3m/s), shallow - Riffles, rapids and runs.
- Fast, deep - Usually rapids and runs.

The relative contribution of each of the above mentioned classes at a site was estimated and indicated as:

0 = Absent

1 = Rare (<5%)

2 = Sparse (5-25%)

3 = Moderate (25-75%)

4 = Extensive (>75%)

For each depth-flow class, the following cover features (cf) -considered to provide fish with the necessary cover to utilise a particular flow and depth class- were investigated:

- Overhanging vegetation
- Undercut banks and root wads
- Stream substrate
- Aquatic macrophytes

The amount of cover present at each of these cover features (cf) was noted as:

0 = absent

1 = Rare/very poor (<5%)

2 = Sparse/poor (5-25%)

3 = Moderate/good (25-75%)

4 = Extensive/excellent (>75%)

The fish habitat cover rating (HCR) was calculated as follows:

- The contribution of each depth-flow class at the site was calculated ($df/\Sigma df$).
- For each depth-flow class, the fish cover features (cf) were summed ($\Sigma cf$).

  $HCR = df/\Sigma df \times \Sigma cf$.

The amount and diversity of cover available for the fish community at the selected sites was graphically expressed as habitat cover ratings (HCR) for different flow-depth classes as a stacked bar chart.

Fish species identified were compared to those expected to be present at the site, which were compiled from a literature survey including Skelton 2001. Fish sampling was performed by means of a fixed generator driven electro-fishing device.

## Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans 2007) is based on the premise that “drivers” (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species. This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category (EC). Fish expected to occur in the system is summarised in Table 30.

**Table 30: Intolerance ratings as well as frequency of occurrence (FROC) (Kleynhans et al., 2007)**

**scores for naturally occurring fish species expected to occur in the Pongola River in the study area (DWS RQIS PES/EIS database listings for SQR W45A-02246 Pongola River).**

| SPECIES NAME | COMMON NAME | INTOLE-RANCE RATING | * FROC score | COMMENTS |
|---|---|---|---|---|
| *Anguilla bengalenis labiate* | African mottled eel | 2.9 | 2 | Overall, similar to other South African eels. Penetrates far inland. |
| *Anguilla bicolor bicolor* | Shortfin eel | 0.0 | 2 | Widespread but uncommon along east and south-east African coast where it is restricted to coastal reaches of rivers. |
| *Anguilla marmorata* | Giant mottled eel | 2.8 | 2 | Madagascar rivers and adjacent islands as well as south-east Africa to Eastern Cape |
| *Anguilla mossambica* | Longfin eel | 2.8 | 2 | East coast rivers from Kenya south to Cape Agulhas, also Madagascar and adjacent islands |
| *Barbus afrohamiltoni* | Plumb barb | 3.0 | 2 | Lowveld reaches from the tropical east coast rivers from the lower Zambezi to the Pongola. |
| *Barbus paludinosis*[1] | Straightfin barb | 1.8 | 1 | Widespread |
| *Barbus trimaculatus* | Threespot barb | 2.2 | 1 | Common in many river systems of southern Africa |
| *Barbus unitaeniatus* | Longbeard barb | 1.7 | ** 1 | Widely distributed in southern Africa |
| *Brycinus imberi* | Imberi | 2.2 | 1 | East coast rivers from the Pongola northwards to the Rufigi in Tanzania |
| *Clarias gariepinus* | Sharptooth Catfish | 1.4 | 1 | Widespread throughout southern Africa. |
| *Hydrocynus vittatus* | Tigerfish | 3.3 | 1 | Okovango, Zambezi and Lowveld reaches of coastal systems south to the Pongola. |
| *Labeo rosae* | Rednose labeo | 2.4 | 1 | Lowveld region of the Limpopo, Incomati and Pongola systems |
| *Labeobarbus marequensis* | Largescale yellowfish | 2.6 | ** 1 | Widely distributed from the middle and lower Zambezi south to the Pongola system. |
| *Mesobola brevianelis* | River sardine | 2.3 | 1 | East coastal rivers from Limpopo to Umfolozi in KwaZulu-Natal |
| *Micralestes acutidens* | Silver robbers | 2.3 | 1 | Cunene, Okavango, Zambezi and east coast rivers south to Pongola. |
| *Notobranchius orthonotus* | Spotted killifish | 4.2 | ** 1 | Coastal plain from the lower Zambezi region to the Mkuze in KwaZulu-Natal. |
| *Oreochromis mossambicus* | Mozambique Tilapia | 1.3 | 1 | East coastal rivers from the Lower Zambezi River south to the Bushman's system, Eastern Cape. |

**Intolerance ratings: Tolerant: 1-2; Moderately tolerant :> 2-3; Moderately Intolerant: >3-4;Intolerant: >4**
*** Frequency of occurrence (FROC) scores were not listed for catchment W45A in Kleynhans *et al.* 2007, but such scores were listed for W45B and were adopted for the purposes of this report;**
**** Where frequency of occurrence (FROC) scores were not listed in Kleynhans *et al.* 2007, a FROC score of "1" was allocated for the purposes of this study.**

**Table 30 (continued): Intolerance ratings as well as frequency of occurrence (FROC) (Kleynhans et al., 2007) scores for naturally occurring fish species expected to occur in the Pongola River in the study area (DWS RQIS PES/EIS database listings for SQR W45A-02246 Pongola River).**

| SPECIES NAME | COMMON NAME | INTOLE-RANCE RATING | * FROC score | COMMENTS |
|---|---|---|---|---|
| *Pseudocrenilabrus philander* | *Southern mouthbrooder* | *1.3* | *1* | *From the Orange and southern KwaZulu-Natal northwards throughout the region. Extends to southern Congo tributaries and Lake Malawi.* |
| *Schilbe intermedius* | *Silver catfish* | *1.7* | *1* | *Cunene, Okavango, Zambezi and east coast rivers south to Pongola.* |
| *Synodontis zambezensis* | *Brown squeaker* | *2.3* | *** 1* | *Middle and lower Zambezi south to Pongola system.* |
| *Tilapia rendalli* | *Redbreast tilapia* | *1.8* | *** 1* | *Cunene, Okavango, Zambezi and east coast rivers south to Pongola.* |
| *Tilapia sparrmanii* | *Banded Tilapia* | *1.3* | *1* | *Extensively translocated south of the Orange in the Cape.* |

**Intolerance ratings: Tolerant: 1-2; Moderately tolerant :> 2-3; Moderately Intolerant: >3-4;Intolerant: >4**
*** Frequency of occurrence (FROC) scores were not listed for catchment W45A in Kleynhans *et al.* 2007, but such scores were listed for W45B and were adopted for the purposes of this report;**
**** Where frequency of occurrence (FROC) scores were not listed in Kleynhans *et al.* 2007, a FROC score of "1" was allocated for the purposes of this study.**
**Note: The following species were listed as occurring in the catchment/sub-quaternary catchment (SQR), but is unlikely to occur at the Mboza 1 site based on distribution/location within the catchment/SQR (e.g. estuarine species that are unlikely to occur in fresh water or species on the edge of their distribution range):**
***Acanthopagrus berda* (River Bream), *Aplocheilichthys johnstoni* (Johnston's topminnow), *Awaous aeneofuscus* (freshwater goby), *Glossogobius callidus* (river goby), *Glossogobius giurus* (tank goby), *Liza macrolepis* (large scale mullet), *Megalops cyprinoides* (oxeye tarpon), *Myxus capensis* (freshwater mullet), *Redigobius dewaali* (checked goby) and *Petrocephalus catostoma* (Churchill).**
**The following species were listed as occurring in the catchment/sub-quaternary catchment (SQR), but is unlikely to occur at the Mboza 1 site based on habitat preferences (most notably depth and vegetation cover):**
**Preference for vegetated areas and hence expected not to occur at site Mboza 1: *Aplocheilichthys myaposae* (Natal topminnow), *Aplocheilichthys katangae* (striped topminnow), *Barbus annectens* (broadstriped barb), *Barbus radiatus* (Beira barb), *Barbus toppini* (east coast barb), *Barbus viviparous* (bowstripe barb), *Ctenopoma multispine* (multispined climbing perch), *Marcusenius macrolepidotus* (bulldog)**
**Preference for deep pools and hence expected not to occur at site Mboza 1: *Labeo molybdinus* (leaden labeo)**
**Preference for rocky sections and hence expected not to occur at site Mboza 1: *Labeo congoro* (purple labeo), *Labeo cylindricus* (redeye labeo)**

# APPENDIX 2: WETLAND ASSESSMENT METHODS AND INDICES EMPLOYED

## Classification System for Wetlands and other Aquatic Ecosystems in South Africa (2013)

All wetland or riparian features encountered within the linear development were assessed using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems, hereafter referred to as the "Classification System" (Ollis *et. al*., 2013). A summary of Levels 1 to 4 of the classification system are presented in Table 31 and 32, below.

**Table 31: Classification System for Inland Systems, up to Level 3.**

<table>
<tr><th colspan="3">WETLAND / AQUATIC ECOSYSTEM CONTEXT</th></tr>
<tr><td>LEVEL 1:<br>SYSTEM</td><td>LEVEL 2:<br>REGIONAL SETTING</td><td>LEVEL 3:<br>LANDSCAPE UNIT</td></tr>
<tr><td rowspan="4">Inland Systems</td><td rowspan="4">DWA Level 1 Ecoregions<br>OR<br>NFEPA WetVeg Groups<br>OR<br>Other special framework</td><td>Valley Floor</td></tr>
<tr><td>Slope</td></tr>
<tr><td>Plain</td></tr>
<tr><td>Bench<br>(Hilltop / Saddle / Shelf)</td></tr>
</table>

**Table 32: Hydrogeomorphic (HGM) Units for the Inland System, showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.**

| FUNCTIONAL UNIT | | |
|---|---|---|
| LEVEL 4:<br>HYDROGEOMORPHIC (HGM) UNIT | | |
| *HGM type* | Longitudinal zonation/ Landform / Outflow drainage | Landform / Inflow drainage |
| **A** | **B** | **C** |
| River | Mountain headwater stream | Active channel |
| | | Riparian zone |
| | Mountain stream | Active channel |
| | | Riparian zone |
| | Transitional | Active channel |
| | | Riparian zone |
| | Upper foothills | Active channel |
| | | Riparian zone |
| | Lower foothills | Active channel |
| | | Riparian zone |
| | Lowland river | Active channel |
| | | Riparian zone |
| | Rejuvenated bedrock fall | Active channel |
| | | Riparian zone |
| | Rejuvenated foothills | Active channel |
| | | Riparian zone |
| | Upland floodplain | Active channel |
| | | Riparian zone |
| Channelled valley-bottom wetland | (not applicable) | (not applicable) |
| Unchannelled valley-bottom wetland | (not applicable) | (not applicable) |
| Floodplain wetland | Floodplain depression | (not applicable) |
| | Floodplain flat | (not applicable) |
| Depression | Exorheic | With channelled inflow |
| | | Without channelled inflow |
| | Endorheic | With channelled inflow |
| | | Without channelled inflow |
| | Dammed | With channelled inflow |
| | | Without channelled inflow |
| Seep | With channelled outflow | (not applicable) |
| | Without channelled outflow | (not applicable) |
| Wetland flat | (not applicable) | (not applicable) |

### *Level 1: Inland systems*

From the classification system, Inland Systems are defined as **aquatic ecosystems that have no existing connection to the ocean**[2] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but **which are inundated or saturated with water, either permanently or periodically.** It is important to bear in mind, however, that certain Inland Systems may have had a historical connection to the ocean, which in some cases may have been relatively recent.

### *Level 2: Ecoregions & NFEPA Wetland Vegetation Groups*

For Inland Systems, the regional spatial framework that has been included at Level 2 of the classification system is that of the DWA's Level 1 Ecoregions for aquatic ecosystems (Kleynhans *et. al.,* 2005). There are a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland (figure below). DWA Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) groups vegetation types across the country according to Biomes, which are then divided into Bioregions. To categorise the regional setting for the wetland component of the NFEPA project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting Bioregions into smaller groups through expert input (Nel *et. al*., 2011). There are currently 133 NFEPA WetVeg Groups. It is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

[2] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

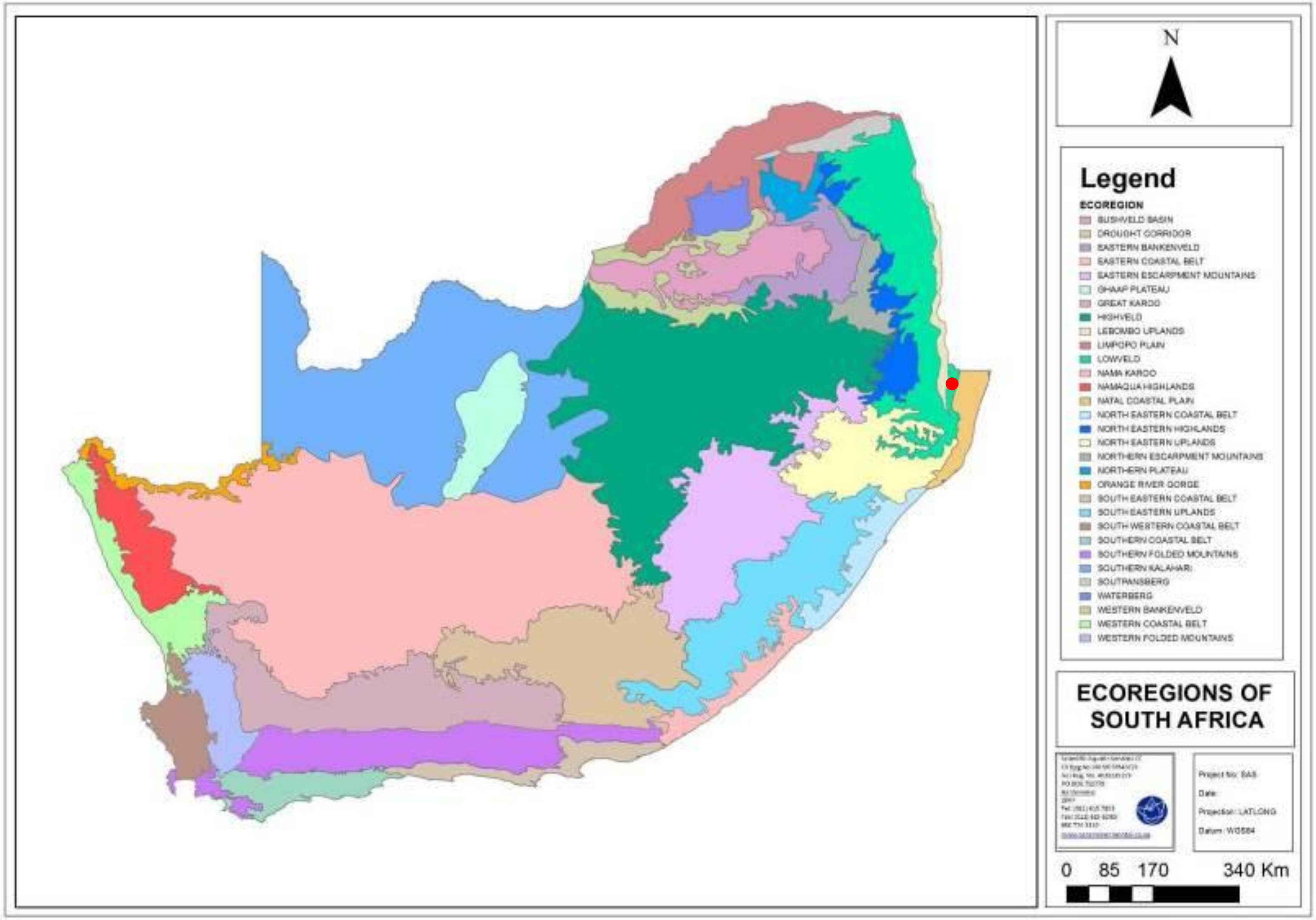


**Figure 24: Map of Level 1 Ecoregions of South Africa, with the approximate position of the study area indicated in red.**

### *Level 3: Landscape Setting*

At Level 3 of the proposed classification system for Inland Systems, a distinction is made between four Landscape Units (Table 31) on the basis of the landscape setting (i.e. topographical position) within which an HGM Unit is situated, as follows (Ollis *et. al.,* 2013):

- **Slope:** an included stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley;
- **Valley floor:** The base of a valley, situated between two distinct valley side-slopes;
- **Plain:** an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land; and
- **Bench (hilltop/saddle/shelf):** an area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately perpendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

### *Level 4: Hydrogeomorphic Units*

Eight primary HGM Types are recognised for Inland Systems at Level 4A of the classification system (Table 32), on the basis of hydrology and geomorphology (Ollis *et. al*., 2013), namely:

- **River:** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water;
- **Channelled valley-bottom wetland:** a valley-bottom wetland with a river channel running through it;
- **Unchannelled valley-bottom wetland:** a valley-bottom wetland without a river channel running through it;
- **Floodplain wetland:** the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank;
- **Depression:** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates;
- **Wetland Flat:** a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat; and

- **Seep:** a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the classification system to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for "channel", "flat" and "valleyhead seep") is used, for example, in the recently developed tools produced as part of the Wetland Management Series including WET-Health (Macfarlane *et. al*., 2008), WET-IHI (DWAF, 2007) and WET-EcoServices (Kotze *et. al*., 2009).

## Wet-Ecoservices (2009)

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[3] The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et. al.* (2009). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- Flood attenuation;
- Stream flow regulation;
- Sediment trapping;
- Phosphate trapping;
- Nitrate removal;
- Toxicant removal;
- Erosion control;
- Carbon storage;
- Maintenance of biodiversity;
- Water supply for human use;
- Natural resources;
- Cultivated foods;
- Cultural significance;
- Tourism and recreation; and
- Education and research.

[3] Department of Water Affairs and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999*

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the wetlands.

Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the wetland.

**Table 33: Classes for determining the likely extent to which a benefit is being supplied.**

| Score | Rating of the likely extent to which the benefit is being supplied |
|---|---|
| <0.5 | Low |
| 0.6-1.2 | Moderately low |
| 1.3-2 | Intermediate |
| 2.1-3 | Moderately high |
| >3 | High |

## Index of Habitat Integrity (IHI)

To assess the PES of the wetland and riparian features, the IHI for South African floodplain and channelled valley bottom wetland types (Department of Water Affairs and Forestry Resource Quality Services, 2007) was used.

The WETLAND-IHI is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI has been developed to allow the NAEHMP to include floodplain and channelled valley bottom wetland types to be assessed. The output scores from the WETLAND-IHI model are presented in A-F ecological categories (table below), and provide a score of the PES of the habitat integrity of the riparian system being examined.

**Table 34: Descriptions of the A-F ecological categories (after Kleynhans, 1996, 1999).**

| Ecological Category | PES % Score | Description |
|---|---|---|
| A | 90-100% | Unmodified, natural. |
| B | 80-90% | Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. |
| C | 60-80% | Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. |
| D | 40-60% | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. 20-40% Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |
| E | 20-40% | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. |

| Ecological Category | PES % Score | Description |
|---|---|---|
| **F** | 0-20% | Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible. |

## Ecological Importance and Sensitivity (EIS)

The method used for the EIS determination was adapted from the method as provided by DWA (1999) for wetlands. A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The mean of the determinants is used to assign the EIS category as listed in Table 35 below.

**Table 35: Descriptions of the EIS Categories.**

| EIS Category | Range of Mean | Recommended Ecological Management Class[4] |
|---|---|---|
| Very high<br>Resources that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these resources is usually very sensitive to flow and habitat modifications. | >3 and <=4 | A |
| High<br>Resources that are considered to be ecologically important and sensitive. The biodiversity of these resources may be sensitive to flow and habitat modifications. | >2 and <=3 | B |
| Moderate<br>Resources that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these resources is not usually sensitive to flow and habitat modifications. | >1 and <=2 | C |
| Low/marginal<br>Resources that are not ecologically important and sensitive at any scale. The biodiversity of these resources is ubiquitous and not sensitive to flow and habitat modifications. | >0 and <=1 | D |

## Recommended Ecological Category (REC)

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability, but carries a higher risk of ecosystem failure." [5]

The REC (Table 36) was determined based on the results obtained from the PES, reference conditions and EIS of the resource (sections above), and is followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

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[4] Ed's note: Author to confirm exact wording for version 1.1

[5] Department of Water Affairs and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources 1999*

A wetland may receive the same class for the PES as the REC if the wetland is deemed in good condition, and therefore must stay in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as enhance the PES of the wetland feature.

**Table 36: Description of REC classes.**

| Class | Description |
|---|---|
| A | Unmodified, natural |
| B | Largely natural with few modifications |
| C | Moderately modified |
| D | Largely modified |

## Wetland zone delineation

For the purposes of this investigation, wetland and riparian habitat is defined in the National Water Act (1998) as including the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized 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.

The wetland and riparian zone delineation took place according to the method presented in the final draft of "A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas" published by the DWAF in February 2005. An updated draft version of this report is also available and was therefore also considered during the riparian delineation (DWAF, 2008). The foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

- The position in the landscape, which will help identify those parts of the landscape where wetlands are more likely to occur;
- The type of soil form (i.e. the type of soil according to a standard soil classification system), since wetlands are associated with certain soil types;
- The presence of wetland vegetation species; and
- The presence of redoxymorphic soil feature, which are morphological signatures that appear in soils with prolonged periods of saturation.

By observing the evidence of these features in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWAF, 2005 and 2008).

Riparian and wetland zones can be divided into three zones (DWAF, 2005). The permanent zone of wetness is nearly always saturated.
The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year, but is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland/riparian area.

# APPENDIX 3: ENVIRONMENTAL IMPACT ASSESSMENT METHOD EMPLOYED

The following parameters are used to describe the impact/issues in this assessment:

**1. Nature**

This is a brief written statement of the environmental aspect being impacted upon by a particular action or activity.

**2. Extent (E)**

Extent refers to the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact.

- Site (1) – Within the construction site.
- Local (2) – Within a radius of 2 km of the construction site.
- Regional (3) – the scale applies to impacts on a provincial level and parts of neighbouring provinces.
- National (4) – the scale applies to impacts that will affect the whole South Africa.

**3. Duration (D)**

Duration indicates what the lifetime of the impact will be.

- Short-term (1) – less than 5 years.
- Medium-term (2) – between 5 and 15 years.
- Long-term (3) – between 15 and 30 years.
- Permanent (4) – over 30 years and resulting in a permanent and lasting change that will always be there.

**4. Intensity (I)**

Intensity describes whether an impact is destructive or benign.

- Very High (4) – Natural, cultural and social functions and processes are altered to extent that they permanently cease.
- High (3) – Natural, cultural and social functions and processes are altered to extent that they temporarily cease.
- Moderate (2) – Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way.
- Low (1) – Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected.

**5. Probability (P)**

Probability describes the likelihood of an impact actually occurring.

- Improbable (1) – Likelihood of the impact materialising is very low.
- Possible (2) – The impact may occur.
- Highly Probable (3) – Most likely that the impact will occur.
- Definite (4) – Impact will certainly occur.

**6. Cumulative (C)**

In relation to an activity, means the impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.

**7. Significance (S)**

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

| Score | | Elaboration |
|---|---|---|
| **– (13 – 16 points)** | NEGATIVE VERY HIGH | Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a "very high impact" is likely to be a fatal flaw. |
| **– (10 – 12 points)** | NEGATIVE HIGH | These are impacts which individually or combined pose a significantly high negative risk to the environment. These impacts pose a high risk to the quality of the receiving environment. The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment. |
| **– (7 – 9 points)** | NEGATIVE MODERATE | These are impacts which individually or combined pose a moderate negative risk to the quality of health of the receiving environment. These systems would not generally require immediate action but the deficiencies should be rectified to avoid future problems and associated cost to rectify once in HIGH risk. Aesthetically and/or physically non-compliance can be expected over a medium term. In this case the impact is medium term, moderate in extent, mildly intense in its effect and probable. Mitigation is possible with additional design and construction inputs. |
| **– (4 – 6 points)** | NEGATIVE LOW | These are impacts which individually or combined pose a deleterious or adverse impact and low negative risk to the quality of the receiving environment, and may lead to potential health, safety and environmental concerns. Aesthetically and/or physical non-compliance can be expected for short periods. In this case the impact is short term, local in extent, not intense in its effect and may not be likely to occur. A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure. |
| **0** | NEUTRAL | Impact is neither beneficial nor adverse. These are impacts which cannot be classified as either positive or negative or classified and null and void in the case of a negative impact being adequately mitigated to a state where it no longer renders a risk. |
| **+ (4 – 6 points)** | POSITIVE LOW | These are impacts which individually or combined pose a low positive impact to the quality of the receiving environment and health, and may lead to potential health, safety and environmental benefits. In this case the impact is short term, local in extent, not intense in its effect and may not be likely to occur. A low impact has no permanent impact of significance. |
| **+ (7 – 9 points)** | POSITIVE MODERATE | These are impacts which individually or combined pose a moderate positive effect to the quality of health of the receiving environment. In this case the impact is medium term, moderate in extent, mildly intense in its effect and probable. |
| **+ (10 – 12 points)** | POSITIVE HIGH | These are impacts which individually or combined pose a significantly high positive impact on the environment. These impacts pose a high benefit to the quality of the receiving environment and health, and |

| Score | | Elaboration |
|---|---|---|
| | | may lead to potential health, safety and environmental benefits. In this case the impact is longer term, greater in extent, intense in its effect and highly likely to occur. The effects of the impact may affect the broader environment. |
| **+ (13 – 16 points)** | POSITIVE VERY HIGH | These are permanent and important beneficial impacts which may arise. Individually or combined, these pose a significantly high positive impact on the environment. These impacts pose a very high benefit to the quality of the receiving environment and health, and may lead to potential health, safety and environmental benefits. In this case the impact is long term, greater in extent, intense in its effect and highly likely or definite to occur. The effects of the impact may affect the broader environment. |

# APPENDIX 4: IHAS SCORE SHEET

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**: PONGOLA
**Site Name**: MBOZA1
**Date**: 17/10/2015

| SAMPLING HABITAT | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | 0 | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | 9 | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | 12 | |
| | **HABITAT TOTAL (MAX 55):** | | | | 21 | |
| **STREAM CONDITION** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | 30 | |
| | **TOTAL IHAS SCORE (%):** | | | | 51 | |

# APPENDIX 5: SASS5 Score Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| DATE: 17/10/2015 | TAXON | | S | VG | GSM | TOT | TAXON | | S | VG | GSM | TOT | TAXON | | S | VG | GSM | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | A | | A | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | | | | Blepharoceridae | 15 | | | | |
| SITE CODE: MBOZA1 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: PONGOLA | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | | | |
| SITE DESCRIPTION: REPRESENTATIVE CROSS | Leeches | 3 | | | A | A | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: HOT, DRY, NO RAIN | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 25.8 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.97 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 6.3 mg/l | Atyidae | 8 | | B | | B | Veliidae/M..veliidae* | 5 | | 1 | | 1 | Muscidae | 1 | | | | |
| Cond: 417 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | A | | A | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: 4 DOM SP: PRAUS | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | B | | B | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: 2 | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | A | | A |
| HAND PICKING/VISUAL OBS: YES | Heptageniidae | 13 | | A | A | A | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | A | | A |
| **FLOW**: LOW | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | A | | A |
| **TURBIDITY**: LOW | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 0 | 82 | 22 | 85 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | A | | A | Leptoceridae | 6 | | 1 | 1 | A | **NO OF TAXA:** | | 0 | 13 | 3 | 14 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 0 | 6.3 | 7 | 6.1 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 51% | | | |
| | Coenagrionidae | 4 | | B | | B | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | A | | A | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

# APPENDIX 6: IHIA Score Sheets

**Instream Habitat Integrity**

| Weights | 14 | 13 | 13 | 13 | 14 | 10 | 9 | 8 | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SITE** | **Water abstraction** | **Flow modification** | **Bed modification** | **Channel modification** | **Water quality** | **Inundation** | **Exotic macrophytes** | **Exotic fauna** | **Solid waste disposal** | **Total Score (%)** | **Classification** |
| **Mboza 1** | 7 | 12 | 4 | 7 | 2 | 0 | 0 | 1 | 1 | 78 | C (Moderately modified) |

| | | | | | |
|---|---|---|---|---|---|
| *None (0)* | *Small (1 – 5)* | *Moderate (6 – 10)* | *Large (11 – 15)* | *Serious (16 – 20)* | *Critical (21 – 25)* |

**Riparian Zone Habitat Integrity**

| Weights | 13 | 12 | 14 | 12 | 13 | 11 | 12 | 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **SITE** | **Vegetation removal** | **Alien encroachment** | **Bank erosion** | **Water abstraction** | **Flow modification** | **Channel modification** | **Water quality** | **Inundation** | **Total Score (%)** | **Classification** |
| **Mboza 1** | 11 | 7 | 9 | 4 | 9 | 8 | 1 | 0 | 71 | C (Moderately modified) |

| | | | | | |
|---|---|---|---|---|---|
| *None (0)* | *Small (1 – 5)* | *Moderate (6 – 10)* | *Large (11 – 15)* | *Serious (16 – 20)* | *Critical (21 – 25)* |

**Combined Habitat Integrity**

| SITE | *INSTREAM HABITAT* | *RIPARIAN ZONE* | *IHI SCORE* | *CLASS* |
|---|---|---|---|---|
| **Mboza 1** | 78 | 71 | 74 | C (Moderately modified) |