4a Old Main Road, Judges Walk, Kloof, KwaZulu-Natal South Africa 3610
PO Box 819 Gillitts 3603 South Africa

Telephone: +27 (0)31 764 7130 Facsimile: +27 (0)31 764 7140
Web: www.gcs-sa.biz

Proposed Mbokodweni River Pedestrian Bridge between Emansomini and Umlazi Y Section in Umlazi, eThekwini Municipality, KwaZulu-Natal

Wetland and Riparian Zone Assessment Report

Version - 1

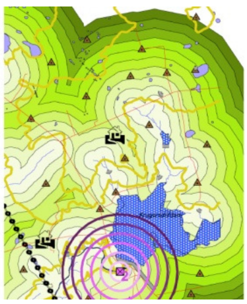
18 November 2014

GCS Project Number: 14-501

Prepared For:

SiVEST SA (Pty) Ltd




Wetland & Riparian Zone Assessment Report

Version - 1

18 November 2014

Prepared For:
SiVEST SA (Pty) Ltd

DOCUMENT ISSUE STATUS

Report Issue	Draft for client review		
Version No.	1		
GCS Reference Number	14-501		
Title	Proposed Wewe River Pedestrian Bridge between Sandfields and Burbreeze in Tongaat, eThekwini Municipality, KwaZulu-Natal: Wetland & Riparian Zone Assessment Report		
	Name	**Signature**	**Date**
Author	Ryan Edwards		18.11.2014
Document Reviewer	Russell Stow		18.11.2014
Director	Pieter Labuschagne		18.11.2014

EXPERTISE TO CARRY OUT THE SPECIALIST STUDY

The author, Ryan Edwards, holds a Bachelor of Science (BSc) in Geography and Environmental Management, a Bachelor of Science Honours (BSc Hons) in Geography and Environmental Management and a Master of Science (MSc) in Environmental Science (Research Masters). The author's MSc dissertation was on wetland geomorphology and as such the author has expertise in the methods of data collection, analysis and interpretation in the discipline of geomorphology. Furthermore, the author has 6 years experience in wetland and riparian zone assessments and is competent in data collection and analysis methods related to such assessments that include: soil sampling, description and analysis; vegetation sampling, description and analysis; wetland ecosystem/ecological importance determination; wetland ecosystem/ecological health determination; and wetland impact assessment. The author also has experience in wetland offset mitigation and wetland rehabilitation and management. The author is currently accredited as a professional natural scientist by the South African Council for Natural Scientific Professions (SACNASP) under the field of practice – 'environmental science'.

DECLARATION OF INDEPENDANCE

I, **Ryan Edwards**, declare that --

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing
  - any decision to be taken with respect to the application by the competent authority; and
  - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this report are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist

GCS (Pty) Ltd

Name of company (if applicable)

18 November 2014

Date

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Project Background and Description

The applicant/developer, eThekwini Municipality, intends to develop a pedestrian bridge across the Mbokodweni River to link the Emansomini and Umlazi Y-section suburbs located within the greater Umlazi area, in the eThekwini Municipality, KwaZulu-Natal Province.

The proposed bridge is planned to comprise a 36m long concrete structure with three piers with the central pier founded into solid rock as shown in the conceptual design drawing included in **Appendix A**.

The proposed alteration to the beds, banks and characteristics of the Mbokodweni River freshwater ecosystems resulting from the establishment of the pedestrian bridge are considered listed activities under the National Environmental Management Act (1998) and water uses under the National Water Act (1998). In this regard, GCS (Pty) Ltd ('GCS') was appointed by the environmental assessment practitioner (EAP), SiVEST, on behalf of the eThekwini Municipality, to undertake a wetland and riparian assessment of the watercourses to be affected by the pedestrian bridge crossing.

1.2 Terms of Reference

The appointed terms of reference were to:

- Delineate the wetland and riparian areas within 32m of the proposed development.
- Classify the delineated wetland and riparian units according to accepted classification systems.
- Provide a qualitative description of the present ecological state of the delineated wetland and riparian areas.
- Assess the functional and ecological importance of the delineated wetland and riparian areas.
- Identify and describe the potential impacts to be imparted on the delineated wetland and riparian units resulting from the proposed activity.
- Provide mitigation measures to avoid, minimise, repair and/or offset the severity/magnitude of the potential impacts on the delineated wetland and riparian units.

2 OVERVIEW OF FRESHWATER ECOSYSTEMS

2.1 Key Concepts and Definitions

An ecosystem is any definable ecological system or unit that consists of all organisms/biota (species, populations, communities) in a given area, the abiotic/physical environment (light, minerals, soil, water etc.) within that area, and the interactions and energy flows between these biotic and abiotic factors. An ecosystem's abiotic and biotic composition and structure is determined by the state of a number of interrelated environmental factors. Changes in any of these factors (e.g. nutrient availability, temperature, light intensity, grazing intensity, species population density etc.) will result in dynamic changes to the nature of these systems.

Aquatic ecosystems are ecosystems found specifically in the presence of water. There are two main types of aquatic ecosystems, namely marine ecosystems and freshwater ecosystems. This study focuses on the freshwater ecosystems associated with watercourses. For the purposes of this study, watercourses are defined as any distinct natural geomorphic feature or habitat associated with flowing water. The watercourse related ecosystems/habitats assessed as part of this study were lotic ecosystems (e.g. streams, rivers and associated riparian zones) and wetland ecosystems only.

2.1.1 Streams, Rivers and Riparian Zones

Rivers and streams are natural channels that are permanent, seasonal or temporary conduits of freshwater. In terms of ecological habitats, rivers and streams comprise in-stream aquatic habitat and riparian habitat. Generally, riparian zones mark the outer edge of stream and river systems.

A riparian zone is a zone or habitat, comprising bare soil, rock and/or vegetation that is:

- associated with a watercourse;
- commonly characterised by alluvial soils; and
- inundated or flooded to an extent and with a frequency sufficient to support vegetation species with a composition and physical structure distinct from those of adjacent land areas (DWAF, 2005).

Riparian areas include plant communities adjacent to and affected by surface and subsurface hydrologic features, such as rivers, streams, lakes or drainage paths (DWAF, 2005). Riparian areas represent the interface between aquatic and terrestrial ecosystems and as such the vegetation within riparian areas have a mix of aquatic and terrestrial elements that creates unique habitats (DWAF, 2005). Due to water availability and rich alluvial soils, riparian areas are usually very productive (DWAF, 2005). Tree growth rates are high and the understorey usually comprises a variety of shrubs, grasses and wild flowers (DWAF, 2005).

2.1.2 Wetlands

Wetlands are areas that have water on the surface or within the root zone for extended periods throughout the year such that anaerobic (oxygen deficient) soil conditions develop which favour the growth and regeneration of hydrophytic vegetation (plants which are adapted to saturated and anaerobic soil conditions).

2.2 Importance of Freshwater Ecosystems and Resources

Rivers, streams and wetland systems are vital for supplying and maintaining freshwater (South Africa's most scare natural resource) and are important in providing additional biodiversity, social, cultural, economic and aesthetic services. Furthermore, healthy river and wetland ecosystems increase the resilience to the impacts of climate change by allowing ecosystems and species to adapt as naturally as possible to the changes and by buffering human settlements and activities from the impacts of extreme weather events. Healthy, intact freshwater ecosystems are vital for maintaining resilience to climate change and mitigating its impact on human wellbeing by helping to maintain a consistent supply of water and for reducing flood risk and mitigating the impact of flash floods. However, freshwater ecosystems in South Africa are likely to be particularly hard hit by rising temperatures and shifting rainfall pattern. Ultimately, the degeneration and degradation of freshwater ecosystems represents a serious cost to society in the form of:

- the increased need for intensive freshwater treatment for potable and domestic use;
- decreased feasible supply/yields for all sectors (particularly the agricultural and industrial sectors) and the increasing need for more dam infrastructure;
- decreased potable, domestic and agricultural use value for subsistence users and the related health costs for subsistence populations and the most vulnerable;
- loss of freshwater biodiversity and the important populations they maintain;
- loss of direct freshwater goods particularly for subsistence use (fish, reeds etc.); and
- the loss of indirect freshwater regulating and supporting services like flood attenuation.

We therefore need to be mindful of the fact that without the integrity of our natural river systems, there will be no sustained long-term economic growth or life.

3 LEGISLATIVE CONTEXT

3.1 National Water Act, 1998 (Act No. 36 of 1998) (NWA)

3.1.1 Relevant Definitions

Under Section 1(1) of the NWA, the following definitions are relevant to this study:

Watercourse:

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

Wetland:

Means 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:

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.

In-stream habitat:

Includes the physical structure of a watercourse and the associated vegetation in relation to the bed of the watercourse.

Water resource:

Includes a watercourse, surface water, estuary, or aquifer.

Catchment:

In relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points.

Pollution:

Means the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it -

a) less fit for any beneficial purpose for which it may reasonably be expected to be used; or
b) harmful or potentially harmful -
    a. to the welfare, health or safety of human beings;
    b. to any aquatic or non-aquatic organisms;
    c. to the resource quality; or
    d. to property;

Protection:

In relation to a water resource, means -

a) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way;
b) prevention of the degradation of the water resource; and
c) the rehabilitation of the water resource;

Resource quality:

Means the quality of all the aspects of a water resource including -

a) the quantity, pattern, timing, water level and assurance of in-stream flow;
b) the water quality, including the physical, chemical and biological characteristics of the water;
c) the character and condition of the in-stream and riparian habitat; and
d) the characteristics, condition and distribution of the aquatic biota.

3.1.2 Water Use License Applications

Under Section 21 of the NWA, the impeding and/or diverting of flow of a watercourse [Section 21(c)] and the altering of the bed, banks, course or characteristics of a watercourse [Section 21(i)] are considered water uses that require water use licenses from the Department of Water Affairs (DWA) before the water uses can commerce.

The definitions of the particular terms within Section 21(c) and (i) of the NWA are included in Section 1 of the NWA and Section 2 of Government Notice 1199 dated 18 December 2009 published under Section 39 of the NWA. The relevant definitions are as follows:

Section 2 of GN No. 1199 (2009):

- '**Altering the bed, banks, course and characteristics of a watercourse**' means any change affecting the resource quality within the riparian habitat or 1:100 year floodline.

It is interesting to note that the above definition of a Section 21(i) water use does not include any reference to wetlands although the inclusion of the term 'watercourse' includes wetlands. In keeping with the intention of the legislation, it is assumed that any change affecting the resource quality of a wetland is also included in this definition. It is also important to note that there is no legal stipulation within the definition that any development within 500m of a watercourse requires a Section 21(i) water use. The legislated definition basically states that any activity that will alter the resource quality of a watercourse is considered a Section 21(i) water use irrespective of the proximity of that activity to the watercourse.

- '**Diverting the flow**' means a temporary or permanent structure causing the flow of water to be rerouted in a watercourse for any purpose.

- '**Impeding the flow**' means a temporary or permanent structure causing the flow of water to be rerouted in a watercourse for any purpose.

3.1.3 General Authorisation Applications

Under Section 39 of the NWA, provision has been made for the General Authorisations of Section 21(c) and (i) water uses that are below a specific threshold and are considered of lower significance. The conditions and exclusions of Section 21(c) and (i) water use general authorisations are set out in Government Notice 1199 dated 18 December 2009. Exclusions related to wetlands specifically include:

- 6(a): This notice does not apply to the use of water in terms of Section 21(c) and (i) for the rehabilitation of a wetland.

This means that the rehabilitation of a wetland that is considered a Section 21(c) and/or (i) water use cannot qualify for a general authorisation.

- 6(b): This notice does not apply to the use of water in terms of Section 21(c) and (i) within a 500m radius from the boundary of a wetland.

This means that any alteration to watercourses that is considered a Section 21(c) and/or (i) water use that is located within 500m of a wetland cannot quality for a general authorisation. It is important to note that the 500m wetland buffer threshold is a general authorisation exclusion threshold specifically for Section 21(c) and (i) water uses.

Additional general authorisation conditions included in Section 7 of GN No. 1199 relevant to wetlands include:

- 7(4): The water use must not result in a potential, measurable or cumulative detrimental –
  - change in the stability of a watercourse;
  - change in the physical structure of a watercourse;
  - scouring, erosion or sedimentation of a watercourse; or
  - decline in the diversity of communities and composition of the natural, endemic vegetation.

- 7(5): The water use must not result in a potential, measurable or cumulative detrimental change in the quantity, velocity, pattern, timing, water level and assurance of flow in a watercourse.

- 7(6): The water use must not result in a potential, measurable or cumulative detrimental change in the water quality characteristics of a watercourse.

- 7(7): The water use must not result in a potential, measurable or cumulative detrimental change on the:
  - breeding, feeding and movement patterns of aquatic biota, including migratory species;
  - level of composition and biodiversity of biotopes and communities of animals and microorganisms; or
  - condition of aquatic biota.

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

3.2.1 Listed Activities Related to Wetlands requiring Environmental Authorization

Listed Activity 11 of Listing Notice 1 of the EIA Regulations, 2010 published under the NEMA stipulates that the construction of certain structures and/or infrastructure within 32m of a watercourse (as defined in the NWA) require environmental authorisation subject to the conducting of a Basic Assessment prior to the commencement of such activities.

Further, Listed Activity 18 of Listing Notice 1 of the EIA Regulations, 2010 stipulates that the infilling and/or excavation of more than 5m^3 of soil from a watercourse requires environmental authorisation subject to the conducting of a Basic Assessment (mini-EIA) prior to the commencement of such activities.

The relevant excerpts from the NEMA are shown in **Table 1** below.

Table 1: Relevant Listed Activities Related to Wetlands

Government Notice No.	Activity No.	Activity Description
R. 544	**11**	*"The construction of: (i) canals; (ii) channels; (iii) bridges; (iv) dams; (v) weirs; (vi) bulk storm water outlet structures; (vii) marinas; (viii) jetties exceeding 50 square metres in size; (ix) slipways exceeding 50 square metres in size; (x) buildings exceeding 50 square metres in size; or (xi) infrastructure or structures covering 50 square metres or more; where such construction occurs <u>within a watercourse</u> or <u>within 32 metres of a watercourse</u>, measured from the edge of a watercourse, excluding where such construction will occur behind the development setback line."*
R.544	**18**	*"The infilling or depositing of any material of <u>more than 5 cubic metres into</u>, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock or <u>more than 5 cubic metres from</u>: (i) a watercourse; (ii) the sea; (iii) the seashore; (iv) the littoral active zone, an estuary or a distance of 100 metres inland of the highwater mark of the sea or an estuary, whichever distance is the greater but excluding where such infilling, depositing , dredging, excavation, removal or moving; (a) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or (b) occurs behind the development setback line."*

4 LOCAL SETTING

The following section provides an overview of the study site in terms of climate, drainage setting, geological, vegetation type setting and wetland ecosystem type setting and conservation context with the aim of contextualising the study site within the greater catchment and freshwater ecosystem conservation planning.

4.1 Climate

The study area falls within the Indian Ocean Coastal Belt Biome and more specifically within the KZN Coastal Belt Vegetation Unit, as defined by Mucina & Rutherford (2006). The mean annual precipitation (MAP) and potential evaporation (PET) of this unit is 989mm and 1659mm respectively.

4.2 Drainage and Watercourse Setting

The proposed pedestrian bridge is proposed to cross a section of the Mbokodweni River that bisects the residential suburbs of Emansomini and Umlazi Y-section. The proposed bridge crossing is located in a section of river ±400m downstream of the Sbu Magwanyane Road river bridge and the Philani Valley Shopping Centre, and 120m downstream of the confluence of the Golokodo River with the Mbokodweni River, as shown in **Figure 1**. The Mbokodweni River is a main stem river that flows into the Indian Ocean at Isipingo Beach and has a small estuary. The river mouth is approximately 14km downstream of the proposed bridge site. The bridge site is located within quaternary catchment U60E.

A desktop Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) Assessment (referred to as the PESEIS) has been undertaken for all rivers in South Africa (DWA, 1999). The present ecological state of the Mbokodweni River at the proposed crossing (as assessed in 1999) is largely natural (Class B) and the river condition is rated as a 'C'. However, it is expected that the river is in a poorer condition than that assessed.

4.3 Geological Setting

According to the eThekwini geology spatial dataset, the geology underlying the bridge site is alluvium and the surrounding geology comprises Dwyka Tillite. Thus, the soils within the valley bottom areas are expected to be a mix of fine silts and clays and coarser sandy deposits.

4.4 Vegetation Type Setting

The bridge site is located within the KZN Coastal Belt Vegetation Unit (CB 3) as defined by Mucina & Rutherford (2006). However, the site in particular would have likely coincided with that of the Subtropical Alluvial Vegetation Unit (AZa 7) and the Subtropical Freshwater Wetlands Unit (AZf 6) as defined by Mucina & Rutherford (2006). Both are azonal vegetation units located within the larger zonal KZN Coastal Belt Vegetation Unit (Mucina & Rutherford, 2006). Therefore, under natural conditions, the study area and surrounding landscape would have been broadly characterised by these three vegetation types.

4.4.1 KZN Coastal Belt Vegetation Unit (CB 3)

The KZN Coastal Belt vegetation unit predominantly comprises subtropical coastal forest with patches of primary grassland prevailing in hilly, high rainfall areas where pressure from natural fire and grazing regimes prevailed (Mucina & Rutherford, 2006). This vegetation unit is considered endangered and poorly protected with less than 0.6% receiving formal protection (Mucina & Rutherford, 2006). Of the remaining 50%, only a small proportion is conserved in the Ngoye, Mbumbazi and Vernon Crookes Nature Reserves.

4.4.2 Subtropical Alluvial Vegetation Unit (AZa 7)

The typical riparian vegetation found within the different alluvial floodplain habitats of the AZa 7 Unit as defined by Mucina & Rutherford (2006) are:

- Frequently flooded lower banks (marginal riparian habitat): Usually populated by transient herbaceous plant communities characterised by short-lived, nutrient demanding flora.
- Banks of slow flowing rivers: Reed beds and reed dominated communities.
- Backswamp and abandoned channel (oxbow) depressions: Reed beds and emergent macrophytic vegetation.
- Lower and middle terraces: Patches of flooded grassland.
- High terraces experiencing occasional flooding: Riparian thickets.

In addition, smaller subtropical rivers within the KZN Coastal Belt are also often lined by woody riparian plant communities dominated by trees such as *Rauvolfia caffra* (Quinine Tree) *Syzygium cordatum* (Water Berry Tree), *Ficus sur* (Cape Fig), *Trema orientalis* (Pigeon Wood) and *Phoenix reclinata* (Date Palm).

4.4.3 Subtropical Freshwater Wetland Vegetation Unit (AZf 6)

The freshwater wetland vegetation typical of AZF 6 comprise reed, sedge and rush marshes and grass meadows within waterlogged, low lying areas (Mucina & Rutherford, 2006). This vegetation unit is considered least threatened.

4.5 Wetland Ecosystem Type Setting

4.5.1 National Freshwater Ecosystem Priority Areas and Threat Status

The National Freshwater Ecosystem Priority Area (NFEPA) project (Nel *et al*., 2011), is the first formally adopted national freshwater conservation plan that provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting the sustainable use of water resources that includes rivers, wetlands and estuaries. The purpose of the NFEPA project was to: (Nel *et al*., 2011)

- Identify Freshwater Ecosystem Priority Areas, referred to as 'FEPAs', to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free flowing rivers.

FEPA maps show various different categories each with different management implications. The categories include river FEPAs and associated sub-quaternary catchments, wetland FEPAs, wetland clusters, Fish Support Areas (FSAs) and associated sub-quaternary catchments, fish sanctuaries, phase 2 FEPAs and associated sub-quaternary catchments, and Upstream Management Areas (UMAs). Categories relevant to this study are river FEPAs, wetland FEPAs and wetland clusters.

Furthermore, the NFEPA includes a national inventory of all mapped freshwater ecosystems as well as the Present Ecological State (PES) of these systems.

According to the current NFEPA coverage, the Mbokodweni River and its sub-quaternary catchment is not classified as a river FEPA. No wetland areas have been identified within close proximity to the proposed bridge site in the National Wetland Inventory. However, this does not eliminate the possibility of wetland habitat being present. The closest wetland downstream of the bridge site picked up on the NFEPA coverage is the wetland associated with the Mbkodweni/Isipingo River estuary. A wetland FEPAs is also located at the estuary outlet but a review of 2013 aerial photography indicates that no wetland is present.

In terms of the NFEPA wetland habitat/vegetation groups, the watercourses fall within the Indian Ocean Coastal Belt Group 2. The ecosystem threat status of this group is classified as

'Critically Endangered' and the protection level is classified as 'Poorly Protected'. It is important to note that no primary wetland habitat that can be considered to be representative of the group is present within the watercourses assessed. However, secondary wetland vegetation is present.

4.5.2 Role in Municipal Open Space and Biodiversity Conservation Planning

The portion of Mbokodweni River in-stream and riparian habitat under investigation has been included in the Durban Metropolitan Open Space System (D'MOSS) and is classified as 'mixed floodplain freshwater wetland' (**Figure 1**). This portion appears to be the only ecological corridor linking the upstream catchment areas with that of the remaining coastal areas. Thus, the Mbokodweni riparian corridor can be considered important from an open space/conservation planning perspective.

Figure 1: Project Site and Environmental Setting

5 METHODS

5.1 Wetland Assessment

5.1.1 Delineation

The outer temporary boundaries of the wetlands onsite were delineated using the method contained within the DWAF guideline 'A practical field procedure for the identification and delineation of wetlands and riparian areas' (DWAF, 2005). This guideline document stipulates that consideration be given to four specific wetland indicators required to determine the outer edge of the temporary boundary of a wetland. These indicators are:

- Terrain Unit - identify those parts of the landscape where wetlands are most likely to occur e.g. valley bottoms and low lying areas.
- Soil Form - identify the soil forms associated with prolonged and frequent saturation.
- Soil Wetness - identify the soil morphological "signatures" (redoximorphic features) that develop in soils characterised by prolonged and frequent saturation.
- Vegetation - identify the presence of hydrophytic vegetation associated with frequently saturated soils.

For this study the soil wetness indicator was considered the most important indicator for determining the outer boundary of wetlands and the other three indicators were used in a confirmatory role. The reasons or this being that soil wetness indicators provide a long-term indication of soil saturation levels and persist in the soil profile even if they are degraded or desiccated, thereby providing an indication of the natural extent of wetlands.

Soil and vegetation sampling was carried out along transects across the valley bottom and low-lying areas in the vicinity of proposed development. At each sample point, soil was sampled at 0-10 cm and 40-50 cm and dominant vegetation within a 5m radius of the sample point was recorded. The soil matrix chroma was recorded for each soil sample according to the Munsell Soil Colour Chart, as well as the degree and colour of mottling or any other redoximorphic features. Soil formation identification was not undertaken and considered unnecessary in this study.

A conventional handheld Global Positioning System (GPS) was used to record the location of the soil sampling points along each transect. The GPS points were then imported into ArcGIS 10 and the outer temporary wetland boundary along each transect determined. The boundary points were then combined to form a single continuous boundary using contour information, aerial photography and knowledge on the hydraulic conductivity of the soils. The GPS is expected to be accurate up to 3 metres.

5.1.2 Classification

The delineated wetlands were classified into individual hydro-geomorphic (HGM) units as per the proposed National Wetland Classification System developed by SANBI (2009). This was achieved by observing the topographical and geomorphic setting, and the general hydrology of the wetland units during the site visit.

5.1.3 Desktop Present Ecological State (PES)

No formal present ecological state assessment of the delineated wetland units was included in the appointed scope of work for this study.

A qualitative description of the hydrological, geomorphological and ecological characteristics of the delineated wetland units were provided only based on a review of existing information for the local watercourses, a review of the latest aerial photography, and a visual assessment undertaken during the field work. The following aspects and characteristics were recorded during the site visit for each watercourse type:

- Catchment transformation
- Broad vegetation communities
- Presence of direct disturbance
- Presence of erosion and sedimentation
- Presence of alien plant invasion
- Presence of water pollution

5.1.4 Functional Importance / Wetland Ecosystem Services

The current level and extent of the ecosystem services being provided by the delineated wetland units was determined using the WET-EcoServices tool developed by Kotze *et al*. (2007). WET-EcoServices is designed for inland palustrine wetlands i.e. marshes, floodplains, vleis and seeps. It was developed to assess the goods and services that individual wetlands provide in order to allow for more informed planning and decision-making. The assessment is undertaken by determining the likely "effectiveness" or ability of a wetland to deliver an ecosystem service as well as providing a measure of the extent to which the wetland is delivering an ecosystem service referred to as "opportunity" (Kotze *et al*., 2007).

The ecosystem services assessed included:

- Regulating and supporting services:
    - Flood attenuation
    - Streamflow regulation
    - Sediment trapping
    - Phosphate removal
    - Nitrate removal
    - Toxicant removal
    - Erosion control
    - Carbon storage
- Biodiversity maintenance services
- Provisioning benefits:
    - Water for human use
    - Harvestable resources
    - Cultivated foods
- Cultural services:
    - Cultural heritage
    - Tourism and recreation
    - Education and research

Specific information required to be entered into the predesigned WET-EcoServices spreadsheet was gathered during the field visit and during a desktop analysis using ArcView GIS 10. Once all the required information was entered into the spreadsheet, the effectiveness, opportunity and overall functional scores for each the ecosystem services provided by the wetland units was generated. Each overall functional score was then rated according to the rating scale in **Table 2** below.

Table 2: Classes for determining the likely extent to which a service is being supplied

Score	<0.9	0.9-1.5	1.6-2.4	2.5-3.0	>3.0
Level at which a service is being provided	Low	Moderately Low	Intermediate	Moderately High	High

The overall functional scores generated by the WET-EcoServices spreadsheet for each service do not incorporate the size of the wetlands and the size of the wetland's catchment, which are both important factors in understanding the importance of the services provided. Therefore, the overall functional scores were contextualised (weighted/adjusted) in light of the size of the wetland and the wetland's catchment to provide an indication of the importance of the wetland systems.

5.2 Riparian Zone Assessment

5.2.1 Riparian Zone Delineation

For this study, the edge of the riparian zone was used to represent the outer edge of stream and river systems onsite. In contrast to wetland areas, riparian zones are usually not saturated for periods long enough to develop hydric soils and associated redoximorphic features (DWAF, 2008). Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channels (DWAF, 2008).

The outer boundaries of the riparian areas onsite were delineated using the method contained within the DWAF guideline 'A practical field procedure for the identification and delineation of wetlands and riparian areas' (DWAF, 2005). This guideline document stipulates that consideration be given to four specific riparian indicators required to determine the outer edge. These indicators are:

- Landscape position – identify those parts of the landscape where riparian zones are most likely to occur e.g. along streams and rivers within valley bottom areas.
- Presence of alluvial soils – identify the presence of alluvial soils and fluvial deposits.
- Topography and morphological features associated with riparian areas – identify key morphological features created by fluvial activity.
- Vegetation associated with riparian areas – identify changes in plant species composition, structure and vigour relative to terrestrial/upland areas.

Soil and vegetation sampling, and the recording of riparian morphological features, was carried out along transects across the valley bottom and low-lying areas in the vicinity of proposed development. At each sample point, soil was sampled at 0-10 cm and 40-50 cm and dominant vegetation within a 5m radius of the sample point was recorded. The key morphological features associated with riparian zones that were investigated included:

- Active Channel Bank: The bank of the channel that has been inundated at sufficiently regular intervals to maintain channel form and to keep the channel free of vegetation (DWAF, 2005).
- Macro Channel Bank: The outer bank of a compound channel. The flood bench between active and macro-channel banks are usually vegetated (DWAF, 2005).

- Bar: Accumulations of sediment deposited within and along the edges of channels (DWAF, 2005).
- Mid-Channel Bar: Single bar(s) formed within the middle of the channel; flow on both sides (DWAF, 2005).
- Flood Bench (inundated by annual flood): Area between the active and macro-channel, usually vegetated (DWAF, 2005).
- Floodplain (inundated by annual flood): A relatively level alluvial (sand or gravel) area lying adjacent to the river channel, which has been constructed by the present river in its existing regime. Distinction should be made between active flood plains and relic flood plains (DWAF, 2005).
- Terrace (infrequently inundated): Area raised above the level regularly inundated by flooding (DWAF, 2005).
- High Terrace (rarely inundated): Relict floodplains which have been raised above the level regularly inundated by flooding due to lowering of the river channel (DWAF, 2005).

A conventional handheld Global Positioning System (GPS) was used to record the location of the soil sampling points, vegetation changes and key riparian morphological features along each transect. The GPS points were then imported into ArcGIS 10 and the outer boundary along each transect determined. The boundary points were then combined to form a single continuous boundary using contour information and aerial photography. The GPS is expected to be accurate up to 3 metres.

5.2.2 River Type Classification

The delineated rivers systems were classified according to the following attributes:

- Perenniality / flow type – perennial, seasonal or ephemeral
- Geomorphic zone - Based on Rowntree and Wadeson's (2000) geomorphological zonation of river channels
- Channel width

5.2.3 Preliminary Present Ecological State (PES)

The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The qualitative ecological state of the riverine habitats was assessed using an adapted version of the Index of Habitat Integrity (IHI) tool developed by Kleynhans (1996) that is currently used as part of the South African River Health Programme (RHP). The tool aims to assess the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict on the habitat integrity of the system. These disturbances include abiotic factors, such as water abstraction, weirs, dams, pollution and dumping of rubble, and biotic factors, such as the presence of alien plants and aquatic animals which modify habitat, as summarised in **Table 3** below.

Table 3: Criteria to be assessed for PES

CRITERION	RELEVANCE
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al.*, 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al.*, 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al.*, 1992). Refers to physical removal for farming, firewood and overgrazing. Includes both exotic and indigenous vegetation.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.

CRITERION	RELEVANCE
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Each of the above attributes was scored according to the classes described in **Table 4** below.

Table 4: Descriptive classes for the assessment of modifications to habitat integrity (adapted from Kleynhans 1996)

IMPACT CATEGORY	DESCRIPTION	SCORE
None	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area is affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

The PES category was then determined based on the mean score as per threating guidelines shown in **Table 5** below.

Table 5: Habitat integrity categories (Kleynhans 1996)

CATEGORY	DESCRIPTION	SCORE (% of Total)
A	Unmodified, natural.	100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-99
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 have occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions are extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural	0-19

CATEGORY	DESCRIPTION	SCORE (% of Total)
	habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

5.2.4 Ecological Importance and Sensitivity (EIS) Assessment

The ecological importance of the stream and river systems was assessed using the Ecological Importance and Sensitivity (EIS) tool developed by Kleynhans (1999).

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

The following ecological aspects should be considered as the basis for the estimation of ecological importance and sensitivity (Kleynhans, 1999):

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity should be taken into account for both the in-stream and riparian components of the river.
- Habitat diversity should also be considered. This can include specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc.
- With reference to points 1 and 2, biodiversity in its general form should be taken into account as far as the available information allows.
- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species, should be considered.
- The presence of conservation or relatively natural areas along the river section should also serve as an indication of ecological importance and sensitivity.
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes should also be considered.

Each one of these aspects was systematically rated and the median of these scores was calculated to derive the ecological importance and sensitivity category as per **Table 6**.

Table 6: Ecological Importance and Sensitivity Categories

Ecological Importance And Sensitivity Category	Range Of Median
<u>Very high</u> Quaternaries (main-stem river in quaternary) that are considered unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3 and <=4
<u>High</u> Quaternaries that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but may have a substantial capacity for use.	>2 and <=3
<u>Moderate</u> Quaternaries that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.	>1 and <=2
<u>Low/marginal</u> Quaternaries that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.	>0 and <=1

5.3 Impact Assessment

The significance of the potential impacts to local freshwater ecosystem services and aquatic/wetland biodiversity associated with the impacts of the proposed development on the delineated wetland and riparian areas was assessed as per **Table 7** below.

Table 7: Impact Assessment Criteria Descriptions and Scoring System

Score	Rating	Description
Intensity (I)		
5	High	Degree of change to local ecosystem services, resources and/or biodiversity is high (critical/severe) as a result of ecosystem destruction/loss, collapse, modification and degradation. Includes direct, indirect and cumulative effects.
4	Medium-High	Degree of change to local ecosystem services, resources and/or biodiversity is moderately-high (large/serious) as a result of ecosystem destruction/loss, collapse, modification and degradation. Includes direct, indirect and cumulative effects.
3	Medium	Degree of change to local ecosystem services, resources and/or biodiversity is moderate as a result of ecosystem destruction/loss, collapse, modification and degradation. Includes direct, indirect and cumulative effects.
2	Medium-Low	Degree of change to local ecosystem services, resources and/or biodiversity is moderately-low (mild) as a result of ecosystem destruction/loss, collapse, modification and degradation. Includes direct, indirect and cumulative effects.
1	Low	Degree of change to local ecosystem services, resources and/or biodiversity is low

Score	Rating	Description
		(limited) as a result of ecosystem destruction/loss, collapse, modification and degradation. Includes direct, indirect and cumulative effects.
Duration (D)		
5	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
4	Long-term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (30 – 100 years).
3	Medium-term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
2	Medium-short	The impact and its effects will continue or last for the period of a relatively long construction period and/or a limited recovery time after this construction period, thereafter it will be entirely negated (5 – 10 years).
1	Short-term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 5 years).
Extent (E)		
5	National & International	Effects of an impact experienced within a large geographic area beyond national boundaries and occurring at a national scale (>500km radius of the site).
4	Provincial & Regional	Effects of an impact experienced regionally beyond provincial boundaries and occurring at a provincial scales (e.g. between a 200km to 500km radius of the site).
3	Municipal & District	Effects of an impact experienced within the local town or suburban area (e.g. between a 20km to 200km radius of the site).
2	Local	Effects of an impact experienced within the local area or town/suburb (e.g. between a 1km to 20km radius of the site).
1	Site & Surrounds	Effects of an impact are experienced within or in close proximity (<1km) to the project site. However, the size of the site needs to be taken into account.
Probability (P)		
5	Definite	Impact will certainly occur (Greater than 90% chance of occurrence).
4	Probable	The impact is highly probable and will likely occur (Between a 70% to 90% chance of occurrence).
3	Possible	The impact may/could occur and has occurred elsewhere under the same conditions (Between a 40% to 70% chance of occurrence).
2	Unlikely	The chance of the impact occurring is moderately-low (Between a 20% and 40% chance of occurrence).
1	Improbable	The chance of the impact occurring is extremely low (Less than a 20% chance of occurrence).
SIGNIFICANCE = (I*2)+D+E+P		
17 - 20	High	Totally unacceptable. Impact should be avoided and limited opportunity for offsets.
14 -16	Medium-High	Generally to totally unacceptable. Impact should be avoided, mitigated or remediated unless offset by positive gains in other aspects of the environment that are of critically high importance i.e. national or international importance only.
11 - 13	Medium	Undesirable to generally unacceptable. Ideally impact should be avoided, mitigated or remediated unless offset by positive gains in other aspects of the environment that are of moderately-high to high importance.
8 - 10	Medium-Low	Acceptable. Minimise impact as far as possible as part of duty of care.
4 - 7	Low	Acceptable. Minimise impact as far as possible as part of duty of care.

6 LIMITATIONS, ASSUMPTIONS AND UNCERTAINTIES

6.1 Delineation Inaccuracy

In open sky conditions with limited tree cover, the GPS utilised is considered to be accurate up to 1m. However, under cloudy and/or tree cover, the accuracy of the GPS is reduced to 10-20m. Therefore, where tree cover resulted in substantial inaccuracies, aerial photography and contour information was utilised to refine and extrapolate the edges of the watercourses.

6.2 Riverine Habitat Integrity Assessment Limitations

It must be stressed, however, that any single-site, ground-based method will lack longitudinal continuity and may not adequately reflect an accurate assessment of the habitat integrity of the entire river (Kemper, 1999). Low confidence must therefore automatically be attached to any desktop/intermediate assessments based on the modified habitat integrity methodology, particularly in the case where extensive knowledge of the system is unavailable (Kemper, 1999).

Furthermore, the inherent subjective nature of the rating of the criteria as part of the IHI tool (Kleynhans, 1996) must also be considered as well as the fact the level of assessment undertaken was preliminary to intermediate. However, such a level of assessment was considered sufficient for the purposes of this study.

6.3 Vegetation Information Limitations

The vegetation information is based on the structure and dominant plants observed and no formal vegetation plots were undertaken within the wetland and riparian areas assessed. Furthermore, there was limited flowering of species due to field work being undertaken in the winter season, making plant identification difficult for some species. Thus, the list of vegetation cannot be considered exhaustive but the lists provide a general indication of the broad composition of the wetland and riparian vegetation communities encountered.

6.4 Study Exclusions

No aquatic macro-invertebrate, fish or terrestrial faunal sampling and assessments was undertaken as part of this study. The assessment of biodiversity importance as part of the Ecological Importance and Sensitivity (EIS) assessment was based on the habitat type and condition observed during the field work. This however, does not eliminate the possibility of threatened faunal species occurring within the areas to be affected.

7 RESULTS & DISCUSSION: DELINEATION, CLASSIFICATION AND KEY HABITAT CHARACTERISTICS

Soil and vegetation sampling, as well as the identification of key morphological terrain features, within 32m of the proposed bridge site enabled the identification and delineation of the Mbokodweni River in-stream, wetland and riparian habitats as shown in **Figure 2**.

In terms of classification, the main channel sampled was found to be a perennial lowland river of varying width (5 – 8m). The Mbokodweni River wetland and riparian area was found to comprise the following distinct morphological features:

- Active channel with marginal and non-marginal riparian vegetation
- Relic bars and flood benches with seasonal wetland habitat
- Active floodplain with seasonal wetland habitat
- Macro channel banks
- Terraces
- Hillslope seepage wetland (associated with old terrace)

7.1 Active Channel

The active channel immediately upstream and in the vicinity of the existing wooden pedestrian bridge is ±8m wide and 1-1.5m deep. The water depth was ±20cm. At the time of the site visit, flow was gentle but apparent. Upstream and at the current bridge crossing, the channel bed comprised solely of sandy alluvium with limited evidence of bedrock. It is expected that the bed has been modified by excessive sedimentation associated with disturbances to flow and sediment regimes.

About 30m downstream of the existing bridge, a riffle section occurs as the channel gradient and flow velocity increases and the bed changes from alluvium to gravel, cobbles and boulders. Flow was observed to be moderate in this riffle section. The water depth was ±10cm.

Immediately below the existing bridge, a small pool is located just off the main channel and is characterised by stagnant ‘pool-like’ flow conditions. The surface of the water in this stagnant zone was infested with the floating aquatic plant *Spirodela* sp. (Duckweed) contributing to an additional biotope.

In-stream macro invertebrate biotope diversity was moderate along the reach surveyed with 'gravel, sand and mud', stones-in-current present', 'marginal vegetation in-current', 'marginal vegetation out-of-current' and aquatic floating vegetation present.

The marginal vegetation of the active channel was totally dominated by an unknown semi-aquatic grass (still to be identified). Other marginal vegetation present in lower abundances were isolated clumps of the exotic obligate *Colocassia esculenta* (Madumbe) and the indigenous obligate aquatic fern *Cyclosorus interruptus* (Marsh Fern).

Based on a visual assessment, water clarity of the Mbokodweni water column was moderately-poor upstream and at the current bridge crossing and became clearer at the riffle section. No discernible odours were picked up during the field work. Plastic litter was prevalent within the channel.

The active banks show signs of recent incision and modification during the last wet season and have been modified in places by people and cattle gaining access to the water. However, the incision remains relatively low in terms of elevation relative to the bed of the channel. Understandably, channel bank incision is more severe at the riffle section.

Marginal bank vegetation comprised secondary herbaceous communities dominated largely by the indigenous invasive mat-forming grass *Stenotaphrum secundatum* (Buffalo Grass), a common indigenous invasive of alluvium. The active channel banks comprised solely of sandy alluvium.

7.2 Floodplain

The active channel was bordered by a floodplain wetland located ±1-2m above the present channel. The soils sampled within the floodplain comprised sandy, yellow-brown alluvial topsoils overlying medium grey silty clay. The sandy topsoils comprised medium to coarse sand with realtively high matrix chromas (3-4) with very few, large orange mottles. At 30-50cm depth, the soils changed abruptly to silty clay with low matrix chromas (0-1) and abundant, large orange-red mottles. This indicates that the floodplain wetland is inundated seasonally.

Onsite observations indicated that the floodplain surface has undergone regular disturbance in the form of regular sedimentation events, overgrazing and associated trampling and compaction, as well as physical excavation disturbance associated with the establishment of the current pedestrian bridge.

The floodplain was generally sparsely vegetated as a result of sediment deposition from the previous rainy season in conjunction the intense grazing of the vegetation and soil compaction along cattle thoroughfares. In addition, the uneven nature of the surface also indicates past excavation activities, some of which may be associated with the building of the most recent pedestrian bridge. Further, a road fill platform founded by boulders has been established within the edge of the floodplain.

The dominant plant community within the floodplain was dominated by pioneering, mat-forming grasses like *S. secundatum*, *Cynodon dactylon* (Couch Grass) and clumps of robust obligate sedges like *Cyperus dives* (Giant Sedge), *Cyperus latifolius* and *Eleocharis limosa* (Finger Rush). The sparser areas are also heavily invaded by the woody alien invasive *Datura ferox*. Conspicuous but less abundant pioneering and invasive wetland species included *Ludwigia octovalvis*, *Ageratum houstonianum* and *Parthenium* sp.

It is also important to note that the eastern edge of the floodplain is characterised by the occurrence a robust sedge dominated community dominated by *C. dives*, *C. latifolius*, *E. limosa* and *Phragmites mauritianum*. The increased soil saturation associated with this change is likely due to lateral subsurface water inputs occurring at the base of the slope.

7.3 Flood Bench

A small alluvial flood bench borders the right bank of the channel downstream of the existing bridge. The flood bench was ±30cm above the water level. The flood bench plant communities comprised a dense mat of *S. secundatum*, *Pycreus unioloides* (Uniola Flat Sedge) and *Parthenium* sp., all pioneer and invasive species known to invade wetlands and marginal riparian areas.

7.4 Terrace

Inland of the informal road fill embankment, an old alluvial floodplain surface is present. Soil sampling revealed that the top 50cm of the soil profile comprised yellow-brown coarse sand and gravel indicating past fluvial activity. The soils were not hydric but were definitely alluvial and characteristic of the riparian zone. The terrace surface was highly disturbed and modified by overgrazing and past excavation activities and vegetation cover at the time of the site visit was sparse. The vegetation that was present included clumps of pioneer grasses like *C. dactylon* and *Sporobolus pyramidalis* as well as alien invasive species like *D.ferox* and *Parthenium* sp.

Figure 2: Delineated Wetland and Riparian Areas

8 RESULTS & DISCUSSION: PRESENT ECOLOGICAL STATE (PES)

8.1 Current Impacts

The integrity of the riparian and wetlands habitats assessed has been impacted and modified by a number of direct (onsite) impacts and indirect (catchment) impacts. Based on onsite observations and a review of desktop information, the direct and indirect impacts included:

Direct impacts:

- Clearing, infilling, excavation and modification of the floodplain and terraces for the establishment of:
  - Extensive fill and spoil material.
  - Existing pedestrian bridge.
  - Stormwater outlets.
- Clearing and compaction of the wetland and riparian areas by informal pedestrian paths.
- Trampling, compaction and disturbance to floodplain wetland soils and vegetation due to overgrazing and frequent and intense burning.

Indirect impacts:

- Flow and sediment regime modification due to catchment transformation. Particularly increased flood peaks and decreased sediment inputs.
- Active bed and channel, flood bench and floodplain modification (erosion, incision, sedimentation etc.) as a result of altered flow and sediment regimes.
- In-stream water quality degradation as a result of numerous pollution point-sources within the catchment (e.g. urban stormwater outlets, surcharging sewer manholes etc.).
- Litter and solid waste pollution and associated water quality and habitat degradation.
- In-stream, riparian and wetland plant community transformation and alien invasive and ruderal/pioneer plant species domination and proliferation as a result of all the above-listed direct and indirect impacts.

8.2 Rapid Visual Assessment of Habitat Integrity

8.2.1 Riverine (Riparian) Habitat

The PES assessment was only undertaken for the riverine habitat (active channel and banks). An assessment of the PES of the larger system was not undertaken.

The results and scores for the IHI assessment are summarised in **Table 8** below. As a result of the above-listed impacts, the PES of both the in-stream and riparian habitats was assessed as being in a **Category D** state (Largely Modified).

Table 8: Index of Habitat Integrity Scores

Assessment Criteria	Score	Weighting	Weighted Score	Final IHI Score
In-Stream Habitat:				
Water Abstraction	2	14	1.12	12.88
Flow Modification	15	13	7.8	5.2
Bed Modification	20	13	10.4	2.6
Channel Modification	18	13	9.36	3.64
Water Quality Modification	15	14	8.4	5.6
Inundation	11	10	4.4	5.6
Exotic Macrophytes	5	9	1.8	7.2
Alien Aquatic Fauna	2	8	0.64	7.36
Solid Waste Disposal	12	6	2.88	3.12
		100	**46.8**	**53.2**
Riparian Habitat:				
Vegetation Removal	21	13	10.92	2.08
Exotic Vegetation Encroachment	18	12	8.64	3.36
Bank Erosion	10	14	5.6	8.4
Channel Modification	15	12	7.2	4.8
Water Abstraction	0	13	0	13
Inundation	5	11	2.2	8.8
Flow Modification	15	12	7.2	4.8
Water Quality Modification	5	13	2.6	10.4
		100	**44.36**	**55.64**

8.2.2 Wetland Habitat

For the purposes of this study, the ecological state of the floodplain wetland unit is a synthesis of the hydrological, geomorphological and vegetation health of the systems. Under natural conditions the wetland would have been fed by the seasonal flooding of the Mbokodweni River as well as lateral subsurface inputs from surrounding slopes. Based on the high level of catchment transformation, it is expected that the volume and intensity of hydrological inputs has increased, thus altering wetland hydrology. In terms of the water distribution and retention within the wetland, the main channel has not incised too substantially below the present floodplain and thus permanent inundation during the summer season is expected. Furthermore, erosion on the floodplain is minimal. Thus, for the remaining floodplain wetland area the retention and distribution of flows remains relatively intact. It is important to note, however, that there has been some infilling of the wetland edges, representing complete hydrological transformation. Thus, overall, wetland hydrology is speculated to be moderately modified (Ecological Category C).

In terms of geomorphology, catchment transformation has likely resulted in the reduction of sediment inputs over time and the increase in flood peaks has resulted in increased rates of erosion along the river. At present, channel incision below the floodplain has been small and thus the floodplain still receives sediment associated with summer season inundation. Thus, overall, wetland geomorphology is speculated to be moderately modified (Ecological Category C).

In terms of vegetation, the wetland communities observed are all secondary pioneer dominated communities that are a response to a number of direct and indirect human disturbances like too frequent burning, overgrazing, past excavation activities, pedestrian thoroughfare, informal and formal pedestrian bridge establishment and past infilling activities. These activities have combined to transform all of the natural plant communities on the floodplain. Thus, overall, wetland vegetation is speculated to be largely to seriously modified (Ecological Category D/E).

9 RESULTS & DISCUSSION: ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS) ASSESSMENT

9.1.1 Riverine (Riparian) Habitat

The current state ecological importance and sensitivity assessment of the riverine habitat as delineated in **Figure 2** was undertaken only. An assessment of the ecological importance of the larger system was not undertaken.

The river system was assessed as being of **moderate ecological importance** and sensitivity according to the EIS (DWAF, 1999) tool as summarized in **Table 9** below. This moderate rating is described as: "Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use." (DWAF, 1999).

Table 9: Ecological Importance and Sensitivity Scores

Ecological Importance & Sensitivity (EIS)	**Mbokodweni River**
Rare & endangered biota	0
Unique biota	0
Intolerant biota	1
Species richness	1
Diversity of aquatic habitats/features	2
Refuge value of habitats	2
Sensitivity of habitats to flow changes	2
Sensitivity of habitats to water quality changes	2
Migration route/corridor (aquatic & riparian)	3
Conservation importance ito protected areas & heritage sites	0
EIS Score	**1.5**
EIS Ranking	**Moderate**

9.1.2 Wetland Habitat

The current state functional importance of the floodplain wetland as delineated in **Figure 2** was undertaken only. An assessment of the functional importance of the adjacent hillslope seepage unit was not undertaken.

The WET-EcoServices assessment tool (Kotze *et al.*, 2007) revealed that the wetland has a moderately-high ability to provide sediment trapping services and a moderate ability to provide phosphate removal, nitrate removal and toxicant removal services (**Table 10**). This is because the floodplain is active and captures and stores sediment during flood events.

Due to the substantial transformation of the wetland's catchment, flood peaks have increased and water quality has decreased. Thus, the opportunity for the realization of flood attenuation, sediment trapping, phosphate removal, nitrate removal, toxicant removal and erosion control services is moderate to moderately-high. As a result, the overall functional scores for sediment trapping were moderately-high and that for the rest of the water quality enhancement services were moderate.

Taking into account the relative small size of the floodplain wetland and the large size of the wetland's catchment, the sediment trapping and the water quality enhancement services can be considered to be of moderate importance.

Table 10: Ecosystem Services Scores

Ecosystem Services	Effectiveness	Opportunity	Overall Score
Flood attenuation	1.4	3.2	2.3
Stream flow Regulation	n/a	n/a	1.2
Sediment Trapping	2.7	2.7	2.7
Phosphate Removal	2.2	2.3	2.3
Nitrate Removal	1.8	2.5	2.2
Toxicant Removal	1.9	2.3	2.1
Erosion Control	1.5	2.8	2.1
Carbon Storage	n/a	n/a	0.3
Biodiversity Maintenance	0.5 (Noteworthiness)	1.3 (Integrity)	0.9
Water Resources	n/a	n/a	1.4
Natural Resources	n/a	n/a	1.6
Cultivated Foods	n/a	n/a	1.6
Cultural Significance	n/a	n/a	1.0
Tourism & Recreation	n/a	n/a	0.6
Education & Research	n/a	n/a	0.5

10 PLANNING IMPLICATIONS AND CONSTRAINTS

Due to the moderate ecological importance and sensitivity of the river system and the moderate functional importance of the floodplain wetland, there are no fatal flaws to the current alignment of the proposed pipeline as long as:

- impacts to the main active channel are minimised,
- water quality impacts are avoided, and
- the current functionality of the Mobokdweni floodplain wetland is maintained.

These conditions can be achieved by implementing and adhering to best practice impact minimisation measures recommendations provided in **Section 11** below.

11 POTENTIAL IMPACT PREDICTION, DESCRIPTION AND MITIGATION

This section describes and assesses the predicted potential impacts on the integrity and functionality of the portion of the Mbokodweni River and floodplain system assessed in the vicinity of the proposed pedestrian bridge. The impact of the proposed pedestrian bridge as shown in **Figures 1** and **2**, and in **Appendix A**, was assessed.

11.1 Impacts Resulting from Construction Phase Activities

The construction activities associated the proposed development are listed as follows:

- Bridge footprint clearing (vegetation and soil stripping)
- Bridge pier/plinth foundation earthworks
- Channel flow diversion around bridge pier/plinth sites (only if located within in-stream habitat)
- Pier/plinth construction site dewatering (only if located within in-stream habitat)
- Pier/plinth construction
- Topsoil and subsoil stockpiling
- Hazardous substances storage, handling, mixing and disposal
- Stormwater management and erosion control
- Waste generation and disposal

11.1.1 Physical Disturbance Impacts

Impact Description:

The proposed construction of the pedestrian bridge will involve the physical modification of the wetland, riparian and in-stream areas within the construction footprint. The physical clearing of the construction servitudes will result in the clearing of wetland and riparian vegetation and topsoil, and the exposure of the bare surfaces to the elements. Such clearing and physical modification activities will likely result in the increased sedimentation of the in-stream areas, particularly during rainfall events. Furthermore, sedimentation is likely to occur as a result of soil and bank destabilization associated with the physical modification activities irrespective of rainfall events.

At this stage, only a conceptual design of the proposed bridge has been provided to the author and there is no definitive clarity on whether the bridge pier / plinths will be located in the active channel bed and banks. Furthermore, no details on the construction methods for the bridge crossing have been provided. For the purposes of this study it is assumed that at least one bridge pier / plinth will be located within the active channel and that a number of piers will be established within the floodplain wetland (it is assumed that no fill material will be established within the floodplain). The establishment of a plinth within the in-stream habitat would involve the establishment of access for heavy machinery across the active channel to the plinth foundation construction zone likely via a rock-fill or sand bag running track, the diversion of flow around the pier / plinth foundation construction zone using sandbags, the dewatering of the construction zone and the establishment of the foundation and concrete works. It is likely that flow would need to be flumed through/underneath the running track and around the in-stream construction zone. The channel bed would be permanently modified for the establishment of the construction running track and the piers / plinths.

Secondary impacts to the in-stream habitats resulting from such intense physical disturbances would be localized increased flow velocities at diversion / flume pipe outlets, the unsettling of the fine bed sediments and increased water column turbidity, the destabilization of the active channel banks and the slumping of bank material into the in-stream habitat, increased sediment deposition as a result of slumping and bank erosion, and ultimately the further modification and degradation of the local in-stream habitats in terms of sediment regime and water quality.

Secondary impacts to the riparian habitats include channel bank erosion and marginal vegetation sedimentation, increased floodplain, terrace and flood bench soil disturbance, and ultimately increased alien invasive plant proliferation.

Furthermore, the proposed clearing and modification of the watercourses unit may also result in the death of sedentary fauna like frogs and chameleons. As the watercourses to be affected are already highly disturbed, generalist and adaptable sedentary species are likely present and the potential for threatened and conservation worthy faunal fatalities is low. Nevertheless, the potential for sedentary wetland/riparian faunal fatalities is moderately-high.

Overall the anticipated change in the integrity of the floodplain wetland as a whole as a result of direct physical disturbances will likely be moderately-low at most and the impact will likely be localized. The impact on riverine habitat integrity could be moderate in a worst case scenario but is likely to also be moderately-low due to the already ‘largely modified’ state of the system. Ultimately, the impact on key regulating and supporting ecosystem services will be low in the long-term.

Recommended Mitigation Measures:

Bridge alignment and crossing design recommendations:

- The bridge must be aligned so that the river and associated floodplain are crossed at as close to right angles to the direction of flow as possible.
- To minimise the impacts to the floodplain wetland, only piers/plinths may be established within the floodplain wetland and no fill material must be deposited within the floodplain wetland. Thus, the bridge must extend across the entire floodplain wetland.
- Wherever possible, piers / plinths should be located outside of the active channel. Where unavoidable for substantiated reasons, only one pier/plinth must be established within the active channel.
- The proposed bridge must not impact any existing sewerage or water infrastructure.

General site setup recommendations:

- The edge of the active channel, floodplain wetland, hillslope seepage wetland and riparian terrace must be clearly demarcated using danger tape and stakes prior to construction commencing. Failure to do so should warrant financial penalties / fines.
- Access routes to the construction zone and the location of the construction laydown / storage areas must be agreed on by the Environmental Control Officer (ECO) prior to construction commencing. Thereafter, the access route and laydown/ storage must be clearly demarcated and all areas outside of these areas considered no-go areas. Laydown and storage areas must not be located within the floodplain wetland.
- Soil stockpiles areas must also be designated and be located outside of the floodplain wetland. The location of the soil stockpiles must be agreed upon by the ECO prior to construction commencing.
- If applicable, the location of the existing sewer and water pipelines must be surveyed and demarcated prior to construction commencing.

Construction and rehabilitation recommendations for bridge crossing:

- Construction should be undertaken in the winter months between the months of April and August.
- A photographic record of the state of the wetland riparian areas prior to construction must be compiled for reference and rehabilitation purposes.
- Disturbance to the delineated wetland and riparian areas along the bridge route should be restricted to a one-way construction right-of-way (ROW) corridor. The width of the ROW corridor should be as narrow as practically possible and should be demarcated and fenced off during the site setup phase to the satisfaction of the ECO.
- Once the construction ROW is established, all areas outside of the demarcated ROW must be considered no-go areas. Encroachment into no-go areas without prior approval from the ECO must be penalised with a fine.
- The construction ROW should comprise a one-way running track of a maximum width of 4m.
- Wherever possible, the running track should not be established within the active channel and should extend into the wetland/riparian areas from each valley side to the furthest pier construction site.
- Where a running track across the active channel is necessary, the running track must be established on top of either a berm of sandbags or imported rock. The running track across the active channel should be as narrow as possible and must be strictly one way.
- Flow should be diverted through the running track berm using short flume pipes established during the running track establishment or using the coffer dam method whereby the running track is only established from one side to the plinth/pier site.

- Erosion control must be established at flume pipe or coffer dam diversion outlets.
- If dewatering is required, a dewatering area must be designated on the floodplain 20m from the edge of the active and macro-channels. The pumped water should be discharged into discharge areas comprising haybales.
- Before clearing, indigenous plants suitable for rescue are to be relocated to a temporary holding area by a vegetation specialist / botanist. Indigenous plants suitable for rescue include sedges and grass clumps.
- Before stripping, all vegetation within the wetland and riparian areas must be chopped down by hand prior to more intensive clearing and alteration. Any fauna encountered during the clearing process must be relocated to the adjacent habitats under the supervision of the ECO.
- Thereafter, the working servitude is to be stripped of topsoil and vegetation to a nominal depth and this top soil placed at a temporary stockpile area and maintained for re-use.
- Topsoil and subsoil must be stored separately.
- Wherever possible, excavations within the watercourses should be undertaken by hand. If this is unfeasible for sound reasons, a small excavation vehicle may be used.
- Once the bridge is completed, the running track must be removed by hand wherever possible.
- Once completed, the disturbed bed and banks of the streams and wetlands must be re-shaped under the supervision of the ECO.
- Compacted wetland and riaprian soils along the running track must be ripped to a depth of 20cm.
- Once the riparian areas are re-shaped and the compacted soils are ripped, topsoil from that particular area must be reinstated to the satisfaction of the ECO.
- The prepared soils along the construction corridor must be re-vegetated via the planting of rescued plants and via hand broadcasting and plugs by a professional landscaper or horticulturalist. The seed mix should comprise an indigenous grass mix comprising of 'runner' grasses like *Cynodon dactylon* var. Sea Green.
- If the river banks require rehabilitation, The banks must be armoured against erosion using biodegradable geofabrics to facilitate establishment of vegetation e.g. Geojute®. *C. dactylon* var. Sea Green plugs should be planted on the banks.
- The areas to be hand broadcasted must be lightly watered before planting to ensure that the seed material does not come into contact with dry ground.
- The seed mixture must be evenly broadcasted over the entire surface of the construction corridor. In this regard, a mechanical seeding device may be used in order to ensure a uniform distribution of grass seed over the area to be rehabilitated.
- The grass seed must be lightly worked into the upper topsoil layer by means of hand labour (using a rake).

- The seeded area must be watered daily until planting has been completed.
- The soil must be kept moist for the first two weeks after hand broadcasting to ensure seed germination. Thereafter irrigation should be applied weekly until reasonable groundcover is obtained.
- Watering should be gentle so that rill erosion is avoided and minimised.
- Any erosion damage resulting from watering/irrigation must be repaired immediately.
- The disturbed area should be monitored for erosion and alien plant encroachment weekly for a month, and monthly for 3 months.
- Alien plants within the rehabilitated area must be eradicated immediately. The alien plant species should be removed by hand-pulling where possible. Herbicides should be utilised where hand pulling is not possible.
- ONLY herbicides which have been certified safe for use in watercourses by independent testing authority to be used.
- The ECO must undertake a close-out audit after the monitoring period and sign-off on the success of the rehabilitation.
- A detailed method statement for the bridge crossing must be submitted to the ECO by the contractor for approval prior to construction commencing.

General construction management measures:

- All contractor staff working onsite must undergo an environmental induction prior to moving onto site and all site managers must be well acquainted with the construction phase environmental management programme (EMPr). This EMPr must be kept onsite at all times. Failure to show proof of staff inductions and failure to keep the EMPr onsite must be penalised with a fine. The education of the contractor staff is the responsibility of the site manager. The appointed ECO must oversee the induction programme.
- Strict solid waste management and disposal measures must be included in the construction phase environmental management programme (EMPr).
- Chemical toilets must be provided for the construction workers and these toilets must be located at least 20m away from all wetland and riparian areas and should be regularly serviced.

Alien plant removal recommendations:

- All bare surfaces across the construction site must be checked for alien plants at the end of every week and alien pants removed by hand pulling and adequately disposed.

Stormwater management and erosion control recommendations:

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

- Clearing activities must only be undertaken during agreed working times and permitted weather conditions. If heavy rains are expected, clearing activities should be put on hold. In this regard, the contractor must be aware of weather forecasts.
- Construction activities should be scheduled to minimise the duration of exposure to bare soils on site, especially on steep slopes.
- The full length of works must NOT be stripped of vegetation prior to commencing with other activities.
- The unnecessary removal of groundcover from slopes must be prevented, especially on steep slopes.
- Sandbags and silt fences must be available for use to control runoff, especially on sloping surfaces.
- The berms, sandbags and/or silt fences must be monitored for the duration of the construction phase and repaired immediately when damaged. The berms, sandbags and silt fences must only be removed once vegetation cover has successfully re-colonised the embankments.
- After every rainfall event, the contractor must check the site for erosion damage and rehabilitate this damage immediately. Erosion rills and gulleys must be filled-in with appropriate material and silt fences must be established along the gulley for additional protection until grass has re-colonised the rehabilitated area.

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

<u>**Impact Assessment:**</u>

A description and rating of the potential impact of the direct physical disturbance of the wetland and riparian areas is provided in **Table 11** below. The significance of the direct physical impacts on freshwater ecosystem and resources was assessed as being medium-low and acceptable provided that the mitigation measures provided are strictly adhered to.

Table 11: Impact Assessment for Physical Disturbance Impacts

Impact Assessed	*Reduction/ degradation in freshwater ecosystem services and biodiversity as a result of physical disturbance impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	1	Low	1	Low

Extent	2	Local	2	Local
Duration	2	Medium-short	1	Short-term
Probability	5	Definite	5	Definite
Impact Significance	**11**	**Medium-Low**	**10**	**Medium-Low**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	No Loss	n/a	No Loss
Cumulative Effects	n/a	Limited	n/a	Limited

11.1.2 Water Quality Impacts

Impact Description:

The undertaking of construction work within the riparian and in-stream habitat will expose these habitats to increased pollution risks. Surface runoff and/or river water contamination may occur during the construction phase as a result of negligence, inappropriate planning, lack of supervision and general handling errors. Potential pollutants include cement, oils, hydrocarbons, chemical admixtures and waste from chemical toilets. The degree of contamination depends on the extent of the chemical spill or the cumulative effects of a number of chemical spills.

Cement and hydrocarbons are considered toxicants that reduce water quality through the alteration of pH, biological oxygen demand and turbidity that ultimately results in negative impacts on the survival and mortality rates of aquatic biota. Besides reducing water quality, the toxicants also have direct impacts on aquatic biota like the clogging/coating of gills and the contamination of aquatic food (e.g. detritus, bacteria, algae, higher plants and invertebrates).

No sampling of the in-stream water quality was undertaken as part of the assessment. However, based on the moderately-high level of catchment transformation, high number of pollution point sources in the catchment and observed water quality, it is expected that the current stream water quality of the river is moderately poor. Thus, the impact on local stream water quality and aquatic biota resulting from the envisaged worst-case episodic contamination impacts during the construction phase will likely be moderate in terms of the cumulative effect on local water quality. Nevertheless, pollution of the Wewe River will likely lead to further degradation from an ecological perspective as well as contribute cumulatively to a decreased water quality downstream.

In terms of the impacts to wetlands, potential contamination of the artificial wetland include the domination of a particular species as a result of the competitive advantage created by pollutants or the dieback of floral and faunal species and the resultant loss of biodiversity (Coetzee, 1995). However, it is important to note that the monotypic floral species assemblages observed were likely already impacted on by water quality changes. Thus, the impact of further contamination events on habitat integrity will be reduced.

Due to the already poor state of the in-stream and riparian habitat, the change in the state of the riverine habitat as a result of water quality impacts will likely be moderately-low at most and the impact will likely be localized to the Wewe Siphon Dam. Furthermore, the impact will be medium-short-term in duration and possible to probable in terms of probability.

Recommended Mitigation Measures:

Hazardous substances handling, storage and disposal recommendations:

- If applicable, hazardous storage and refuelling areas must be bunded prior to their use on site during the construction period. The number of bunds and their location and their construction should occur during the site setup phase.
- Mixing and/or decanting of all chemicals and hazardous substances must take place on a tray, shutter boards or on an impermeable surface and must be protected from the ingress and egress of stormwater.
- Cement and concrete mixing must not take place within the vicinity of the active channel and floodplain and hillslope seepage wetlands.
- Every effort must be made to capture concrete/cement spillage during the establishment of the piers / plinths within the wetland and riparian areas.
- No vehicles transporting concrete, asphalt or any other bituminous product may be washed on site.
- Vehicle maintenance should not take place on site unless a specific bunded area is constructed for such a purpose.
- Ensure that transport, storage, handling and disposal of hazardous substances is adequately controlled and managed. Correct emergency procedures and cleaning up operations should be implemented in the event of accidental spillage.
- Implement appropriate operation and maintenance of construction equipment to avoid petrochemical products from polluting the soil.
- A spill contingency plan for both the construction phase must be drawn up and incorporated into the EMPr. This should include procedures to guide the clean-up of accidental spillages and its disposal.
- Bins should be provided to all areas that generate waste e.g. worker eating and resting areas and the camp site. General refuse and construction material refuse should not be mixed.

Impact Assessment:

A description and rating of the potential impact of water quality impacts (during the construction phase) is provided in **Table 12** below. The significance of the water quality impacts on freshwater ecosystem and resources was assessed as being medium and generally unacceptable under a poor mitigation scenario. With the effective implementation of appropriate mitigation, the impact was assessed as being of low significance and acceptable.

Table 12: Impact Assessment for Water Quality Impacts

Impact Assessed	*Reduction/ degradation in freshwater ecosystem services and biodiversity as a result of water quality impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	2	Medium-Low	1	Low
Extent	3	Municipal	2	Local
Duration	2	Medium-short	1	Short-term
Probability	4	Probable	3	Possible
Impact Significance	**13**	**Medium**	**8**	**Low**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	No Loss	n/a	No Loss
Cumulative Effects	n/a	Limited	n/a	Limited

11.2 Impacts Resulting from Operational Phase Activities

Potential operation impacts to riverine habitat integrity will be:

- Floodplain deactivation.
- Flow alteration (if piers/plinths located within the in-steam habitat).
- Shading out of a section of riparian and in-stream habitat underneath the bridge.
- Increased risk of solid waste disposal into the river by bridge users.

11.2.1 Floodplain Deactivation Impacts

Impact Description:

If fill material is established within the floodplain wetland as part of bridge crossing, the sections of the floodplain immediately downstream of the fill material will be starved of sediment and inundation and thus be deactivated. This would essentially result in the loss of flood attenuation and phosphate removal services associated with the deactivated area and contribute to the cumulative reduction in flood attenuation and phosphate trapping services within the Mbokodweni River system. The outcome of this function reduction will be a small increase floodpeaks downstream, which, when considered cumulatively, could be a moderate impact.

Recommended Mitigation Measures:

No fill material must be established within the floodplain wetland and the entire floodplain should be spanned using piers/plinths.

Impact Assessment:

A description and rating of the potential impact of the deactivation of portions if the floodplain is provided in **Table 13** below. The significance of the deactivation impacts on freshwater ecosystem and resources was assessed as being medium and generally unacceptable under a poor mitigation scenario. With the effective implementation of appropriate mitigation, the impact was assessed as being of low significance.

Table 13: Impact Assessment for Floodplain Deactivation Impacts

Impact Assessed	*Reduction/ degradation in freshwater ecosystem services and biodiversity as a result of floodplain deactivation impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	2	Medium-Low	1	Low
Extent	3	Municipal	1	Site
Duration	4	Long-term	4	Long-term
Probability	5	Probable	1	Unlikely
Impact Significance	**16**	**Medium**	**8**	**Low**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	Low	n/a	No Loss
Cumulative Effects	n/a	Medium	n/a	Low

11.2.2 Flow Alteration Impacts

Impact Description:

Physical bank and bed modification and the establishment of piers / plinths within the riparian and in-stream habitat will likely to alter flow paths which could also lead to some channel erosion and sedimentation, especially during large storm events. Further erosion will contribute to increased bank disturbance and in-stream sedimentation and ultimately increased invasion of the riparian areas by alien and indigenous pioneer plant species and increased turbidity and bed sedimentation.

Due to the already poor state of the in-stream and riparian habitat, the change in the state of the riverine habitat as a result of the anticipated flow diversion will likely be low to moderately-low at most and the impact will likely be localized.

Recommended Mitigation Measures:

Wherever possible, no piers or plinths should be established within the active channel. Where not feasible for substantiated reasons, a maximum of one pier/plinth must be established.

Impact Assessment:

A description and rating of the potential impact of the flow impacts is provided in **Table 14** below. The significance of the flow impacts on freshwater ecosystem and resources associated with the establishment of one pier within the channel was assessed as being medium-low.

Table 14: Impact Assessment for Flow Alteration Impacts

Impact Assessed	*Reduction/ degradation in freshwater ecosystem services and biodiversity as a result of flow alteration impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	1	Low	0	n/a
Extent	1	Site	0	n/a
Duration	4	Long-term	0	n/a
Probability	3	Possible	0	n/a
Impact Significance	**10**	**Medium-Low**	**0**	**No Impact**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	No Loss	n/a	No Loss
Cumulative Effects	n/a	Medium-Low	n/a	Low

11.2.3 Shade Impacts

Impact Description:

A small portion of the riparian and in-stream habitat under the proposed bridge will become shaded for all or part of the day indefinitely. This will reduce sunlight exposure to the effected in-stream and riparian areas and result in decreased water temperatures and plant growth.

Due to the already poor state of the in-stream and riparian habitat and the small area affected, the change in the state of the riverine habitat as a result of shading will likely be low and the impact will be localized.

Recommended Mitigation Measures:

n/a

Impact Assessment:

This impact was not formally assessed due to its negligible nature.

11.2.4 Solid Waste Impacts

Impact Description:

By nature, the existing and proposed bridge increased/increases the risk of the disposal of solid waste and other waste materials (e.g. grey water) directly into the river, which would contribute to the degradation in water quality and in-stream bed and bank habitats.

Due to the already poor state of the in-stream and riparian habitat, the change in the state of the riverine habitat as a result of increased solid waste inputs will likely be moderately-low at most and the impact will likely be localized. Furthermore, the impact will be long-term in duration and probable in terms of probability.

It is important to note, however, that such an impact is already present with the existing bridge and as such the proposed bridge will not result in a new or more substantial impact relative to the current scenario.

Recommended Mitigation Measures:

Educational signs must be established on, or adjacent to, the bridge entrances to educate the local residents on the Mbokodweni River and prohibitions with regards to solid waste and other hazardous substances.

Impact Assessment:

A description and rating of the potential solid waste impact is provided in **Table 12** below. The significance of the solid waste impacts on freshwater ecosystem and resources was assessed as being medium and generally unacceptable under a poor mitigation scenario. With the effective implementation of appropriate mitigation, the impact was assessed as being of low significance.

Table 15~~12~~: Impact Assessment for Floodplain Deactivation Impacts

Impact Assessed	*Reduction/ degradation in freshwater ecosystem services and biodiversity as a result of solid waste impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	1	Low	1	Low
Extent	2	Local	2	Local
Duration	4	Long-term	4	Long-term
Probability	4	Probable	4	Probable
Impact Significance	**12**	**Medium-Low**	**12**	**Medium-Low**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	Low	n/a	Low
Cumulative Effects	n/a	Medium-Low	n/a	Medium-Low

12 CONCLUSION

GCS (Pty) Ltd was appointed by SiVEST, on behalf of the eThekwini Municipality, to conduct a wetland and riparian assessment of the portions of the Mbokodweni River to be directly affected by the proposed pedestrian bridge to link the Emansomini and Umlazi Y-section suburbs in the eThekwini Municipality. The appointed scope of work was to delineate all wetland and riparian habitat within 32m of the proposed bridge crossing, describe the ecological state and functional importance of the Mbokodweni River wetland and riparian habitats, and identify, describe and assess the potential impacts of the proposed bridge on the Mbokodweni River and freshwater ecosystem services/resources as well as identify mitigation measures to be implemented.

Soil and vegetation sampling in conjunction with the recording of riparian morphological features identified the presence of a wetland and riparian zone comprising the following morphological features:

- Active channel bank
- Seasonal floodplain wetland
- Hillslope seepage wetland
- Flood bench
- Terrace

The riparian and wetlands habitats delineated have been impacted and modified by a number of direct (onsite) impacts and indirect (catchment) impacts. Based on onsite observations and a review of desktop information, the direct and indirect impacts included:

<u>Direct impacts:</u>

- Clearing, infilling, excavation and modification of the floodplain and terraces for the establishment of:
    - Extensive fill and spoil material.
    - Existing pedestrian bridge.
    - Stormwater outlets.
- Clearing and compaction of the wetland and riparian areas by informal pedestrian paths.
- Trampling, compaction and disturbance to floodplain wetland soils and vegetation due to overgrazing and frequent and intense burning.

<u>Indirect impacts:</u>

- Flow and sediment regime modification due to catchment transformation. Particularly increased flood peaks and decreased sediment inputs.
- Active bed and channel, flood bench and floodplain modification (erosion, incision, sedimentation etc.) as a result of altered flow and sediment regimes.
- In-stream water quality degradation as a result of numerous pollution point-sources within the catchment (e.g. urban stormwater outlets, surcharging sewer manholes etc.).
- Litter and solid waste pollution and associated water quality and habitat degradation.

- In-stream, riparian and wetland plant community transformation and alien invasive and ruderal/pioneer plant species domination and proliferation as a result of all the above-listed direct and indirect impacts.

As a result of the above-listed impacts, the integrity of both the in-stream and riparian habitats was assessed as being in a Category D state (Largely Modified). Similarly, the integrity of the floodplain wetland was also assessed as being moderately to largely modified.

In terms of importance, the riverine system was assessed as being of moderate ecological importance and sensitivity despite the moderately-high level of modification due to the moderate value of the riverine system in terms of refuge value and moderate sensitivity to flow changes. It is also important to note that the riverine system is important in terms of ecological connectivity between upstream and downstream reaches and is currently included in D'MOSS.

The floodplain wetland was assessed as being of moderate functional importance due largely to the moderate level at which flood attenuation, sediment trapping and water quality enhancement services are being provided as well as large size of the wetland's catchment.

In terms of potential impacts, the development of a new pedestrian bridge is expected to result in a number of potential direct and indirect impacts to the Mbokodweni River in-stream and riparian habitat and floodplain wetland habitat during the construction and operational phases. These impacts are broadly grouped into the following categories:

<u>Construction Phase Impacts:</u>

- Direct physical disturbances and associated impacts
- Water quality impacts

<u>Operational Phase Impacts:</u>

- Floodplain deactivation impacts
- Flow diversion impacts
- Shade impacts
- Solid waste impacts

Overall, the most significant potential impacts are:

- the direct physical disturbance and associated erosion and sedimentation impacts during the construction phase;

- the water quality impacts during the construction phase; and
- the floodplain deactivation impacts during the operational phase.

The change in current riverine and wetland integrity as a result of the potential impacts arising during the construction phase activities was assessed as being moderately-low as long as best practice planning, design, construction and rehabilitation measures are implemented by the contractor. A comprehensive list of mitigation measures to reduce construction phase impacts has been provided to guide the ECO and contractor and it is important that these measures are strictly adhered to.

The change in current riverine integrity as a result of the potential impacts arising during the operational phase activities on was assessed as being moderate if a portion of the floodplain is in-filled for the bridge crossing but low to moderately-low if the floodplain area is appropriately spanned to ensure that there is no floodplain deactivation.

Overall, the anticipated impact to riverine habitat integrity was generally assessed as being moderately-low due to the already impacted state of the in-stream, riparian and wetland habitat.

Impact significance was assessed based on the anticipated potential impacts to freshwater ecosystems services and associated resources. Only the potential construction phase water quality impacts and the operational floodplain deactivation impacts were assessed as being of medium significance under a worst-case or poorly mitigated scenario. With the implementation of the recommended mitigation measures, the significance of these potential impacts can be reduced to acceptable levels. With regards the rest of the identified potential impacts, the significance of these impacts are assessed as being of low to moderately-low significance. Nevertheless, it is important that the mitigation measures recommended for these impacts are adhered to in line with the duty of care principle of the NEMA.

13 REFERENCES

Coetzee, M. A. S. 1995. Water Pollution in South Africa: It's Impacts on Wetland Biota; In Cowan, G. I. (ed). Wetlands of South Africa. Department of Environmental Affairs and Tourism (DEAT), Pretoria.

Collins, N. B. 2005. Wetlands: The basics and some more. Free State Department of Tourism, Environmental and Economic Affairs.

Driver, A., Nel, J. L., Snaddon, K., Murray, K., Roux, D. J., Hill, L., Swartz, E. R., Manuel, J. and Funke, N. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. Report to the Water Research Commission. WRC Report No. 1801/1/11.

Kleynhans CJ 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). Journal of Aquatic Ecosystem Health, 5: 41-54.

Kotze, D., Marneweck, G., Batchelor, A., Lindley, D. and Collins, N. 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services provided by wetlands. Wetland Management Series. Water Research Commission Report TT 339/09.

Macfarlane, D., Kotze, D., Ellery, W., Walters, D., Koopman, V., Goodman, P. and Goge, M. 2009. WET-Health: A technique for rapidly assessing wetland health. Wetland Management Series. Water Research Commission Report TT 340/09.

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

Nel, J. L., Murray, K. M., AM Maherry, A. M., Petersen, C. P., DJ Roux, D. J., Driver, A., Hill, L., van Deventer, H., Funke, N., Swartz, E. R., Smith-Adao, L. B., Mbona, N., Downsborough, L. and Nienaber, S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. Report to the Water Research Commission. WRC Report No. 1801/2/11.

River-Wise. 2012. Wetland Delineation and Assessment, Proposed Factories and Taxi Rank, KwaMashu E, eThekwini. Specialist Report prepared for ECA Consulting. Project No: 030-2012. River-Wise, Pietermaritzburg.

Rowntree KM and RA Wadeson. 2000. Field manual for channel classification and condition assessment. National Aquatic Ecosystem Biomonitoring Programme Report Series No. 13. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

SANBI (2009). Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

APPENDIX A – CONCEPTUAL DESIGNS