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Proposed Wewe River Pedestrian Bridge between Sandfields and Burbreeze in Tongaat, eThekwini Municipality, KwaZulu-Natal

Wetland and Riparian Zone Assessment Report

Version - 2

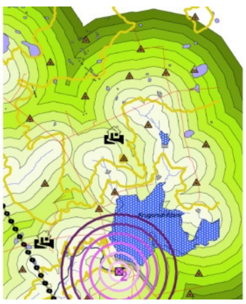
10 October 2014

GCS Project Number: 14-491

Prepared For:

SiVEST SA (Pty) Ltd

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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)

10 October 2014

Date

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1 INTRODUCTION

1.1 Project Background and Description

The applicant/developer, eThekwini Municipality, intends to develop a pedestrian bridge across the Wewe River to link the Sandfields and Burbreeze suburbs located within the greater Tongaat 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 Wewe 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 within a watercourse or within 32 metres of a watercourse, 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 more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock or more than 5 cubic metres from: (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 Wewe River that bisects the residential suburbs of Sandfields and Burbreeze, and is located in a section of river between the Dudley Pringle Dam located 800m upstream and the Wewe Siphon Dam located 1km downstream as shown in **Figure 1**. The Wewe River is a left bank tributary of the oThongathi River that flows into the Indian Ocean south of the Zimbali Coastal Forest Estate. The confluence of the Wewe River with the oThongathi River is approximately 3km downstream of the proposed bridge site.

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, 2014). The present ecological state of the oThongathi River at its confluence with the Wewe River (as assessed in 1999) is moderately modified (Class C) and the river condition is rated as a 'D'.

4.3 Geological Setting

According to the eThekwini geology spatial dataset, the geology underlying the bridge site is alluvium and the surrounding geology comprises Pietermaritzburg Shale. 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 Wewe 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 FEPAs to the bridge site is a modified patch of valley bottom wetland located 500m upstream immediately below the Dudley Pringle Dam, and an artificial wetland associated with the Wewe Siphon Dam which in reality has limited true wetland habitat.

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, however, that no primary wetland habitat that can be considered to be representative of the group is present within the watercourses assessed. Most of the riparian and wetland habitat was highly modified and degraded and characterised by secondary vegetation communities.

4.5.2 Role in Municipal Open Space and Biodiversity Conservation Planning

The portion of Wewe 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 Wewe and Golomi River wetland, riparian and open water habitats with the greater oThongathi freshwater ecosystem. Thus, the Wewe 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:

- <u>Active Channel Bank</u>: 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).
- <u>Macro Channel Bank</u>: The outer bank of a compound channel. The flood bench between active and macro-channel banks are usually vegetated (DWAF, 2005).
- <u>Bar</u>: 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.
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 habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

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	>2 and <=3

Ecological Importance And Sensitivity Category	Range Of Median
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.	
Moderate 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
Low/marginal 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 (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

Score	Rating	Description
		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 Wewe River in-stream and riparian zone as shown in **Figure 2**. In terms of classification, the main channel sampled was found to be a perennial lowland river of varying width (3 – 12m). The Wewe River riparian area was found to comprise the following distinct morphological features:

- Active channel bank
- Macro channel bank
- Flood bench
- Floodplain
- Terrace

7.1 Active Channel

Upstream of the proposed bridge crossing, the current active channel is 3-4m wide and 0.5-1m deep. At the time of the site visit, flow was moderate within the active channel due largely to a small local steepening in longitudinal bed gradient (riffle). The channel bed upstream of the riffle comprised sand, gravel and cobbles. At the riffle, the bed comprised largely of dark, angular shale boulders, cobbles and gravel.

In-stream macro invertebrate biotope diversity was low with only ‘rocks-in-current’ and ‘marginal vegetation in-current’ present. The marginal vegetation of the active channel was dominated by the semi-aquatic grass *Echinochloa pyaramidalis* (Antelope Grass) and to a lesser extent by *Pennisetum natalense*.

Along the proposed bridge alignment (current pedestrian crossings) the active channel abruptly widens and deepens into an approximately 8m wide and 1-2m deep channel that is characterised by stagnant ‘pool-like’ flow conditions. The stagnant flow is a result of the impoundment of flow by the Siphon Dam downstream. It was observed that the proposed bridge alignment roughly marks the upper-most effects of impoundment.

During the site visit, the bed comprised thick sand and mud deposits and it is expected that the original bed habitat has long been smothered and in-filled by thick layers of sediment deposition. In-stream biotope diversity was low with only ‘gravel, sand and mud’ and ‘marginal vegetation out-of-current’ present. A large infestation of the exotic floating aquatic weed *Pistia stratiotes* (water lettuce) was also present on top of the open water immediately below the pipe bridge contributing to an additional biotope.

Based on a visual assessment, water quality in the stagnant in-stream areas appears to be moderately-poor to poor as evidenced by the sewage-like smell, the oily-like scum layer, solid waste pollution and the proliferation of *P. stratiotes* on the water surface.

In the vicinity of the proposed bridge crossing, a sewer pipeline has been established across the river via a pipe bridge and the banks in the vicinity of this pipeline have been physically modified by earthworks. Pedestrian pathways had also been established to and from the pipe bridge through the channel banks as the local residents currently use the pipe bridge to cross the river. This has resulted in bank compaction and limited vegetation cover.

Upstream of the proposed bridge crossing, the marginal vegetation of the active channel generally comprised dense clump grasses dominated by the alien invasive *Pennisetum purpureum* (Napier Fodder) and by *E. pyaramidalis*. At, and downstream of the proposed bridge crossing, marginal vegetation cover was limited with sparse, weed dominated grass and herbaceous vegetation cover dominated by *P. purpureum*. A dense stand of *Phragmites mauritianus* and *E. pyaramidalis* was also present within the active channel associated with an excavated depression on the floodplain that has been cut into the active channel bank.

The non-marginal bank vegetation communities present comprised mixes of dense alien invasive dominated herbaceous and grass dominated plant communities with some woody elements and sparse weedy herbaceous communities located within the more disturbed areas along the current pedestrian path and sewer pipeline servitude. The dense grass and herbaceous riparian bank communities comprised grass and herbaceous communities with some woody elements dominated by the invasive species: *P. purpureum*, *Morus alba* (Mulberry), *Solanum mauritianum* (Bugweed) and *Stenotaphrum secundatum* (Buffalo Grass) with some less dominant indigenous riparian and wetland species that included *Ficus sur* (Cape Fig) and *Ludwigia octovalvis*. At and downstream of the proposed bridge crossing, riparian vegetation was sparse and dominated by invasive weedy species that included *P. purpureum* and *Centella asiatica*, as well as *Thunbergia alata* (Back-eyed Susan) within the more shaded areas.

7.2 Flood Bench

Upstream of the proposed crossing, the right bank of the active channel is bordered by a ±3m wide food bench. The flood bench is a near-flat surface elevated approximately 1m above the bed of the active channel. The flood bench terminates at the base of a steep 1-

2m high bank that comprises the left macro-channel bank. The flood bench disappears as the channel widens at the proposed bridge crossing. Vegetation cover on the flood bench comprised clumps of *P. purpureum* separated by sparsely vegetated areas dominated by *S. secundatum* and various weedy herbs.

7.3 Macro-Channel

The active channel is located within a larger, incised channel referred to as a macro-channel. For the purposes of this study, the macro-channel marks the outer boundary of the active channel and where the flood bench is present, it marks outer boundary of the flood bench. In general, the macro-channel banks showed evidence of modification and instability in form of slumping and sparse vegetation cover. The vegetation of the macro-channel generally reflected that of the non-marginal active channel vegetation described above.

7.4 Floodplain

The alluvial floodplain delineated represents a remnant of a once larger floodplain area that has been encroached upon by residential development. The surface of the remaining floodplain area has been highly modified by earthworks and clearing activities associated with residential development and sewer pipelines.

It is expected that the natural flow regime of the channel has been substantially modified by the effects of the upstream Dudley Pringle Dam and downstream Wewe Dam. These dams have acted to reduce the floodpeaks of the portion of the Wewe Rover under investigation and thus reduce the water and sediment inputs to the floodplain. This has effectively transformed the floodplain surface into more of a terrace surface.

The alluvial soils sampled between 0-50cm depth comprised relatively uniform, leached, poorly structured, medium brown-grey fine sand with a matrix colours ranging from 10YR 4/2-3 to 10YR 4/4. Most of the soils sampled had no mottles but gleyed depletions were present, although rare. This indicates that very weakly temporary wetland soils are present within the floodplain. However, for the purpose of this study, the majority of the floodplain was considered a riparian floodplain. Upstream of the proposed bridge crossing, the alluvial floodplain has been modified by excavation activities and an artificial wetland habitat is located within one of the excavated depressions as shown in **Figure 2**.

In terms of vegetation, the floodplain was characterised by a number of disturbed, monotypic, secondary plant communities that included a dense stand of *P. purpureum* and a secondary grass dominated patch dominated by the indigenous invasive grass *Eragrostis curvula* (Weeping Love Grass). The vegetation within the wet excavated depression comprised a dense, monotypic stand of the invasive facultative and obligate wetland species: *P. mauritianum*, *P. purpureum*, *E. pyaramidalis* and *Colocassia esculenta* (Madumbe). The floodplain areas upstream of the excavated depression are predominantly woody and dominated by *Eucalyptus* sp. and *Syzygium cordatum* (Water Berry) with limited basal herbaceous cover.

7.5 Terrace

The left macro-channel bank of the river was found to be bordered by a 5-8m wide terrace lying approximately 3m above the elevation of the channel bed. The terrace comprised a disturbed and dry alluvial surface with fine sandy alluvium and moderate to sparse vegetation cover. The terrace areas were generally shaded as a result of the occurrence of large trees like *Eucalyptus* sp. and S. *cordatum*. The groundcover was characterised by a secondary weedy herbaceous layer that was dominated by *Setaria megaphylla* (Broad-leaved Bristle Grass), *T. alata* and *Sphagneticola trilobata*. *Protorhus longifolia* (Cape Beech) sapplings were also common.

Soil sampling revealed that no hydric soils were present within the terraces. The soils comprised medium to light brown-grey fine sandy alluvium with relatively low matrix chromas (3-4) but no evidence of redoximorphic features like mottles and depletions.

Due to the alteration of the natural flow regime by the upstream and downstream dams, it is likely that the terrace is not inundated at present.

Figure 2: Delineated Riparian Areas

8 RESULTS & DISCUSSION: PRESENT ECOLOGICAL STATE (PES)

8.1 Current Impacts

The integrity of the portion of the river system 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 river system for the establishment of :
  - Residential properties and embankments.
  - Sewer pipeline and pipe bridge.
  - Stormwater outlets.
- Clearing and compaction of the river system by informal pedestrian paths.

Indirect impacts:

- Flow and sediment regime modification due to catchment transformation and the effect of upstream and downstream dams. Particularly decreased flood peaks and sediment inputs as a result of the upstream and downstream dams.
- Bed, channel and riparian zone modification (erosion, incision 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 and riparian 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 Habitat Integrity

The PES assessment was only undertaken for the riverine habitat as delineated in **Figure 2**. 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 E** state (Seriously Modified).

Table 8: Index of Habitat Integrity Scores

Criteria	Score	Weighting	Weighted Score	Final IHI Score
In-Stream Habitat:				
Water Abstraction	11	14	6.16	7.84
Flow Modification	23	13	11.96	1.04
Bed Modification	21	13	10.92	2.08
Channel Modification	20	13	10.4	2.6
Water Quality Modification	20	14	11.2	2.8
Inundation	18	10	7.2	2.8
Exotic Macrophytes	18	9	6.48	2.52
Alien Aquatic Fauna	5	8	1.6	6.4
Solid Waste Disposal	15	6	3.6	2.4
		100	**69.52**	**30.48**
Riparian Habitat:				
Vegetation Removal	22	13	11.44	1.56
Exotic Vegetation Encroachment	23	12	11.04	0.96
Bank Erosion	18	14	10.08	3.92
Channel Modification	20	12	9.6	2.4
Water Abstraction	10	13	5.2	7.8
Inundation	25	11	11	0
Flow Modification	25	12	12	0
Water Quality Modification	5	13	2.6	10.4
		100	**72.96**	**27.04**

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

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 **low/marginal ecological importance** and sensitivity according to the EIS (DWAF, 1999) tool as summarized in **Table 9** below. This low/marginal rating is described as: "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" DWAF, 1999).

Table 9: Ecological Importance and Sensitivity Scores

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

It is important to note, however, that Wewe River in-stream habitat is likely moderately sensitive to pollutant inputs due to the damming of flow and water stagnation that is encouraging the accumulation of sediment and pollutants. In addition, the portion of the Wewe River under investigation has been included in the D'MOSS and the downstream Siphon Dam has been classified as a Wetland FEPA. Thus, although disturbed and characterised by low aquatic biodiversity, conservation plans still ascribe value to the system and thus the portion of the river habitat assessed should likely be considered of **moderate ecological importance and sensitivity**.

10 RESULTS & DISCUSSION: FUNCTIONAL IMPORTANCE ASSESSMENT

Although no true wetland habitats were identified, the alluvial floodplain will provide ecosystem services similar to that of a floodplain wetland, specifically flood attenuation services and potential cultivated food benefits. For this reason, the likely level and importance of flood attenuation and cultivated food ecosystem services/benefits provided by the floodplain area was formally assessed using the WET-EcoServices assessment tool (Kotze *et al.*, 2007) developed for wetlands.

The floodplain unit was assessed as providing a moderate/intermediate level of flood attenuation services and a low level of cultivated food benefits. Contextualizing these ratings, the flood attenuation services are considered of **moderately-low** importance due to the small size of the floodplain and the effects of the upstream and downstream dams that have acted to reduce flood events through the portion of the river under investigation. The potential cultivated food services are considered of **moderate** importance due to flat open land being available in a relatively poor area.

It is also important to note that the excavated artificial marshy depression on the floodplain is also providing some water quality enhancement services in the form of sediment trapping, nitrate removal, phosphate removal and toxicant removal, as well as capturing solid waste. These services are likely being provided at a moderate level due to the discharge of stormwater directly into this depression via an outlet headwall. These services are likely of moderate importance in terms of buffering the main river from additional pollutants.

11 PLANNING IMPLICATIONS AND CONSTRAINTS

Due to the low ecological importance and sensitivity of the river system and associated in-stream and riparian habitats, there are no fatal flaws to the current alignment of the proposed pipeline as long as best practice impact minimisation measures are implemented and adhered to (See recommendations provided in **Section 12** below). At a general level, the main planning recommendation would be to focus development within the most disturbed zones and least sensitive habitats. It is the author's opinion that the most sensitive habitat is the active channel bed and banks (in-stream habitat) and the artificial excavated marshy habitat. Thus, wherever possible, these habitats should be spanned and direct physical impacts avoided.

12 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 Wewe River system assessed in the vicinity of the proposed pedestrian bridge. As requested by the EAP, SiVEST, the impact of the proposed pedestrian bridge as shown in **Figures 1** and **2**, and in **Appendix A**, was assessed.

12.1 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

12.1.1 Physical Disturbance Impacts

The proposed construction of the pedestrian bridge will likely involve the physical modification of the riparian and in-stream areas within the construction footprint. The physical clearing of the construction servitudes will result in the clearing of 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 erosion and sedimentation of onsite and downstream riparian and in-stream areas 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 section of the floodplain and terrace will be in-filled for the establishment of bridge embankments. 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 macro-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 may also result in the death of sedentary fauna like frogs, chameleons and millipedes. 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.

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 direct physical disturbances will likely be moderately-low at most and the impact will likely be localized. However, the impact will be long-term in duration and definite in terms of probability.

12.1.2 Water Quality Impacts

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.

12.1.3 Combined Impact to Riverine Habitat Integrity

Ultimately the above-listed impacts will result in the alteration of the current hydrology, geomorphology and ecology of the riparian and in-stream habitats delineated. It is anticipated that the impact to ecological integrity of the delineated river system will be **moderately-low** assuming that construction is undertaken in a responsible manner. Poor construction practices (worst-case scenario) will likely result in a moderate impact to ecological integrity over the short to medium term.

12.1.4 Potential Impacts to Downstream Freshwater Ecosystems

It is highly likely that the in-stream habitats downstream of the delineation site will also be affected, mostly in terms of sedimentation and water quality impacts. As has already been discussed, the impounded water above the Wewe Siphon Dam basically starts at the proposed bridge crossing and, as a result, the downstream habitats have largely been flooded or in-filled by sediment and the remaining habitats are lacustrine in nature. The downstream habitat is characterized by sediment and pollutant accumulation and as such is sensitive to increased pollutant and sediment inputs over time. Thus, further pollutant and sediment inputs would contribute to the degradation of the dam water quality.

However, the expected change in habitat integrity of the Siphon Dam lacustrine habitat as a result of the proposed development is expected to be moderately-low at most. In terms of the impacts to the downstream oThongathi River, it is likely that the dam is actually buffering the river from small additional water quality impacts through the aerobic, anaerobic, settling and biological processes within the dam. If the construction is managed properly, the extent and intensity of the impacts felt downstream should be reduced to local and moderately-low levels respectively. Fortunately, contamination events will be episodic over a relatively short construction phase, thus reducing the impact on downstream aquatic habitat over the long term.

12.1.5 Recommended Mitigation Measures

Bridge alignment and crossing design recommendations:

- The proposed bridge must not impact any existing sewerage infrastructure.
- The bridge must be aligned so that the river is crossed at as close to right angles to the direction of flow as possible.
- Wherever possible, the piers / plinths should be located outside of the active bed and channel. Where unavoidable for substantiated reasons, only one pier/plinth must be established within the active channel.

General site setup recommendations:

- The location of the existing sewer pipelines must be surveyed and demarcated prior to construction commencing.
- During the construction phase, the edge of the active channel, macro channel and artificial wetland depression must be clearly demarcated using danger tape and stakes.
- 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 20m of the active channel or macro channel.

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 riparian areas prior to construction must be compiled for reference and rehabilitation purposes.
- Disturbance to the delineated 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 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 small ingenious shrubs and trees (saplings) 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.
- Soil stockpiles must be located outside of the demarcated active and macro channel banks. The location of these soil stockpiles must be agreed upon by the ECO prior to construction commencing.
- 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 riparian soils along the running track must be ripped to a depth of 30cm.

- 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 hand broadcasting and plugs by a professional. For un-shaded areas, the seed mix should comprise an indigenous grass mix comprising of 'runner' grasses like *Cynodon dactylon* var. Sea Green. If the construction corridor is shaded, the grass mix should comprise shade tolerant species. In addition, the rescued indigenous plants must also be re-planted within the construction corridor by a professional.
- 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 unshaded 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 within 32m of the delineated watercourses 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 riparian and in-stream 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.

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 10m of the active and macro-channels.
- Every effort must be made to capture concrete/cement spillage during the establishment of the piers / plinths within the macro and active channels.
- 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.

12.2 Impacts Resulting from Operational Phase Activities

Potential operation impacts to riverine habitat integrity will be:

- 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.

12.2.1 Flow Alteration Impacts

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 moderately-low at most and the impact will likely be localized. However, the impact will be long-term in duration and definite in terms of probability.

12.2.2 Shade Impacts

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, the change in the state of the riverine habitat as a result of shading will likely be low and the impact will likely be very localized. However, the impact will be long-term in duration and definite in terms of probability.

12.2.3 Solid Waste Impacts

The establishment of the bridge will result in the increased temptation to dispose of solid waste and other waste materials (e.g. grey water) directly into the river, which would contribute to a 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 to the Wewe Siphon Dam. Furthermore, the impact will be long-term in duration and probable in terms of probability.

12.2.4 Combined Impact to Riverine Habitat Integrity

Ultimately the above-listed operational impacts will result in the alteration of the current hydrology, geomorphology and ecology of the riparian and in-stream habitats delineated. It is anticipated that the impact to ecological integrity of the delineated river system will be **moderately-low**.

12.2.5 Impacts to Downstream Freshwater Ecosystems

It is highly likely that the in-stream habitats downstream of the delineation site will also be affected, mostly in terms of sedimentation and water quality impacts. However, the expected change in habitat integrity of the Siphon Dam lacustrine habitat and oThongathi River as a result of the operational impacts of the proposed development is expected to be moderately-low at worst.

12.2.6 Recommended Mitigation Measures

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

13 IMPACT ASSESSMENT

13.1 Construction Phase Impacts

A description and rating of the potential construction phase impacts is provided in **Table 10** below. The significance of the construction phase impacts on freshwater ecosystems and resources was assessed as being **medium** (undesirable / 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 10: Impact Assessment for Construction Phase Impacts

Impact 1:	*Reduction/ degradation in freshwater ecosystems and biodiversity as a result of physical disturbance impacts*			
Impact Criteria	**Pre-Mitigation**		**Post-Mitigation**	
	Score	**Rating**	**Score**	**Rating**
Intensity (Degree of Change)	2	Medium-Low	1	Low
Extent	2	Local	2	Local
Duration	2	Medium-short	2	Medium-Short
Probability	5	Definite	3	Possible
Impact Significance	**13**	**Medium**	**9**	**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
Impact 2:	*Reduction/ degradation in freshwater ecosystems 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	2	Local	2	Local
Duration	2	Medium-short	2	Medium-Short
Probability	4	Probable	3	Possible
Impact Significance	**12**	**Medium-Low**	**9**	**Low**
Reversibility	n/a	Reversible	n/a	Reversible
Irreplaceable Loss of Resources	n/a	No Loss	n/a	No Loss
Cumulative Effects	n/a	Moderate	n/a	Limited

13.2 Operational Phase Impacts

A description and rating of the potential operational phase impacts is provided in **Table 11** below. The significance of the operational phase impacts on freshwater ecosystems and resources was assessed as being **medium** (undesirable / generally unacceptable) under a poor mitigation scenario. With the effective implementation of appropriate mitigation, the impact was assessed as being of **medium-low** significance.

Table 11: Impact Assessment for Operational Phase Impacts

Impact 1:	*Reduction/ degradation in freshwater ecosystems 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	1	Low
Extent	1	Site	1	Site
Duration	4	Long-term	4	Long-term
Probability	5	Definite	5	Definite
Impact Significance	**12**	**Medium-Low**	**12**	**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
Impact 2:	*Reduction/ degradation in freshwater ecosystems 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	5	Definite	4	Probable
Impact Significance	**13**	**Medium**	**12**	**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	Medium	n/a	Medium-Low

14 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 Wewe River to be directly affected by the proposed pedestrian bridge to link the Burbreeze and Sandfields 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 Wewe River wetland and riparian habitats and identify and describe the potential impacts of the proposed bridge on the Wewe River 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 riparian zone comprising the following riparian morphological features:

- Active channel bank
- Macro channel bank
- Flood bench
- Floodplain
- Terrace

The delineated Wewe River in-stream and riparian habitats were assessed as being found to be seriously modified and in a poor state (Ecological category E) as a result of direct physical disturbances and indirect catchment related disturbances that have altered hydrological and geomorphological processes. As a result, the riparian areas were found to be dominated by mixes of alien invasive and indigenous ruderal and invasive plant species typical of disturbed freshwater habitats.

The section of the Wewe River in-stream and riparian habitat delineated was assessed as being of low ecological importance and sensitivity. However, the Wewe River in-stream habitat is likely moderately sensitive to pollutant inputs due to the damming of flow and water stagnation that is encouraging the accumulation of sediment and pollutants. In addition, the portion of the Wewe River under investigation has been included in the D'MOSS and the downstream Siphon Dam has been classified as a Wetland FEPA. Thus, although disturbed and characterised by low aquatic biodiversity, conservation plans still ascribe value to the system and thus the portion of the river habitat assessed should likely be considered of moderate ecological importance and sensitivity.

The proposed pedestrian bridge is expected to result in a number of potential direct and indirect impacts to the Wewe River in-stream and riparian 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>

- Flow diversion impacts
- Shade impacts
- Water quality impacts

Overall, the most significant impacts are the direct physical disturbance and associated erosion and sedimentation impacts and the water quality impacts that will/could occur during the construction phase. The operational impacts are considered less significant.

The change in current riverine integrity as a result of the potential impacts arising during the construction phase activities on 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 low to moderately-low at worst and there were limited opportunities for mitigation with the exception of educating bridge users on the importance of rivers and the impacts of and prohibitions related to littering.

Overall, the anticipated impact to riverine habitat integrity was generally assessed as being moderately-low due to the already poor state of the in-stream and riparian 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 were assessed as being of medium significance under a worst-case or poorly mitigated scenario. The solid waste pollution impacts were also assessed as being of medium significance but are an existing impact. 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 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.

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APPENDIX A: CONCEPTUAL BRIDGE DESIGN